



**Student Worksheet**  
**Learning Set on Size, Scale, Function, and Measurement Systems**

Name: \_\_\_\_\_

Date: \_\_\_\_\_

**Does Size Matter?**

**Individual View**

Imagine that scientists have the ability to shrink or enlarge a human being. Choose one extreme (miniaturization to 6 inches tall **or** enlargement to 60 feet tall) and in the space provided below write down some thoughts as to what impact this would have on the ability of a human being to function and why you believe it would or would not be possible for a human being to survive at this size.

**Group View**

Now, get together in your group with students who chose the same extreme and discuss the impact on the function and survival of a human being at that size. On the construction paper provided list the main thoughts of your group. Once you have completed your group list, post it in the front of the room so we can refer to it for our class discussion.

Read the following excerpt from the Scottish geneticist J.B.S. Haldane's essay *On Being the Right Size*. After reading the following excerpt and viewing the short video *Size and Scale – Being the Right Size*, we will revisit as a class the impact of size on human function.

**Excerpt from J.B.S. Haldane's essay *On Being the Right Size*.**

*The most obvious difference between animals are difference in size, but for some reason the zoologist have paid singularly little attention to them. In a large textbook of zoology before me I find no indication that the eagle is larger than the sparrow, or the hippopotamus bigger than the hare, though some grudging admissions are made in the case of the mouse and the whale. But yet it is easy to show that a hare could not be as big as a hippopotamus or a whale as small as a herring. For every type of animal there is a most convenient size and a large change in size inevitably carries with it change of form.*

*Let us take the most obvious of possible cases, and consider a giant man sixty feet high – about the height of Giant Pope and Giant Pagan in the illustrated Pilgrim's progress of my childhood. These monsters were not only ten times as high as Christian, but ten times as thick, so that their total weight was a thousand times his, or about eighty to ninety tons. Unfortunately, the cross sections of their bones were only a hundred times those of Christian, so that every square inch of giant bone had to support ten times the weight borne by a square inch of human bone. As the human thigh-bone breaks under about ten times the human weight, Pope and Pagan would have broken their thighs every time they took a step.*

*...the eye is a rather inefficient organ until it reaches a large size. The back of a human eye on which an image of the outside world is thrown, and which corresponds to the film of a camera, is composed of a mosaic of "rods and cones" whose diameter is little more than the length of an average light wave. Each eye has about a half a million, and for two objects to be distinguishable their images must fall onto separate rods and cones. It is obvious that with fewer but larger rods and cones we should see less distinctly. If they were twice as broad, two points would have to be twice as far apart before we could distinguish them at a given distance. But if their size were diminished and their number increased we should see no better. For it is impossible to form a definite image smaller than the wave-length of light. Hence a mouse's eye is not a small-scale model of a human eye. Its rods and cones are not much smaller than ours, and therefore there are fewer of them. A mouse could not distinguish one human face from another six feet away. In order that they should be of any use at all the eyes of small animals have to be much larger in proportion to their bodies than our own. Large animals on the other hand only require relatively small eyes, and those of a whale and elephant are not much larger than our own...*

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### Scale, Measurement Systems, and the Powers of Ten

Visit the following websites to see 3 demonstrations of the Powers of 10.

- [www.powersof10.com](http://www.powersof10.com) – official Powers of 10 website
- [www.wordwizz.com/pwrsof10.htm](http://www.wordwizz.com/pwrsof10.htm) - A Question of Scale
- <http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/index.html> -Secret Worlds: The Universe Within

Using the [www.wordwizz.com/pwrsof10.htm](http://www.wordwizz.com/pwrsof10.htm) - A Question of Scale website, complete the chart below:

Prefix	What power of 10 does this prefix represent	What object exist at this distance from the earth or at this scale?
peta-	$1 \times 10^{15}$	Entire solar system
giga-	1,000,000,000 or $1 \times 10^9$	Distance of the earth and moon
kilo	1,000 or $1 \times 10^3$	Distance from 1 town to another
deci-	.1 or $1 \times 10^{-1}$	A lily flower with a bee on it
centi-	.01 or $1 \times 10^{-2}$	Approximate width of your pinky fingernail
milli-	.001 Or $1 \times 10^{-3}$	A bee's eye
micro-	0.000001 or $1 \times 10^{-6}$	Virus on a bacterium
nano-	0.000000001 or $1 \times 10^{-9}$	Structure of DNA
pico-	0.000000000001 or $1 \times 10^{-12}$	Inside the electron cloud

## Student Worksheet

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Which is Easier, the SI System or the English System?

#### Important Note

**This is a timed activity. Do not begin the activity until instructed by the teacher.**

1. Complete this page of the activity sheet first. Do not look at the other side until instructed to do so.
2. Use a stopwatch or the clock to time how long it takes you to complete the two tasks on this side of the activity sheet.
3. Read the directions and begin.

#### Directions for task #1

Listed below are various sized metric wrenches. Your first task is to rearrange the wrenches in proper order from the smallest size to the largest size.

6mm            10mm            3mm            5mm            2mm            4mm

\_\_\_\_\_

Smallest -----> Largest

#### Directions for task #2

Listed below are 6 pairs of various sized metric wrenches. Your task is to compare the wrenches in each pair and choose the larger of the two.

6mm	_____	4mm	_____
4mm	_____	5mm	_____
7mm	_____	2mm	_____
3mm	_____	6mm	_____
5mm	_____	4mm	_____
10mm	_____	7mm	_____

How long did it take you complete the 2 tasks on this side of the activity sheet? \_\_\_\_\_

**Complete this side of the activity sheet after you have completed the front side of the activity sheet.**

1. Use a stopwatch or the clock on the wall to time how long it takes you to complete the two tasks on this side of the activity sheet.
2. Read the directions and begin.

**Directions for task #3**

Listed below are various sized non-metric wrenches. Your first task is to rearrange the wrenches in proper order from the smallest size to the largest size.

1/2 inch	1/4 inch	3/8 inch	9/16 inch	3/4 inch	15/32 inch
_____	_____	_____	_____	_____	_____
Smallest ----->					Largest

**Directions for task #4**

Listed below are 6 pairs of various sized non-metric wrenches. Your task is to compare the wrenches in each pair and choose the larger of the two.

1/2 inch	3/8 inch
9/16 inch _____	15/32 inch _____
9/16 inch	1/4 inch
15/32 inch _____	3/8 inch _____
1/4 inch	3/4 inch
15/32 Inch _____	9/16 inch _____

How long did it take you complete the 2 tasks on this side of the activity sheet? \_\_\_\_\_

Which side was easier to complete? \_\_\_\_\_

Which side would you like to have graded? \_\_\_\_\_

## Student Worksheet

Name: \_\_\_\_\_

Date: \_\_\_\_\_

Group members: \_\_\_\_\_

### Making Your Own System of Measurement

#### Objective:

Your group's objective is to develop your own measurement system and use this system to measure common objects located in the classroom.

#### Materials:

String  
Masking tape  
Scissors

#### Procedure:

1. Obtain your materials
2. Choose a common item in the room which will serve as the measurement standard for your system. Be sure the size of your standard is appropriate for the items you plan to measure.
3. Using your measurement standard, mark your string with masking tape so it can be used to measure common items in the classroom.
4. Use the string to measure 7 common items from the classroom and fill in the data chart.
5. Complete the questions and conclusions portion of the activity.

#### Data:

What item did you use for your measurement standard? \_\_\_\_\_

Object Measured	Length of the Object
1.	
2.	
3.	
4.	
5.	
6.	
7.	

## Questions and Conclusions:

1. Were you able to design a measurement system that was reasonably workable and accurate? Explain.
2. Could someone else use your system to measure items in the classroom and get the same results? Explain.
3. Would you get the same number values if you used a different measurement standard? Why or Why not?
4. Is your group's measurement system more or less accurate than the measurement systems developed by the other groups in the class? Explain.

## Student Worksheet

Name: \_\_\_\_\_

Date: \_\_\_\_\_

### Web-based Animation of the Blue Morpho Butterfly

Visit the web-based animation prepared Penn State University's Center for Nanotechnology Education and Utilization: [www.cneu.psu.edu/Amy/index.html](http://www.cneu.psu.edu/Amy/index.html). The animation ties together the themes of size & scale, function, and tools by taking a closer and closer look at the wings of the Blue Morpho butterfly to understand how color is produced by them. This closer and closer look occurs through three stages and covers three different instruments – optical microscopes, SEMs, and AFMs – and the different scales they allow scientist to study.

1. The resolution of the human eye is \_\_\_\_\_.

2. Name the part of the human eye that performs the following functions

The \_\_\_\_\_ and \_\_\_\_\_ allow light to enter the eye.

The \_\_\_\_\_ focuses the light

The image is focused on the \_\_\_\_\_, turned upside down and reversed.

3. A human hair is \_\_\_\_\_ wide.

4. A hair on a butterfly's legs is \_\_\_\_\_ wide.

5. The hairs on a butterfly's leg act as \_\_\_\_\_.

6. The resolution of the best Compound Optical Microscopes is about \_\_\_\_\_.

7. Compound Optical Microscopes use compound \_\_\_\_\_ to magnify an object's image.

8. The scales of a butterfly are \_\_\_\_\_ thick and \_\_\_\_\_ wide.

9. List four things that the scales do for a butterfly.

A. \_\_\_\_\_

B. \_\_\_\_\_

C. \_\_\_\_\_

D. \_\_\_\_\_



## Web-based Animation of the Blue Morpho Butterfly

10. The resolution of the average Scanning Electron Microscope is about

\_\_\_\_\_.

11. With a high resolution Scanning Electron Microscopes objects as small as

\_\_\_\_\_ can be seen.

12. The Scanning Electron Microscope use a beam of \_\_\_\_\_ that reflect off of the sample being analyzed.

13. The wavelength of visible light \_\_\_\_\_.

14. The color of the images produced by a Scanning Electron Microscope is always

\_\_\_\_\_.

15. Using the Scanning Electron Microscope, we can see that butterfly scales have air gaps that are \_\_\_\_\_ wide.

16. These air gaps act as \_\_\_\_\_ and help the butterfly regulate \_\_\_\_\_.

17. The range of resolution of the Atomic Force Microscope is

\_\_\_\_\_.

18. The Atomic Force Microscope has a \_\_\_\_\_ that scans over the surface.

## Web-based Animation of the Blue Morpho Butterfly

19. The average size of the tips used by the Atomic Force Microscope are about

\_\_\_\_\_.

20. The color of the butterfly wing does not come from pigment. This is due to the way the small features in the wing scales interact with light, allowing only certain

\_\_\_\_\_ to reflect to our eyes.

21. \_\_\_\_\_ color effects occur when very thin structures or layers of materials are present at the nanometer or micrometer scale.

22. List 2 current products where you can observe the effects of structural color.

\_\_\_\_\_  
\_\_\_\_\_

23. List 2 ways structural color effects might be used in the future.

\_\_\_\_\_  
\_\_\_\_\_

Nanotechnology is defined as the creation and use of materials or devices at the nanoscale (less 100 nanometers – the molecular level)). Can you think of any other ways we can exploit our understanding of things at the nanoscale?

