Dinosaur Trackway Mechanics

Dinosaur trackways are a type of fossil called trace fossils – traces of an organism's activity. The study of ancient life is done by paleontologists and the study of trace fossils specifically is called ichnology.

Paleontologists can learn a lot from the study of fossil trackways. They can get estimates of the size and weight of the dinosaur, how fast the dinosaur could move, and whether or not they were solitary or traveled in herds.

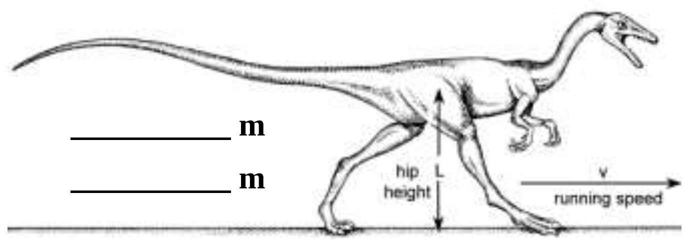
The difficulties in doing this are that there were many different types of dinosaurs (some bipedal and some quadrupedal), tracks will look different in different types of sediments (mud or wet sand, for example), and tracks will change the longer they were exposed to weathering (before burial while still soft and after exposure as impressions in rock).

We're going to see what types of things paleontologists can learn from bipedal dinosaur trackways.

Let's start by measuring some things on our bodies since we're bipedal animals as well. In science, all measurements are done using the metric system so we'll be measuring everything in meters (m) to two decimal places.

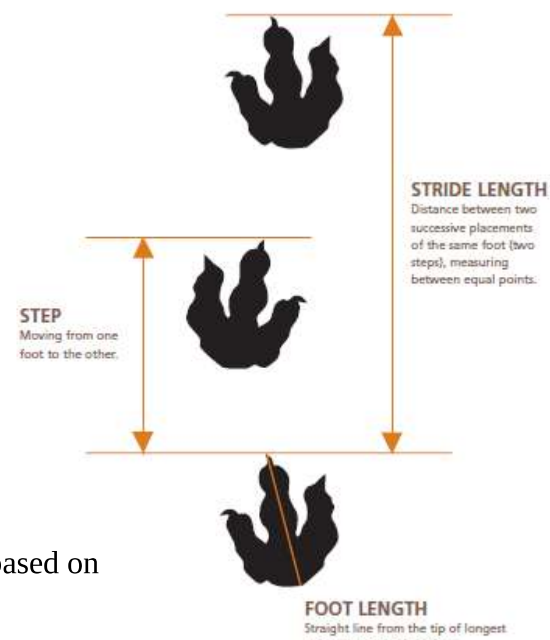
What is the length of your foot (FL) in meters? __________ **m**

What is your hip height(L) in meters? __________ **m**



Now let's look at the relationship between your foot length (FL) and hip height (L). How many foot lengths high is your hip? To find out we'll divide your hip height by your foot length and call this value alpha (α).

α = L / FL = __________



Compare your answer with everyone else's. Are they close? Why or why not? Let's take everyone's α value and average them together (add them and divide by the number of values). Report the average α value below.

α = __________

For bipedal dinosaurs, paleontologists use an average α of 4.0 based on their skeletal fossils. Is our average α close to this value?

The next thing we'll measure is your stride length (SL). This is different from a step distance. The stride length is the distance from some point on your right foot (the tip of your toe, for example) to the same spot on your right foot after two steps (left and right). So, whether walking or running, it's the distance from one foot to the same foot after two steps. The best way to measure this is to take many steps and take an average value.

We'll measure out a distance of 25 meters. Count how many steps it takes to walk this distance and then record how many steps it takes to run this distance (if you end up with a half step at the end it can be recorded as 0.5). We'll also time how long it takes you to walk and run this distance.

How many steps does it take to walk 25 m? __________ steps

How many steps does it take to run 25 m? __________ steps

How long did it take you to walk 25 m? __________ seconds

How long did it take you to run 25 m? __________ seconds

To obtain your stride length (SL) for this distance, divide the number of steps by 2 (remember there are two steps in a stride) and divide this into the distance of 25 meters.

Walking SL = [25 m / (walking steps / 2)] = __________ m

Running SL = [25 m / (walking steps / 2)] = __________ m

We'll also calculate your speed or velocity (v) which is distance (25 m in this case) divided by time (how long it took you to travel that distance in seconds). Velocity is given in units of meters per second (m/s).

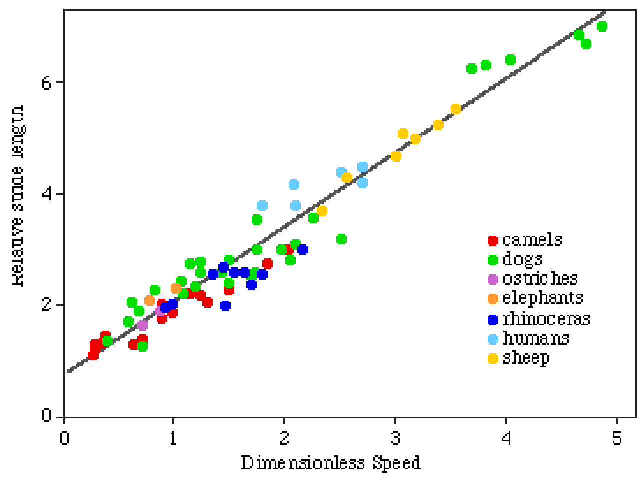
Walking velocity (v) = 25 m / _______ s = __________ m/s

Running velocity (v) = 25 m / _______ s = __________ m/s

How do your values compare to everyone else's?

Over the years, scientists have studied the relationship between stride length and velocity for a variety of different kinds of animals and have determined that this data will graph as a linear relationship.

In other words, you can graph this data with a straight line that shows animals with a short stride length have a slower average velocity and animals with a longer stride length have a faster average velocity. It makes sense when you think about it.



Now let's look at the relationship between your stride length and your hip height for walking and running. We'll call this your gait (G) and define it as stride length (SL) divided by hip height (L). Round this off to the nearest tenth.

Walking G = Walking SL / L = _________ m / _________ m = ________

Running G = Running SL / L = _________ m / _________ m = ________

For dinosaur trackways, paleontologists estimate that an average gait of 2.0 indicates walking and an average gait of 3.0 indicates running. How do yours compare?

Let's now look at some dinosaur tracks. There are two types of dinosaurs represented (a theropod and a hadrosaur). Sketch what each type of track looks like (we'll call them dinosaur A and dinosaur B):

A	**B**

Measure the foot length (FL) of each:

Dinosaur A: FL = __________ m **Dinosaur B: FL = __________ m**

A good estimate of a bipedal dinosaur's hip height (L) is that it's 4 times the foot length (FL).

Dinosaur A: L = __________ m **Dinosaur B: L = __________ m**

A good estimate of a bipedal dinosaur's height (H) is that it's 10 times the foot length (L).

Dinosaur A: H = __________ m **Dinosaur B: H = __________ m**

Now let's get each dinosaurs average stride length (SL). The best way is to measure all of the strides (remember, a stride is two steps) and take the average. Notice that dinosaur A has two distinctly different stride lengths. Measure them separately.

1st part of dinosaur A's strides: ____

2nd part of dinosaur A's strides: ____

All of dinosaur B strides: ____

1st part of dinosaur A: Average SL =__________ m

2nd part of dinosaur A: Average SL =__________ m

All of dinosaur B: Average SL = __________ m

Now we can calculate the speed of the dinosaurs. Scientists, of course, get a lot more complicated when studying dinosaur trackways taking all kinds of factors into account when estimating a bipedal dinosaur's speed. The formula used is actually fairly complex.

$$\text{Velocity} = (0.25 \text{ acceleration of gravity})^{0.5} \times (\text{stride length})^{1.67} \times (\text{hip height})^{-1.17}$$

$$v = 0.25\, g^{0.5}\, SL^{1.67}\, L^{-1.17}$$

Where g, or the acceleration of gravity is 9.8 m/s^2. We can simplify this formula a bit.

$$v = (0.7826) \times (SL)^{1.67} \times (L)^{-1.17}$$

Fortunately we can use a calculator to do this! Let's calculate the velocity for the dinosaurs.

1st part of dinosaur A: v = __________ m/s

2nd part of dinosaur A: v = __________ m/s

All of dinosaur B: v = __________ m/s

What do you think happened here? Can you reconstruct a sequence of events?