9th grade/Dr. Lankar Name: _____ section: _____grade%: _____

LAB Gulliver or why we are the size we are

In *Gulliver's travel* (part I) the hero arrives in Lilliput, a world populated with tiny people. Can a human be scaled down 10 times and survive?

Then (part II) he arrives in Brobdingnag , a world populated with giants. Can a 10 times scaled up human being survive? why or why not ?Using ratios, you can find out why.

Inspired from*: Gulliver's Travels* (1726, amended 1735), officially *Travels into Several Remote Nations of the World, in Four Parts. By Lemuel Gulliver, First a Surgeon, and then a Captain of several Ships*
From: Jonathan Swift

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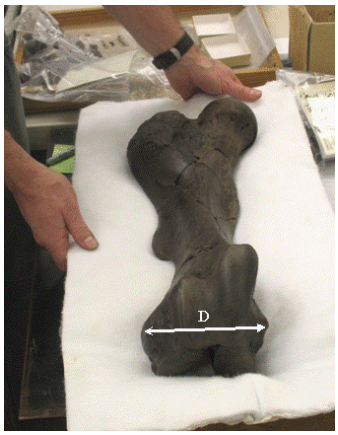
INTRODUCTION

In this lab, using ratios, you will find out why we evolved to be the size we are. A scaled up (x10) or scaled down (÷ 10) human being can't survive long. Unless you change the shape of the human being and that is, if you change the proportions between the legs, the arms, the torso… A gazelle scaled up can't survive unless you change its shape, to make, for example an elephant. But this won't be a gazelle anymore.

PROCEDURE: you need a TI.

Imagine 3 persons. Tiny Jimmy (17cm long), Standard Gulliver (170cm) and, towering Tarah (1700cm). See picture below

Jimmy and Tarah are scale models of Gulliver. Same shape but scaled up or down. The scaling is by 10 for Tarah. That means that her arms will be 10 times longer, the legs 10 times longer, every bones 10 times longer. This also means that the diameter of the bones like the femur will also be 10 times larger.



Any linear dimension (side) will be 10 times Gulliver's corresponding dimensions.

The scaling is by 1/10 for tiny Jimmy. All linear dimensions is divided by 10. Complete the table and we will discuss the results. Understand that the cross-sectional area of our femurs support our weight. Larger the area of the femur, larger is weight supported. Also, remember what we found in a previous lab. As the weight increases, the ratio surface/weight decreases.

Fill the table below:

	Jimmy	**Gulliver**	**Tarah**
Height h	17cm	170cm	1700cm
diameter of femur d (see picture below) hint: diameter is a linear dimension. multiply or divide by 10	____	4cm	____
radius of femur r hint: radius = diameter /2	____	2cm	_____
cross sectional support area of femur A hint: area = pi x (radius)^2 = 3.14 r^2	____	12.6 cm^2	_____
volume of entire body V hint: use Gullivers volume to find Tarah's and Jimmy's	____	60,000 cm^3	_____
Mass of entire body hint: assume density of 1g/cm^3 because we are mostly water mass = density x volume.	____	60kg	_____
weight = mass(kg) x 9.8	____	588N	_____
pressure on bones = weight/ (support area) hint: divide the weight by the cross sectional area of femur since it is the area of femur that supports our weight.	____	47N	____
Surface area of the body. Hint: Use Gulliver' s to find Tarah's and Jimmy's	____	17,000cm^2	_____
surface area / volume hint: divide the surface area of the body by the volume	____	_____	____

ANALYSIS

1) Observe the table. Tarah is scaled up by a factor of ____. It means all her lengths are multiplied by _____. But because the areas are found by multiplying length by length, when compared to Gulliver's, all her areas (area of body and area of femur) are multiplied by _____. Her volume is Gulliver's multiplied by _____!!

2) Let's look at the pressure the weight exert on the areas of the femur supporting the weight . The pressure is the force per unit area. More pressure, more damage to a supporting pole. Compare the pressure for the 3 persons. The weight of Tarah exerts a pressure _____ times Gulliver.
A pressure of 400 N is like 40kg/squared cm or almost 90 pounds/cm^2 !!!
What do you think will happen to Tarah?
If you were to build a giant, what changes would you make so the bones don't break ?

3) Let's look at the surface vs volume ratio. It is the surface of skin (border between inside and outside) available per unit of volume. As the size of the person decreases from Tarah to Jimmy, the ratio _____. As an animal's size decreases, its surface _____ when compared to the weight. If the surface increases, it means more exchange with the outside world. So there will be more _____ loss. How many times more ? _____ (compare the ratio surface vs volume). That means that Jimmy needs to eat _____ times more than Stan to survive.

4) When an animal or object fall 2 forces act on it. The pull due to gravity proportional to the weight. The drag due to air resistance proportional to the surface of the body and speed.
If a mouse or a elephant fall from a 3 floor building, are the damages the same?
hint: as the surface increases, drag increases. As the weight increases, gravity increases

5) If you were to scale up a gazelle by a factor of 2, can you just multiply all the lengths by 2 keeping the proportions the same?

6) Why do you think the same quantity of water will evaporate faster when placed in a large plate that when placed in a glass ?

8) Some really heavy dinosaurs had spikes on their back. Why?

9) Do you think it is easier to peel 1 pound of small potatoes or 1 pound of large potatoes ?

10) Why do you think a human cell can't be too large or too small ?
(hint: the cell exchanges energy and ions with the outside through its membrane).