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.

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx
Rev: mm/yy

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…

Developed by Brett Criswell and David Oertner
Development and distribution partially funded by the **National Science Foundation**

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

Name: _____ Date: _____

Scale, Measurement Systems, and the Powers of Ten

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

- www.powersof10.com – official Powers of 10 website
- 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 - 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-	$1x10^{15}$	Entire solar system
giga-	1,000,000,000 or $1x10^{9}$	Distance of the earth and moon
kilo	1,000 or $1x10^{3}$	Distance from 1 town to another
deci-	.1 or $1x10^{-1}$	A lily flower with a bee on it
centi-	.01 or 1 x 10^{-2}	Approximate width of your pinky fingernail
milli-	.001 0r $1x10^{-3}$	A bee's eye
micro-	0.000001 or $1x10^{-6}$	Virus on a bacterium
nano-	0.000000001 or $1x10^{-9}$	Structure of DNA
pico-	0.000000000001 or $1x10^{-12}$	Inside the electron cloud

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx
Rev: mm/yy

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? _____

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx
Rev: mm/yy

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? _____

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx
Rev: mm/yy

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.	

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx
Rev: mm/yy

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.

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

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. 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. _____

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx

Rev: mm/yy

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.

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx
Rev: mm/yy

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?

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***

NNIN Document: NNIN-xxxx

Rev: mm/yy

Student Worksheet

Name: _____ Date: _____

Introduction to Nanotechnology

Video Worksheet

View the panel discussion video *Introduction to Nanotechnology* (26 minutes) prepared by the Penn State University's Center for Nanotechnology Education and Utilization: www.cneu.psu.edu/edTools.html.

In the space below write an essay explaining what nanotechnology is, give examples of how it is already being used, and suggest ways it may affect our lives in the future. The first sentence has already been written for you.

Nanotechnology is defined as the creation and use of materials or devices at the nanoscale (less than 100 nanometers – the molecular level). _____

Developed by Brett Criswell and David Oertner
*Development and distribution partially funded by the **National Science Foundation***