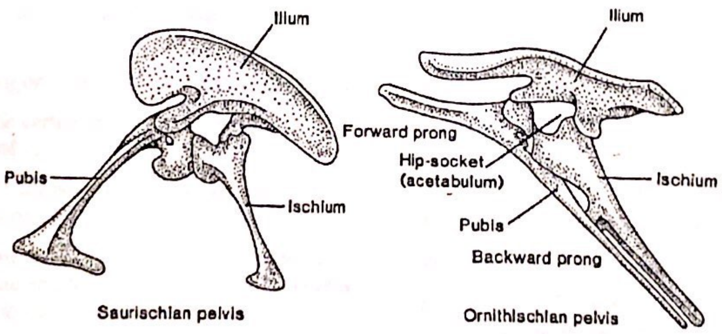
GEOL 1602 **Vertebrate Paleontology Lab** **Name**________________

Don't forget the Linnean classification system!
- Kingdom (Animalia)
  - Phylum (Chordata)
    - Class
      - Order
        - Family
          - Genus
            - Species

Class Dinosauria – Late Triassic to Recent?
- **Order Saurischia** –The lizard-hipped dinosaurs.
  - **Suborder Theropoda** – All of the carnivorous dinosaurs and the first birds. Includes *Tyrannosaurus rex* and *Archaeopteryx.*
  - **Suborder Sauropodomorpha** – The largest of the dinosaurs. Includes the famous *Apatosaurus (Brontosaurus).*
- **Order Ornithischia** – The bird-hipped dinosaurs.
  - **Suborder Onithopoda** – Includes the duck-billed dinosaurs.
  - **Suborder Pachycephalosaurus** – The thick-skulled head butting dinosaurs
  - **Suborder Ceratopsia** – The parrot beaked dinosaurs. Includes the famous *Triceratops.*
  - **Suborder Stegosauria** – Stegosaurs had the big bony plates on their backs.
  - **Suborder Anklyosauria** –The armored dinosaurs.



FIELD TRIP TO THE HOWE-RUSSELL ATRIUM:

Skeletal reproduction of the theropod dinosaur *Allosaurus.* Answer the following questions:

a. Based on pelvic structure, what order of dinosaurs does *Allosaurus* belong to?

b. The posture of this skeleton is consistent with the most recent hypothesis concerning theropod locomotion. Assuming that the *Allosaurus* skeleton is posed in a pursuit position, what would be the function of the tail?

c. Based on the relative size of the skull when compared to the rest of the body, what could have been a reason for the many holes in the skull of *Allosaurus*?

Class Reptilia – Mississippian to Recent

1. This is a turtle skull and an alligator skull. Turtles and tortoises belong to the Order Testudines while alligators, crocodiles and caimans belong to the Order Crocodilia.
   a. Other than the orbits (eye sockets) and nasals, do either of these skulls have holes (fenestrae) on the dorsal (top) surface? Which?

   b. Reptiles are classified into groups based on the fenestrae in the skull. Using Figure 13.5 on page 174, classify the turtle and alligator as diapsid, synapsid, or anapsid.

   c. Reptiles (as well as birds and mammals) are considered amniotes. What is an amniote? What feature allowed amniotes to colonize terrestrial environments?

Class Mammalia - Triassic to Recent

Order Artiodactyla - Artiodactyls represent a wide range of medium to large modern herbivores, including giraffes, camels, pigs, and hippos. Represented here are 3 of the 4 living Artiodactyl families that possess horns (sorry, no giraffes!).

2. Cattle, buffalo, goats, etc. (Family Bovidae) possess non-deciduous (not shed and replaced) horns that are bone outgrowths of the skull. Why would cattle need horns? (Hint: think of how they may have behaved before they were domesticated)

3. Pronghorns (Family Antilocapridae) have non-deciduous horn cores with sheaths that are shed annually. The modern pronghorn is the only remaining species of this family. However, there were many species of pronghorns in the Miocene and Pliocene, all with different horn configurations. How does the position and direction of the horns differ between the pronghorn and the bovid?

4. Deer (Family Cervidae) have deciduous antlers which grow from the base of the skull and are shed every year. Comparing the shedding of deer antlers and pronghorn horns, how may our understanding of the number of extinct species in each group be affected?

5. Another deer skull. This specimen has the jaws (mandible) articulated.

   a. Looking at the ventral (the bottom or base) of the mandible and skull, notice that the molars and premolars of the mandible are narrower and don't align perfectly with the upper tooth row. Is this poor construction? If not, what purpose may this serve?

   b. Also note the anterior (front) dentition of the mandible. There are four teeth on each side (3 incisors and 1 canine). Why would the 3rd incisor and the canine look exactly the same?

   c. Why would there be no upper anterior dentition?

Class Mammalia

Order Perissodactyla - The second group of medium to large herbivorous mammals is the perissodactyls. There are 3 surviving families (horses, rhinos, and tapirs).

6. This is a horse (Family Equidae) skull. The posterior dentition of a horse consists of 3 premolars (2-4) and 3 molars (1-3). Here also are two fossil teeth from a horse. Determine which teeth these are using size, shape, and enamel ridge patterns.

   i. Left or Right? Upper or lower? Premolar or molar? Tooth number?

   ii. Left or Right? Upper or lower? Premolar or molar? Tooth number?

7. Here are two horse molars. Draw the occlusal (chewing) surface of the horse teeth

a. Note the difference in height and occlusal area between the horse molars. If I told you these two molars were from the exact same species, how could you explain the differences in size? (Think of dental wear and the saying, "Don't look a gift horse in the mouth").

b. If fossil horse species were identified based on size, how would this affect species identification?

c. Now compare the horse molars with the deer molars from the skull in specimen 6. Both teeth are composed of alternating sections of enamel ridges and dentin surfaces. Dentin wears faster than enamel. This creates sharp enamel ridges for food shredding and grinding. How do the wear rates compare between deer and horses?

d. Why might horses have many more enamel ridges with winding patterns?

e. Using the "Teeth of Mammals" section in the lab book, what is this type of posterior dentition in the horse called? In the deer?

Class Mammalia

Order Proboscidea - Proboscideans are extremely large terrestrial herbivores characterized by possession of tusks (enlarged incisors) and a trunk (proboscis). Elephants are the only modern representatives; however, mammoths, mastodonts, and gomphotheres were common in North America from the Miocene through Pleistocene.

8. Here is a mastodont molar. Gomphotheres and mastodonts have similar dentitions, with three primary 'lophs' that form troughs and peaks for occlusion with the upper and lower teeth. Between 2 and 3 molars can fit on each upper and lower side (8-12 total). Sketch the occlusal surface.

9. Here is a mammoth molar. Mammoths and elephants also have similar dentitions, with multiple parallel lophs that create numerous enamel ridges for occlusion. On average, only 1 molar can fit on each side (4 total). Sketch the occlusal surface.

   a. What can you infer about the differences in feeding habits between a mammoth and mastodont? Environmental differences?

   b. Using the "Teeth of Mammals" section in the lab book, what is this type of dentition in the proboscideans called?

Class Mammalia

Order Rodentia - Rodents are a diverse small mammal group of varying specialties and habitats, almost all having large, chisel-shaped incisors. Examples are mice, squirrels, moles, and gophers.

10. This skull is from a nutria (Family Castoridae). Notice the two distinct types of teeth. The molars have many enamel ridges while the incisors are extremely large and curved. Using your prior knowledge of this organism's behavior, explain the combination of these two types of teeth.

Class Mammalia

Order Primates - Primates include monkeys, apes, gorillas, and humans.

11. This skull is from a macaque (Family Cercopithecidae), an old-world monkey. Examine the dentition. What is this type called? Sketch a molar.

12. Here is a skull of a peccary (Order Artiodactyla, Family Tayassuidae) – definitely not a primate! Examine the posterior dentition and comment on how it compares to that of the macaque. Sketch a molar.

a. What do the similarities in dentition tell you about food preferences?

b. Both the macaque and peccary have enlarged canines (more so in the peccary), but they may use them differently. What non-feeding uses could these enlarged canines have?

c. If you found an enlarged canine in a fossil skull with no other teeth preserved, could you determine the feeding or behavior of the organism? Explain.

Class Mammalia

Order Carnivora – Carnivrous or meat-eating mammals

13. This is a cast of the famous *Smilodon* (Family Felidae), a saber-tooth cat from the Pliocene and Pleistocene of North America. Here also is a bobcat skull.

   a. Draw a side view of the two cheek teeth. What is this type of tooth called? What specific function do these teeth serve?

   b. The huge canines of *Smilodon* are often found fragmented or broken. How would a broken canine affect the behavior of this cat?

   c. Based upon the size of the canines, what prey size do you think Smilodon hunted?

   d. Compare the *Smilodon* Skull to the dog skull. What is different about the variety of teeth?

Class Mammalia

Order Xenarthra - Xenarthrans (also called edentates) are a strange group, composed only of anteaters, armadillos, and tree sloths today. They have a simple dentition (if at all, as anteaters have no teeth), lacking enamel. However, to make up for no enamel, xenarthrans do have two types of dentine with different hardness, as well as ever-growing teeth.

14. Who does this skull belong to? (Hint: we saw a trilobite exhibit the same type of behavior characterized by this organism).

   a. What is this type of dentition called?

15. Who might this large claw belong to? (It's another famous group from the Pleistocene)

   a. These large herbivores were between a bear and mastodont in size! The teeth are shaped for feeding on plant matter, but why would this creature have such a large claw? Provide two possibilities.

Geology 1602
Dinosaur Trackways Exercise[1]

Introduction
As a part of the paleontology and paleoecology unit, we have created a simulated dinosaur trackway in the hallway adjacent to the laboratory. The chief point of this exercise is that scientists can obtain meaningful data about past life forms and environmental conditions by making reasonable assumptions about the track makers, and by making careful measurements of these ichnofossils.

Background and Assumptions
Organisms such as dinosaurs leave a very scant record in terms of body fossils (bones, shells, skin, teeth, etc.) because of the low preservation potential of the terrestrial environments in which they existed. However, land-dwelling animals often left evidence of their presence, making such things as tracks, trails, burrows, nests, and feeding traces. These traces are often preserved in muddy or shallow water sediments, and because they cannot be transported without being destroyed, they are taken as direct indications of animal presence and behavior. Because modern organisms create similar traces, we can directly study the relationships between animal behavior and the resulting structures; specific to this lab, we can observe relationships between animal size, style of locomotion, length of stride, and footprint size. Such data can then be meaningfully applied to ancient trackways, and conclusions drawn regarding the size and behavior of the ancient track makers.

General Characteristics of Dinosaur Tracks
In terms of their style of locomotion, dinosaurs can be divided into bipeds (walked upright on their hind feet), semi-bipeds (walked upright but occasionally dropped down on all four legs), and quadrupeds (walked on all fours). It is known that carnivorous dinosaurs (the most exciting kind) were bipeds with long, tapering toes that sometimes ended in claws. Herbivorous dinosaurs were either bipedal or quadrupedal, and their toes were usually rounded or U-shaped. The front and back feet of quadrupeds were differently shaped (like yours) and so may be distinguished in trackways. An imprint of the front foot is called the *manus*; that of the rear, the *pes*.

Biomechanics
We cannot directly measure the speed at which an extinct animal moved; however, by making empirical measurements of modern bipeds and quadrupeds traveling at different velocities, we can establish valid modern relationships which can then be applied to the interpretation of ancient trackways. This is because upright tetrapods (humans are bipedal tetrapods), regardless of size, all locomote in the same way. Most animals also travel at speeds which are proportional to their leg and stride lengths.

A number of authors have documented a general relationship between track (foot) length and leg length in terrestrial vertebrates: on average, **leg length = 4x track length**. Track length is measured from the back of the footprint to the end of the middle (longest) toe.

Stride length, or the distance between two successive tracks of the same foot, is measured from either the front or rear of the tracks. From this measurement, one can determine the speed at which the animal was moving (see formula below).

The size of the animal making the track is not so readily quantified. In practice, organism size is estimated by comparing the calculated leg length to scale diagrams or models of reconstructed dinosaurs. The calculations you will make in this exercise are as follows:

Speed $= 0.25 * g^{0.5} * SL^{1.67} * H^{-1.17}$

Where $g = 9.8 m/s^2$
Where SL is Stride length is measured in m from heel to heel or toe to toe on the same side L or R
Where H is hip height (same as leg length) is measured in meters

[1] This exercise has been modified from two papers by Dr. Jeffrey Over, "An Exercise on Dinosaur Trackways for Introductory Science Courses," and "Determining Dinosaur Speed," Journal of Geological Education, V. 43, pp. 204-211, 1995. It has been further edited by your TA as produced by Dr. Joe Lebold.

Name:________________________

Adult dinosaurs ranged in size from 60cm (about chicken-sized) to 30m andemployed several different types of locomotion. The diagram below illustrates some of the basic size and posture differences of dinosaurs. The scale bar between the car and *Triceratops* is 1.8m (6ft) high.

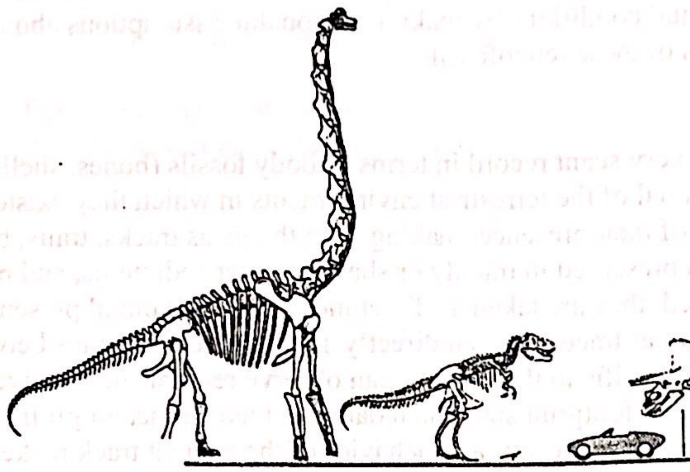


Figure 1: Relative sizes of four dinosaurs and a sports car. Left to right: *Brachiosaurus, Tyrannosaurus, Echinodon*, car, and *Triceratops*. (From Jenkins and Jenkins 1993 and Alexander 1989)

Examine the sets of tracks in the hall outside the classroom and determine the general morphology and behavior type (carnivore or herbivore) of each dinosaur by using the information given in this exercise and by comparing the track size and shape to the scale dinosaur drawings of Figures 3-5. Note that the scale bars in Figures 3-5 are not all the same.

As you work on identifying the dinosaurs, measure the length of pes print and average stride for each dinosaur and record these data in the chart below. Be sure to measure the stride length from the same point on each footprint, e.g. from the center rear of one left foot to the rear of the next left footfall. Calculate leg length. Finally, calculate the actual speed.

Track color	Dinosaur	Foot length (m)	Stride length (m)	Leg length (m)	Actual Speed (m/s)

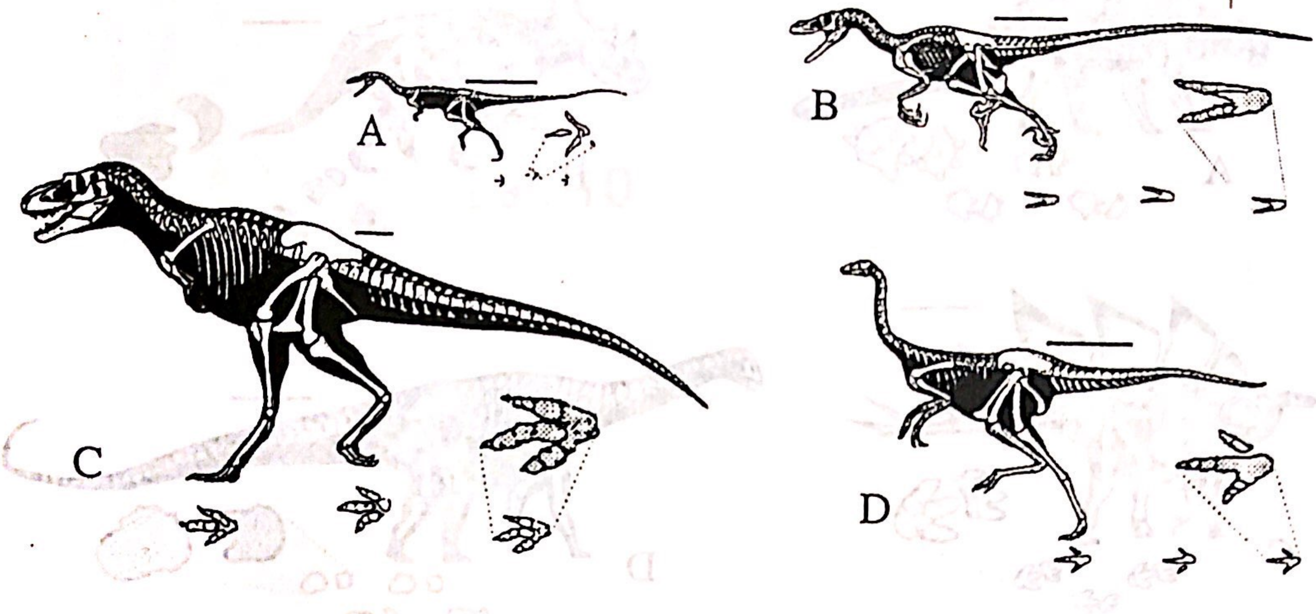


Figure 2: Bipedal carnivorous dinosaurs (theropods) and representative trackways attributed to similar species. Scale bar is 0.5m. A – coelurosaur *Coelophysis* (from Paul 1987) and unnamed trackway (from Thulborn 1990). B – raptor *Velociraptor* (from Paul 1987) and conjectural trackway. C – carnosaur *Albertosaurus* (from Czerkas and Czerkas 1991) and unnamed trackway (from Thulborn 1990). D – ornithomimid *Struthiomimus* (from Wade 1989) and *Ornithomimipus* (ichnogenus; Thulborn 1990).

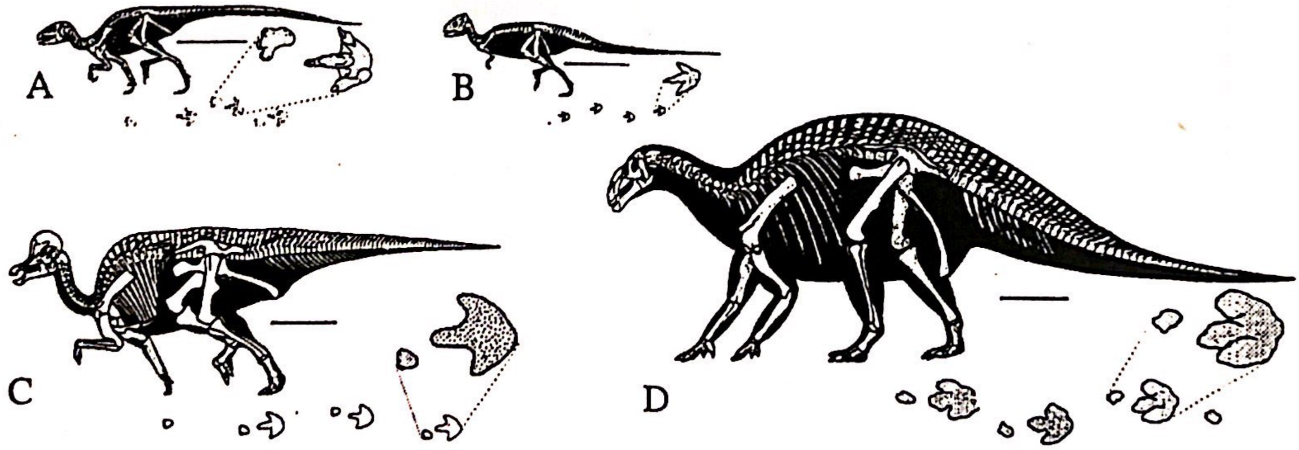


Figure 3: Bipedal and quadrupedal herbivorous ornithopod dinosaurs and representative trackways attributed to similar species. Scale bar is 1.0m. A – ornithischian *Erikosaurus* (from Paul 1987) and *Moyenisaurgous* (ichnogenus attributed to ornithopod; Thulborn 1990). B – pachycephalosaur *Homocephale* (from Paul 1987) and *Anomeopus* (ichnogenus attributed to small ornithopod; Thulborn 1990). C – crested hadrosaur *Hypacrosaurus* (from Paul 1987) and *Gypsichnites* (ichnogenus; Thulborn 1990) with additional conjectural manus prints. D – Iguanodont *Iguanodon* (from Czerkas and Czerkas 1991)and *Caririchnium* (ichnogenus; Thulborn 1990).

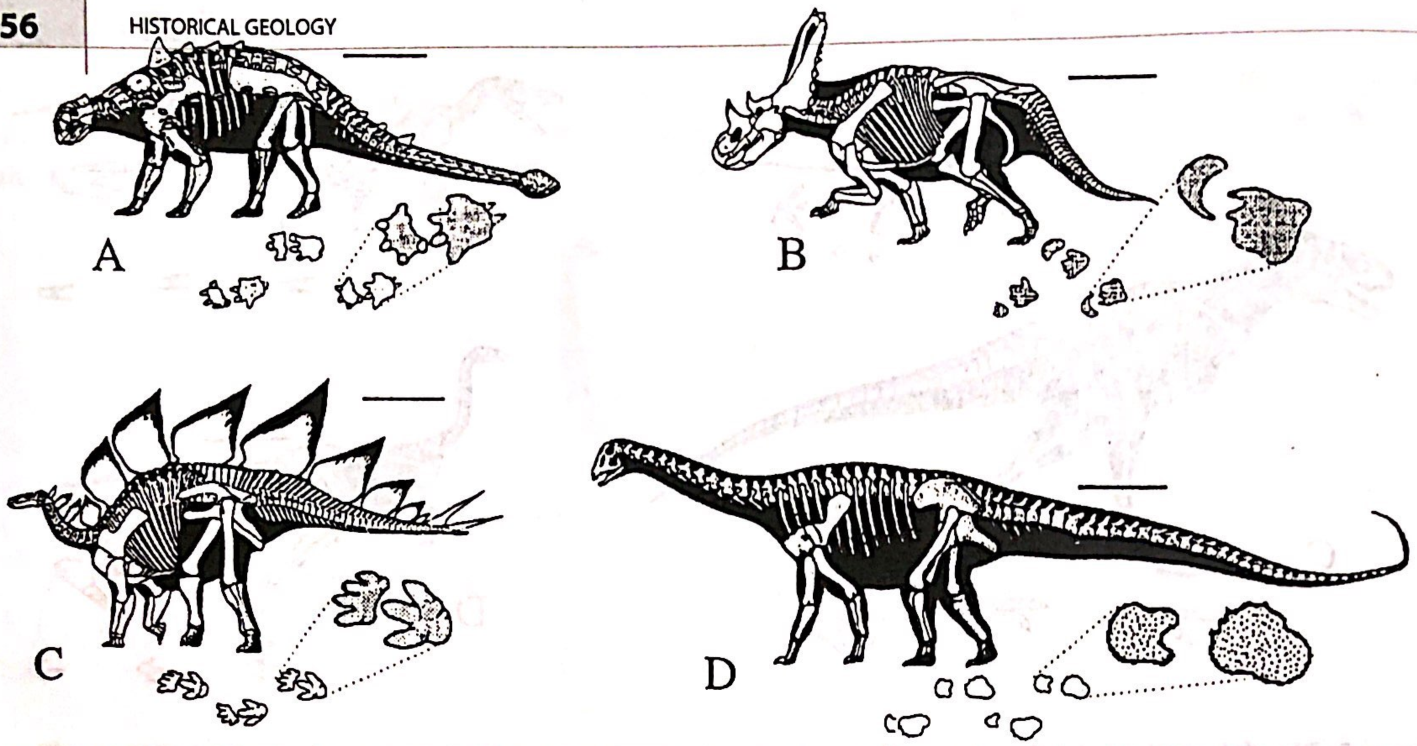


Figure 4: Quadrupedal herbivorous dinosaurs and representative trackways. Scale bar is 1.0m. A – ankylosaur *Euoplocephalus* (from Czerkas and Czerkas 1991) and *Terepodosaurus* (ichnogenus; Thulborn 1990). B – ceratopsian *Chasmosaurus* (from Paul 1987) and unnamed trackway (from Thulborn 1990). C – stegosauran *Stegosaurus* (from Paul 1987) and conjectural trackway (from Thulborn 1990). D – sauropod *Titanosaurus* (from Czerkas and Czerkas 1991) and *Brontopodus* (ichnogenus; Thulborn 1990).