

Name: _____

GEOL 104 Dinosaurs: A Natural History

Smithsonian Assignment II: Dinosaurs, Mesozoic Marine Life, and the Cenozoic Era (but mostly dinosaurs)

DUE: November 22

The Smithsonian Institution's National Museum of Natural History (NMNH) has one of the largest collections of dinosaur and other fossils in the world. This exercise will concentrate on the wonderful dinosaur fossils on exhibit.

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 dinosaur cladograms handed out in class. You may work in teams and discuss your answers; however **ALL WORK YOU TURN IN MUST BE YOUR OWN**. 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

Date

This package works as sort of a self-guided tour. It will start you at one end of the Dinosaur Hall, then lead you through that Hall (including the upstairs), then through the Mesozoic section of the Life in the Ancient Seas Hall, and finally take you into the Hall of Fossil Mammals and Hall of Ice Age Mammals to get a glimpse at life after the Age of the Dinosaurs.

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.

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PART I – THE DINOSAUR HALL

We'll start with the king! Enter the main Dinosaur Hall, and go up the short stack of steps to the "main" level of the hall. Find the *Tyrannosaurus rex* skeleton (shouldn't be too hard...). Gaze at its majesty for a bit. Incidentally, Dr. Holtz worked on the (admittedly limited) text associated with this exhibit. Now, answer the following questions:

- 1) Which are larger? [Its largest manual unguals | Its longest teeth]
- 2) How many digits does it have per manus? _____
- 3) How many digits does it have per pes? _____

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.

- 4) The metatarsus is [less than $\frac{1}{4}$ the femur length | about $\frac{1}{2}$ 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. Read the text and view some of the videos.

- 5) Where was the original skeleton discovered? _____
- 6) The original skeleton has been removed from display, and a plastic copy has been used to replace it. What was the main reason for this switch?

The technology used to make the new cast (laser scanning, computer aided design, rapid prototyping, and such) is pretty interesting. What flaws of the old mount was the Smithsonian team able to correct by using this new technology? (List one flaw, with extra credit for a second).

- 7) Flaw:

Extra Credit)

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

- 8) In *Triceratops* the metatarsus is [less than $\frac{1}{4}$ the femur length | about $\frac{1}{2}$ the femur length | as long as the femur].

Name: _____

Continue on through the ceratopsian and pachycephalosaur exhibits.

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

10) What centrosaurine genus (formerly considered its own genus and species, *Brachyceratops montanensis*) is represented by a juvenile individual?

Primitive (non-ceratopsid) ceratopsians are represented by three skulls: *Protoceratops*, *Bagaceratops*, and *Psittacosaurus*.

11) In the specimens on display here, which one of these is represented by an embryo or hatchling?

12) Several pachycephalosaurs are also on display here. List one of the **species** of pachycephalosaurs on display.

13) Where the original fossil of the specimen you described in question 12 discovered? _____

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

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

15) Where was the specimen of *Heterodontosaurus* discovered? _____

16) [*Thescelosaurus* | *Heterodontosaurus*] is the younger of the two.

Move along to the hadrosaurids, much larger ornithopods.

17) The hind end of *Corythosaurus casuarius* is displayed. Note that the scales of this dinosaur were preserved.

Describe (or draw) what these scales look like:

Name: _____

Further down, the complete skulls of an adult hadrosaurine and a juvenile lambeosaurine are on display.

Examine the skull of the hadrosaurine *Edmontosaurus annectens*, one of the “duckbill-iest” of the duckbills.

18) The naris of *Edmontosaurus* is [larger than | about the same size | smaller than] the orbit.

19) Adults of *Corythosaurus* have a very tall crest over the top of the skull. The skull of the juvenile *Corythosaurus* [does | does not] have the same very tall crest.

Turn around, and find the eggs of the deinonychosaur *Troodon* (the only raptor fossils on display here!) and the baby *Maiasaura* skeleton. *Maiasaura* is a hadrosaurine hadrosaurid. (These Cretaceous fossils are a bit out of place, since all the other dinosaurs in this central island are from the Late Jurassic Morrison Formation).

20) As mounted, the *Maiasaura* is in a [bipedal | quadrupedal] pose.

Turn back around to the wall, and pass the cast of the *Tyrannosaurus rex* skull. Examine the skeleton of *Ceratosaurus nasicornis*. This is the **type specimen** (the original one to which the name was assigned). New research indicates that it wasn't fully grown when it died.

21) How many fingers does it have on each hand? _____

22) From what Epoch did *Ceratosaurus* come? _____

Turn around and face the main island. As mentioned above, all the dinosaurs in the 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).

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

(Incidentally, note the bony armor knobs around the cervical vertebrae).

Name: _____

The central island is dominated by *Diplodocus*, a very long sauropod.

24) Find the **distal** caudals (the tail tip) 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

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

26) 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. One is a macronarian, and one is a diplodocoid. Identify what representative from each group is shown:

27) Macronarian:

28) Diplodocoid:

Extra Credit) Which one has thicker teeth?

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

Name: _____

From this position you can see skeletons of three of the most common herbivorous dinosaurs of the Morrison Formation: *Camarasaurus*, *Diplodocus*, and (down the path) *Stegosaurus*. (The fourth most common Morrison herbivorous dinosaurs, the ornithomimid *Camptosaurus dispar*, is on display as a juvenile, but the adult is currently taken down for repairs). In nature, animals with similar diets divide up the ecosystem so that they reduce direct competition with each other. One way of doing this is by feeding at different heights.

Arrange these three dinosaurs in relative feeding height (assume that they did not rear up):

30) Tallest feeder:

31) Middle feeder:

32) Lowest feeder:

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

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

34) The many little osteoderms (not the plates or spikes) protect what part of this dinosaur?

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

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

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

37) How many digits per pes 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.

38) The blow that damaged the *Allosaurus* was more likely from *Diplodocus* than from *Stegosaurus*. How can you tell?

Name: _____

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.

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

Now head up the stairs. From the upper deck of the Dinosaur Hall, find the overlook and look down at the central island. Look at the dinosaurs from above.

40) Note that the *Allosaurus* is skinnier in the torso and hips than *Stegosaurus* or *Diplodocus*. What advantage might herbivores get from having a wider body?

Turn around and look at the pterosaur exhibit.

Overhead is a reconstruction of the giant pterosaur *Queztlcoatlus*. Find the cast of an actual bone of this pterosaur.

41) As precisely as possible, which bone is represented by a cast? (I.e., don't just say "arm bone"!! You are getting college credit for this...)

42) What evidence on this bone is there that pterosaurs had powerful wings?

Move around to the main pterosaur displays. Take a look at the *Pteranodon* skeletons (either the mounted complete skeleton, or the larger isolated wing).

43) The distal part of the pterosaur wing is comprised of digit [I | II | III | IV | V | VI | VII].

Move to the other side of this panel, and find the exhibit on early birds. There are casts of the first two skeletons of *Archaeopteryx lithographica* on display.

44) What feature of the species, not typically preserved in fossils, is present in these *Archaeopteryx* fossils?

Name: _____

Head over to the ramp, and walk up it a bit. Find the exhibit sign labeled “What’s for Dinner?” that describes the two wall-mounted specimens on the opposite wall. One is the hadrosaurine *Edmontosaurus* (in life position), a contemporary of *Tyrannosaurus* and *Triceratops*. The other (in death position, although tilted so that what was once the upper surface is facing you) is the tyrannosaurid *Albertosaurus* (actually it’s *Gorgosaurus* by current taxonomy), a dinosaur from about 10 million years earlier than *Edmontosaurus*. In fact, it was a contemporary of the centrosaurine *Centrosaurus* that you saw in question 9.

Edmontosaurus, *Triceratops*, and *Tyrannosaurus* are the three most common large dinosaurs of the Hell Creek Formation (the youngest rocks from the Age of Dinosaurs in North America). Take a look at them together from your vantage point (you won’t be able to see all of *Triceratops*, but you can see enough).

45) Which herbivore would have had a higher feeding range? [*Edmontosaurus* | *Triceratops*]

46) Which of the two tyrannosaurids is larger? [*Albertosaurus* | *Tyrannosaurus*]

The directions below will direct you to the next section of this project

PART II – MESOZOIC MARINE LIFE

From the “What’s for Dinner?” plaque, head back downstairs, past the Morrison Formation island, down the small stairs between *Tyrannosaurus* and *Triceratops*, and take a right turn into the Hall of Ancient Life in the Seas. Once there, take a right (that is, go underneath the sign labeled “Act Two – The Mesozoic Era”). This hall 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. The particular section you are in contains exhibits on the marine life of the Age of Dinosaurs.

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).

Name: _____

47) You can see a skeleton of the giant Cretaceous sea turtle *Protostega*. What features of its anatomy show that it was a sea turtle (as opposed to a land-dwelling one)? (List one, with extra credit for another).

48) Several partial skulls of placodonts are available. What evidence is there that placodonts ate shellfish?

49) Find one of the ichthyosaur skeletons. What evidence is there that ichthyosaurs would be unable to come up onto land?

50) There is a skeleton of a plesiosaur on display. Which species is represented?

51) Where was the plesiosaur in question 50 discovered?

52) The flightless marine bird *Hesperornis* (one of the few marine dinosaurs of the Cretaceous) is also on display.

How many bones are present in its forelimb?

53) The beak of *Hesperornis* differs from modern birds in a very important way. What feature is present in *Hesperornis*' beak that is not found in living bird species?

54) Several species of mosasaurs (true marine lizards) are on display. Which species does the largest specimen represent?

55) Where was the specimen of mosasaur in question 54 discovered?

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 shells coiled in a disc, others have straight shells, still others have more complex patterns.

56) List a species of simply coiled ammonite: _____

57) List a species of straight-shelled ammonite: _____

58) List a species of ammonite with a more complex shell: _____

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

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

PART III – LIFE AFTER THE AGE OF DINOSAURS

Now you’ll be heading to the fossil mammal halls. Move down the Hall of Ancient Life in the Seas into the next section (“Act Three – The Cenozoic Era”), and take a right up the steps labeled “Reptiles: Masters of the Land”. On the wall opposite those steps is a small exhibit on the Cretaceous-Tertiary impact and extinction. This exhibit includes a real deep-sea drilling core that actually contains the stratigraphic boundary from the Cretaceous Period to the Tertiary Period.

60) Where was this deep-sea drilling core recovered?

Name: _____

The display shows electron micrographs of the microfossils and other features found in this core. In particular, it shows the foraminifera (single-celled organisms with a calcareous shell) from above and below the impact layer.

61) According to this display, the foraminifera immediately after the impact are best described as

[more diverse, more ornate, larger | less diverse, less ornate, smaller] than the ones before the impact.

From this Cretaceous-Tertiary exhibit, turn left. Turn right (the only option), and then turn left again. 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*.

62) To what modern group of animals is *Hyracotherium vasacciensis* most closely related?

Now head over to the start of the hall, past the “Plants in the Age of Mammals” display, to a glass case display of Mesozoic 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 Tertiary Period, and represent the exhibits in the main Hall of Fossil Mammals.

Compare the actual fossils (not the enlarged white models) of Mesozoic mammals with those of the Paleocene mammals.

63) Does there seem to be a size change from the Mesozoic to the Paleocene? If so, what change occurred?

64) What part of the body is most represented in the Paleocene mammals on display here?

Name: _____

The rest of the Tertiary 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.

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 a species of each of the following that is represented by Green River Shale fossils on display here:

65) Bird: _____

66) Fish: _____

67) Insect: _____

68) Plant: _____

69) The biggest animal in the main Eocene display is *Uintatherium*, 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”):

70) *Diatryma* (a bird):

71) *Smilodectes* (a primate):

72) *Hyrachyus* (a rhinoceros-relative):

Move on to the “Oligocene” Epoch exhibit (which are actually mostly latest Eocene Epoch mammals, by more recent geologic time studies).

73) *Brontotherium hatcheri* is the largest animal on display here. It was a [bipedal carnivore | quadrupedal carnivore | bipedal herbivore | quadrupedal herbivore].

Extra Credit) There are several non-avian reptile fossils in the Oligocene exhibit. List the species name of two, each for extra credit.

Name: _____

Head on over to the Miocene Epoch exhibit.

74) *Moropus* possessed powerful claws on its forelimbs. It was a [herbivore | carnivore].

75) A section of a bone bed (a mass accumulation of fossils) is shown at the Miocene exhibit. What species represents the majority of bones in this bone bed?

Stop over at the evolution of the horse 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. List at least two major different trends in horse evolution, with extra credit for a third trend.

76) Trend 1:

77) Trend 2:

Extra Credit)

Look at the Late Miocene-Early Pliocene Epoch display. The largest mammal here is the proboscideans (elephant relative) *Stegomastodon*.

78) To what modern animal is *Stegomastodon* most closely related?

79) What evidence can you see that the rhinocerotoid *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.

80) What “common” (that is, English) name is given to the giant mammal *Eremotherium*?

Extra Credit) What was its diet?

Name: _____

81) Just like dinosaurs produced the ankylosaurs, so to the mammals produced their own heavily armored forms: the glyptodonts. On display is *Glyptotherium arizonae*. What is this animal's likely diet?

82) In what major functional way was the shell of *Glyptotherium* and other glyptodonts different from that of their modern cousins, the armadillos (also on display)?

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*.

Give the species name for carnivorous mammals on display:

83) Dire wolf:

84) Sabre-toothed cat:

Extra Credit) How do these Ice Age predators compare in size to *Tyrannosaurus rex*?

85) To what group of animals does *Teratornis merriami* belong?

86) According to the display, why might so many carnivorous animals be found in the tar pits?

Further down in the Ice Age Mammal Hall are fossils of northern mammals. The two largest of these shown here are *Mammuthus primigenius* (the woolly mammoth) and *Mammuth americanum* (the mastodon).

87) Where was this skeleton of *Mammuthus primigenius* found?

88) Where was this skeleton of *Mammuth americanum* found?

Name: _____

Find the “mummy” of the extinct bison *Bison crassicornus* on display.

89) In dinosaur “mummies” the actual skin is not preserved, only the impression of the skin. In the case of this bison, however, this is the honest-to-goodness skin and flesh. How was this soft tissue preserved in Nature?

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 where in the world each of the following animals was from:

90) *Megaloceros*:

91) *Diprotodon*:

92) *Dinornis*:

Extra Credit) Which of those three was a dinosaur?

That’s it for this trip! While you are in the museum, use your time to examine some of the other exhibits.