Name:_____

GEOL 104 Dinosaurs: A Natural History
Smithsonian Assignment

DUE ONLINE: November 14

"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, this assignment is covered by the University's Honor Code: I pledge on my honor that I have not given or received any unauthorized assistance on this assignment

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

You will be turning in this assignment on ELMS, choosing the selections or typing in the answers indicated below. You can print out this pdf or have it on your smartphone/tablet or whatever as you go along. Either take notes of the answers and enter them later, or (if you have a good enough connection) you can input the answers directly into ELMS.

The entire East Wing First Floor of the National Museum of Natural History was dedicated to fossil life, including the world famous Dinosaur Hall. However, museum exhibits get out of date over time and need to be revised. We are in the middle of a MAJOR overhaul of the fossil galleries, which won't be completed until the end of 2019! So in the meantime there is a temporary exhibit of dinosaurs from the end of the Cretaceous on the 2nd Floor, behind the Osteology ("Hall of Bones") hall. So we'll use these two halls for this assignment, plus fossils from the Sant Ocean Hall on the First Floor.

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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.

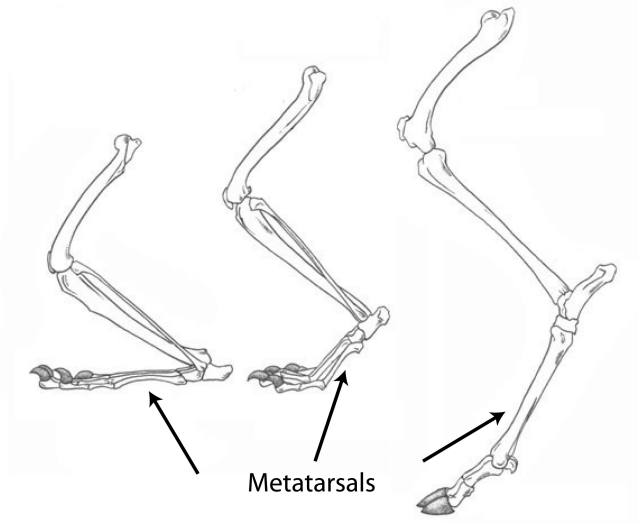
In order to better understand the dinosaurs, we first have to understand the anatomy, behavior, and ecology of modern vertebrates. The Smithsonian's Osteology ("Bones") Hall gives us an excellent opportunity for comparison. We do know a lot more about modern animals (their complete anatomy, including 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. This packet works best if you enter the hall from the Rotunda end.

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:



Name:_____

Opposite the entrance is a set of skeletons of apes and a human. Take a look at the human foot.

1) Humans have a(n) [plantigrade | digitigrade | unguligrade] pes.

We'll compare our foot to other mammals when we get into the main room.

Move along and find the panel about bats. Find the skeleton of *Pteropus samoensis* (the Samoan flying fox).

2) How many digits does *Pteropus samoensis* have in its manus? [0 | 1 | 2 | 3 | 4 | 5 | 6 | 7]

A little further along is the skeleton of the La Plata dolphin (*Pontoporia blainvillei*).

3) Which of the following best describes the teeth of *Pontoporia blainvillei*?

a. Undifferentiated (essentially the same shape from the front of the jaws to the back, although maybe different in size)
b. Differentiated (teeth of very different shapes in different parts of the jaw)

Walk into the main mammal room, and look around a bit. See some of the wonderful diversity of living (and a very recently extinct) members of Mammalia. Now find the primates exhibit, and specifically the proboscis monkey (*Nasalis larvatus*).

4) Which of the following best describes the teeth of *Nasalis larvatus*?

a. Undifferentiated (essentially the same shape from the front of the jaws to the back, although maybe different in size)
b. Differentiated (teeth of very different shapes in different parts of the jaw)

Now find the skeleton of the pronghorn (*Antilocapra americana*).

5) How many teeth are there in each premaxilla in *Antilocapra americana*? [0 | 1 | 2 | 3 | 4 | 5 | 6 | 7]

6) Which of the best describes the lower jaw of *Antilocapra americana?*

a. Continuous teeth from the front to back
b. Teeth only present in the front
c. Teeth only present in the back
d. Nipping teeth present in the front, a diastema (a space without teeth), and then grinding teeth in back

Name:_____

Find the skeleton of the bison (*Bison bison*)

7) Can you see the horns in this particular skeleton? [Yes | No]

8) Like most of the bigger mammals in this exhibit (those a quarter your size or larger), the femur of *Bison* is oriented [parasagittally | sprawling out to the side].

Find the skeleton of the Indian rhino *Rhinoceros unicornis*.

9) Can you see the horn in this particular skeleton? [Yes | No]

10-Extra Credit) Based on the text of the exhibit—and previous knowledge—explain the reason for the observation in 9.

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

[3 | 4 | 5 | 6 | 7 | 8 | 9 | 10]

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

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

[3 | 4 | 5 | 6 | 7 | 8 | 9 | 10]

13) List a feature that would allow *Giraffa* to feed higher in the trees than *Rhinoceros*:

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*.

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

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

16) Review the different types of foot posture, and indicate if the following mammals are **plantigrade**, **digitigrade**, or **unguligrade**. We will only look at the **pes** and ignore the manus for this. [6 pts total]

Coatimundi (*Nasua nasua*)	[plantigrade | digitigrade | unguligrade]
Mandrill (*Mandrillus sphinx*)	[plantigrade | digitigrade | unguligrade]
Bison (*Bison bison*)	[plantigrade | digitigrade | unguligrade]
Tiger (*Panthera tigris*)	[plantigrade | digitigrade | unguligrade]
Indian rhinoceros (*Rhinoceros unicornis*)	[plantigrade | digitigrade | unguligrade]
Bighorn sheep (*Ovis canadensis*)	[plantigrade | digitigrade | unguligrade]

Name:_____

Pass through the circular chamber that discusses the biology of bone into the bird hall.

Find the section on "Running Birds", and the skeleton of the rhea (*Rhea americana*).

17) The unguals are

a. slender and highly curved, like hooks
b. flat on the bottom and straight, like a wedge

18) The penultimate ungual (that is, the one immediate proximal to the ungual) is:

a. as long or longer the other, even more proximal unguals
b. shorter than the other, even more proximal unguals

Find the section on "Arboreal Birds", and the skeleton of the pileated woodpecker (*Dryocopus pileatus*).

19) The unguals are

c. slender and highly curved, like hooks
d. flat on the bottom and straight, like a wedge

20) The penultimate ungual (that is, the one immediate proximal to the ungual) is:

c. as long or longer the other, even more proximal unguals
d. shorter than the other, even more proximal unguals

Find the section on "Aquatic Birds" (right next to the giant leatherback sea turtle *Dermochelys coriacea coriacea*. Find 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.

21) *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).

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

[*Gavia* | *Spheniscus*]

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

[*Gavia* | *Spheniscus*]

Name:_____

Move on into the Reptile & Amphibian room. Compare the manus of the leatherback turtle (*Dermochelys coriacea coriacea*) and the Galápagos tortoise (*Geochelone elephantopus*).

24) Which has long phalanges forming a broad flat surface? [*Dermochelys* | *Geochelone*]
25) Which has short stubby phalanges forming compact foot? [*Dermochelys* | *Geochelone*]

Find the section on snakes, and specifically the Eastern diamondback rattlesnake (*Crotalus adamanteus*). People sometimes think that snakes either don't have tails, or are basically all tails. In animals with legs this isn't a problem, but some people get confused by the legless modern snakes. But there is a distinction between the torso (with dorsal and sacral vertebrae) and the tail (with caudal vertebrae). In life you can look for soft tissues (including the anus, at the point where the tail begins) to distinguish the sections, but you can do so with bones, too. For instance, dorsal and sacral vertebrae have true ribs, but caudals do not. Also, there are often distinction in the shape and size between the (normally larger) torso vertebrae and the (normally smaller) caudal ones.

26) Look at the *Crotalus* skeleton. Which of the following is true?

a. The body is mostly torso, with a much shorter tail.
b. The body is mostly tail, with much shorter torso.
c. The body is about equal parts torso and tail.

Find the crocodilian skeletons. In particular, find the gavial (*Gavialis gangeticus*), and the black caiman (*Melanosuchus niger*).

Compare the skulls of *Melanosuchus* and *Gavialis*.
27) Which genus has a slender narrow snout and needle-like teeth (and thus is specialized for catching relatively small fish)? [*Melanosuchus* | *Gavialis*]
28) Which genus has a broader snout and stouter conical teeth (and thus is specialized for catching fish of all sizes, and land vertebrates as well)? [*Melanosuchus* | *Gavialis*]

29) 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]

30) Which best describes the resting stance of the hindlimb shown in the crocodilians?

a. Parasagittal (upright)
b. Sprawling

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From this point you are going on to the temporary dinosaur hall. Walk into the Fish section of the Osteology gallery, and take a right (near the Eternal Life in Ancient Egypt exhibit) to enter "The Last American Dinosaurs"

PART II – THE LAST AMERICAN DINOSAURS

This hall is devoted to the paleontology of the Hell Creek Formation, rocks from the American West from the very end of the Cretaceous Period. Fossils from these sediments include some of the most famous species of dinosaurs. But there is more to the Hell Creek than just the dinosaurs, and this hall displays these as well.

One of the first dinosaurs to great you is *Triceratops horridus*. Find the specimen where the braincase region of a *Triceratops* has been sawed in half, so that you can see the medial surface of the bones. The brain cavity is labeled, and above it (unlabeled) is a sinus (open space in the face).

31) In *Triceratops*, the brain cavity is [larger | about the same size | smaller] than its sinuses.

Find "Hatcher", the large restored skeleton of *Triceratops*. Look at its hindlimb.

32) Which best describes the stance of the hindlimb in *Triceratops*?

a. Parasagittal (upright)
b. Sprawling

33) Take a look at the pes of *Triceratops*. Which posture does it show?

[plantigrade | digitigrade | unguligrade]

34) Compare the length of the metatarsus to the length of the femur in *Triceratops*. Which of the following best describes the relative length of the metatarsus?

a. Metatarsus about the same length as the femur
b. Metatarsus about ½ the length of the femur
c. Metatarsus about ¼ the length of the femur

Turn around, and find the "An Amazing Diversity of Dinosaurs" display. This describes the various species of dinosaurs from the Hell Creek Formation.

First, we'll use the species as listed.

35) How many species of herbivore are listed? _____

36) How many species total of omnivores and carnivores are listed? _____

However, not everyone would agree on the taxonomy here, or that all the species lived simultaneously. For instance, *Triceratops horridus* and *T. prorsus* didn't live side-by-side; *T. prorsus* is only in the latest part of the Hell Creek, so we should only count them as 1 species together. Also, *Thescelosaurus garbanii* and

Name:_____

Thescelosaurus neglectus are probably just one species, and *Pachycephalosaurus wyomingensis* and *Stygimoloch spinifer* are probably just one species.

37--Extra Credit) How many species of Hell Creek herbivore are there, once you make these recalibrations?

_____

Move along the corner of the wall, and find the "Cow of the Cretaceous" exhibit about *Edmontosaurus annectens*. (Personally, I would regard this as *Anatosaurus annectens*, but that is a splitter-vs.-lumper thing). Look at the skull of *Edmontosaurus*.

38) Which of the best describes the lower jaw of *Edmontosaurus annectens?*

a. Continuous teeth from the front to back
b. Teeth only present in the front
c. Bill in the in the front, a diastema (a space without teeth), and then grinding teeth in back

39--Extra Credit) Overall, to which of the following herbivorous mammal you looked at in Part I is this pattern most similar?

a. The proboscis monkey (*Nasalis larvatus*)
b. The pronghorn (*Antilocapra americana*)

Okay, okay, NOW go over to the *Tyrannosaurus rex*!

40) Which are longer?

a. The longest manual ungual
b. The longest tooth

41) Look at the hindlimb. Which of the following best describes the relative length of the metatarsus?

a. Metatarsus about the same length as the femur
b. Metatarsus about ½ the length of the femur
c. Metatarsus about ¼ the length of the femur

42) Move on to the ecosystem mural, and the wall display of some of the smaller organisms from the Hell Creek Formation. Match the species with the group to which it belongs. [6 pts total]

Habrosaurus dilatus	_____	A. Dromaeosaurid dinosaur
Acheroraptor temertyorum	_____	B. Marsupial mammal
Nelumbago montanum	_____	C. Sirenid salamander
Erlingdorfia montana	_____	D. Multituberculate mammal
Dideplphodon vorax	_____	E. Plant related to living sacred lotus
Meniscoessus robustus	_____	F. Plant related to living sycamores

Name:_____

Find the "Many Survived" display, find the skeletons of *Stangerochampsa* sp. and *Champsosaurus laramiensis*. Go to the side where you can see the skulls.

43) Which of these has a skull like *Gavialis* (long & slender, with thin conical teeth)?

[*Stangerochampsa* | *Champsosaurus*]

44) Which of these has a skull like *Melanosuchus* (shorter & broader, with stouter conical teeth)?

[*Stangerochampsa* | *Champsosaurus*]

Go back and find the complete skeleton of *Didelphodon* (not just the jaws on the Ecosystem wall). Compare the skeleton of *Didelphodon* with that of *Stangerochampsa*.

45) How does the size of *Didelphodon* compare with that of *Stangerochampsa*?

a. Very much smaller (only 1/3 or less in length)
b. Generally the same size (at least 2/3 the length to up to 1/3 longer)
c. Definitely larger (more than twice as long)

46) Towards the end of the gallery, past the displays about ongoing research in the Hell Creek Formation and the fossil preparation lab, and find the display "Are We in Another Mass Extinction?" Specifically, find the display "Last Birds". These are species which have died out in recent decades, or centuries. Match the species to the date of their extinction.

Carolina parakeet (*Conuropsis carolinensis*)	_____	A. End of 14th Century
Dodo (*Raphus cucullatus*)	_____	B. 1662
Eastern moa (*Emeus crassus*)	_____	C. 1918
Ivory-billed woodpecker (*Campephilus principalis*)	_____	D. 1944

PART III – PALEONTOLOGY IN THE 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. But first, let's take a look at the history of fossil apex predators, in the exhibit "Who's On Top?" Use the data provided by this exhibit to answer the next set of questions.

Name:_____

47) Match the letter of the group of apex predator to the time period in which they were dominant. [5 pts total]

100-65 Ma	_____	A. Anomalocariidids
299-251 Ma	_____	B. Eurypterids
416-359 Ma	_____	C. Helicoprionids
444-416 Ma	_____	D. Mosasauroids
542-488 Ma	_____	E. Placoderms

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**.

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

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

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

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

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

52) Find the section labeled ""Who Lives? Who Dies?" Indicate which of the species listed below was a "Victim" or a "Survivor". [4 pts total]

Lahilla larseni	[Victim | Survivor]	*Belemnites densus*	[Victim | Survivor]
Baculites corrugatus	[Victim | Survivor]	*Seriola prisca*	[Victim | Survivor]

Turn around and find the section labeled "The Evolution of the Whale". Look up to find the skeletons of *Maiacetus inuus*, *Dorudon atrox*, and *Basilosaurus cetoides*: primitive whales from the early part of the Cenozoic Era. Of these three, *Maiacetus* is the oldest and the most primitive, *Dorudon* is the intermediate, and *Basilosaurus* is the closest to modern whales (although it is still far more primitive than any living whale).

Name:_____

53) Over their early history, whales [decreased | remained the same size | increased] in size.

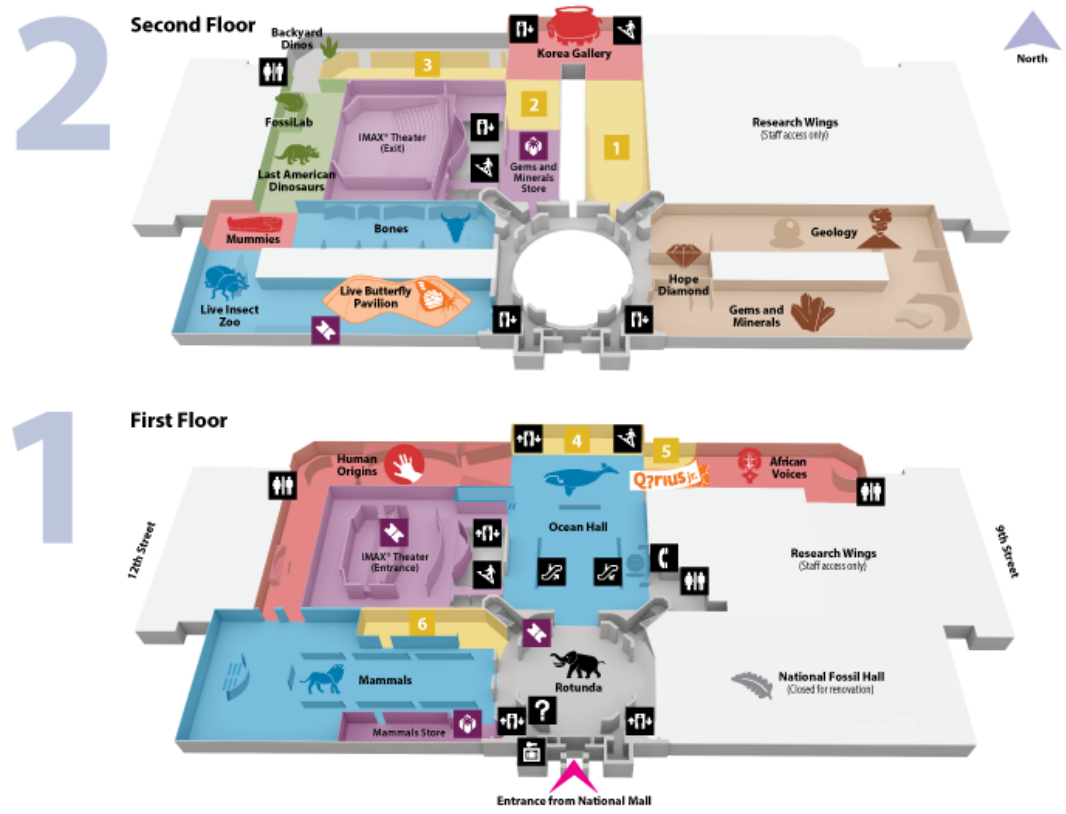
54) Over their early history, the size of the hindlimb of whales

[decreased | remained the same size | increased].

55—Extra Credit) In which of these genera is the pelvic girdle still attached to the vertebral column?

[*Maiacetus* | *Dorudon* | *Basilosaurus*]

Name:_____



SPECIAL EXHIBITIONS

1. *Into Africa* — Second Floor (Opens June 1)
2. *Wilderness Forever* — Second Floor
3. *Beyond Boölywood* — Second Floor (Through August 15)
4. *Portraits of Planet Ocean* — First Floor (Through September 1)
5. *Mali Mud Masons* — First Floor
6. *Iceland Revealed* — First Floor (Opens July 1)

INTENSIVE INTERACTIVES

- Live **Butterflies** and Plants — Second Floor
- Q?rius — Designed for teens — Ground Floor
- Q?rius jr. — Ages 9 and under — First Floor

ANIMALS & ECOSYSTEMS

- Bones — Second Floor
- Live Insect Zoo — Second Floor
- Mammals — First Floor
- Ocean Hall — First Floor
- Birds of DC — Ground Floor

DINOSAURS AND FOSSILS

- National Fossil Hall — Closed for renovation
- Backyard Dinos — Second Floor
- The Last American Dinosaurs — Second Floor
- FossiLab — Second Floor
- *T.rex* Skull — Ground Floor

EARTH SCIENCES

- Gems and Minerals — Second Floor
- Hope Diamond — Second Floor
- Geology — Second Floor

HUMAN DIVERSITY

- Korea Gallery — Second Floor
- Mummies — Second Floor
- African Voices — First Floor
- Human Origins — First Floor

AMENITIES

- Stores
- Tickets
- Dining
- ATM

FACILITIES

Accessible · Escalator · Information Desk · Pay Phone · Security Office · Elevator · First Aid · Locker Storage · Restrooms · Stairs