Nanofibers: Why Go Small?

Name(s) _____

Date_____Class Sec_____

Background: A nanometer is one billionth (1×10^{-9}) of a meter which can be about 3 to 5 atoms in width. Electrospun nanofibers produced from polymer solutions are being used in unique ways by scientists. Nanotechnology allows the manipulation of matter, atom by atom at the "nanoscale." Properties of these materials are amplified due to the fact that many fibers can fit into a very small space. Scientists have found many unique ways to use such fibers from producing new materials capable of blocking moisture, removing of toxins from both water and air, delivering medicines to a specific region in or on the body, and tissue scaffolding. The possibilities are endless as scientists and inventors produce new products formed from these extremely small fibers.

Changing the property of a nanofiber can be done by coating the fiber with a substance of the desired property. This property is enhanced due to the fact that so many of these tiny fibers can be packed into a small space.

Purpose: The purpose of this activity is for students to understand that as the size (diameter) of an object (in this case, a pretzel which is equivalent to a cylinder) decreases, the amount of surface area available increases when compared to its volume. This is called the **surface area to volume ratio**. Students should conclude that if a greater coating is desired on a rod (pretzel), it is better to have several smaller rods rather than one large rod which has an equivalent volume to the smaller rods. Students should be able to relate this to nanoparticles, particularly nanofibers, since their geometry can be described as a long, very thin fiber. Students will also understand how scientists use extrapolation of measured data to determine dimensions too small to measure with current means.

Students will:

- Compare the size of two groups of straight pretzels of different diameters by measuring the diameters and circumferences.
- Calculate the cross-sectional areas, volumes and surface areas of these two groups.
- Construct a data table to contain the diameters, circumferences and lengths of the pretzels, and the calculated cross-sectional areas, volumes, surface areas and surface to volume ratios of each pretzel group.
- Make a graph of diameter v. circumference using the averages of each group.
- Make a graph the radius v. surface area/volume ratio of each group.
- Interpret by finding slope and extrapolating from the graph to obtain values for “nanopretzel.”

Materials: Large (rod) pretzel sticks, medium pretzel sticks, small pretzel sticks, string, scissors, centimeter ruler, vernier caliper, graphing program* or graph paper

*Graphing Programs (Recommended: Vernier Graphing Program)

Procedure: Part 1 – Data Collection

1. Obtain 4 pretzels from each size of pretzels – small, medium and large. Student partners should have a total of 12 pretzels.
2. Using a metric ruler or a vernier caliper, measure the diameter of each of each pretzel and record the data in your data table. The length of each pretzel is 100 mm, which will be a constant value and will be used to calculate the volume of your pretzels.
3. Wrap a piece of string snugly around the outside of each section of pretzel. Mark the string so it represents the circumference of the pretzel.
4. Measure the length of string and record your data under "circumference" in table I of the Data Page.
5. Calculate average diameters and circumferences for each size-set of pretzels.

Procedure: Part 2 – Calculations and Graphing

1. Using averages, Graph **circumference** v. **diameter** placing the circumference on the y-axis and the diameter on the x -axis of your graph. Do this using graph paper, a computer or a graphing calculator. (Make a hard copy of graph.)
2. Find the slope of the graph and compare the slope with the actual value of π. Calculate the percentage error.

3. Calculate the cross sectional area and volume of each pretzel rod using the equations below. Perform calculations on the next page. Show all work and label appropriately.
   a. Cross Sectional Area $= \pi r^2$
   b. Volume = area x height or $\pi r^2 h$
   c. Surface Area of a cylinder = $(2\pi rh) + (2 \pi r^2)$

4. Calculate the surface area to volume ratio by dividing the surface area by the volume for each pretzel size-set. Record values in the data table.

Name: _____ Date _____ Sec _____

Directions: Complete the following data table, calculations, questions and graphs. Please label all graphs with the appropriate labels and units.

Calculations: Show all calculations and underline the final answer.

1. Calculate the slope of the graph of diameter v. circumference.

2. Calculate the error for your value for pi and the accepted value of 3.14.

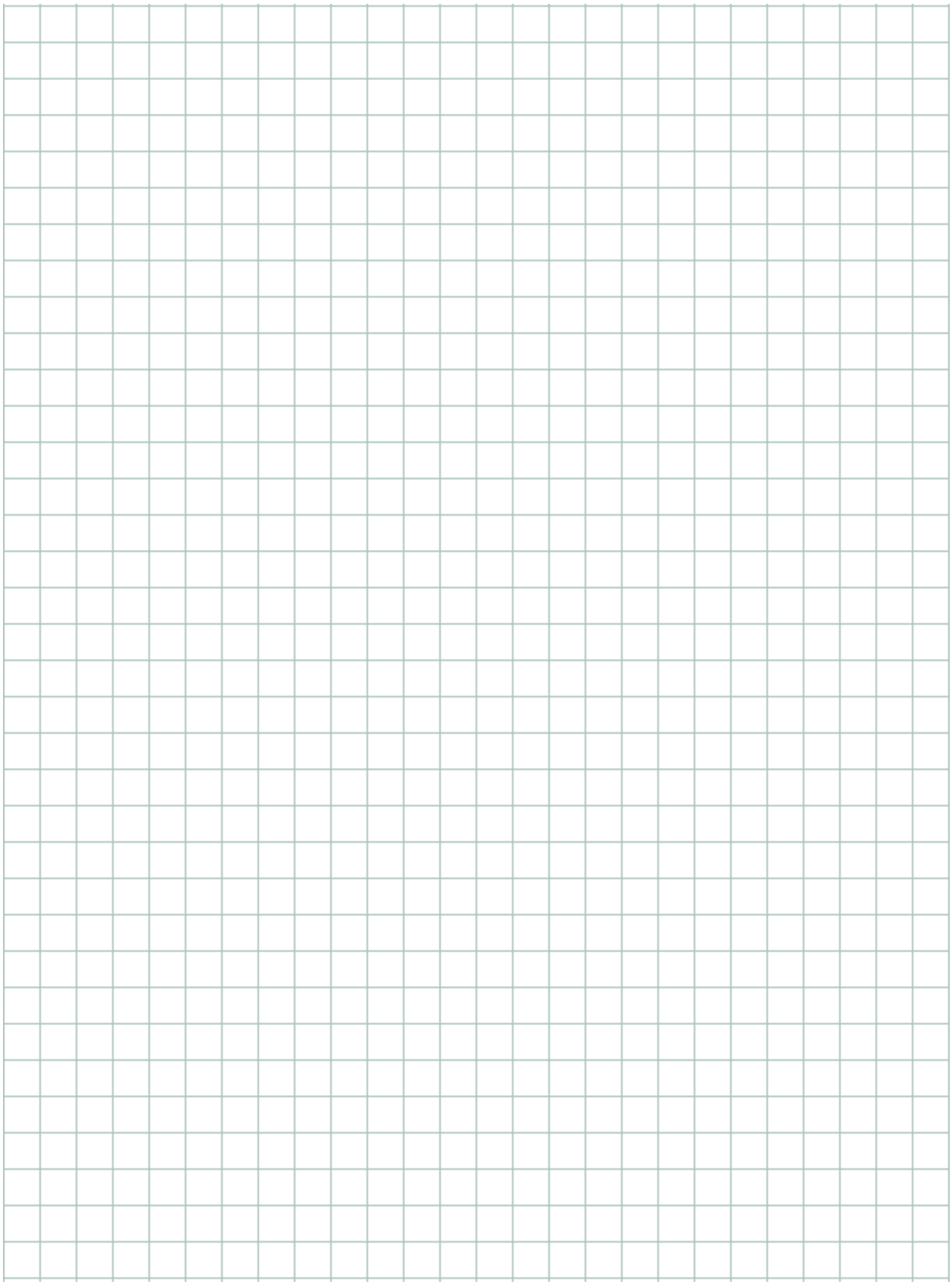
3. Calculate the cross sectional area of each pretzel group using $A = \pi \times r^2$

4. Calculate the volume of each pretzel group $V = \pi \times r^2 \times h$

5. Calculate the surface area of each pretzel group: **$SA = (2\pi rh) + (2 \pi r^2)$**

6. Calculate the Surface Area to Volume Ratio by dividing the surface area of each group by the calculated volume of that group. Which group of pretzels has the largest value? What do you think this means relative to the size (diameter) of the pretzel?

Graph Title: _____



Questions: Please answer in complete sentences.

1. Using your graph, predict the circumference of a pretzel that has a diameter of 2.0 mm.

2. Assuming your graph relationship is linear, what would be the circumference of a "nanopretzel" that has a diameter of 100 nanometers?

3. From your second graph, what happens to the surface/volume ratio of a pretzel as its radius gets larger (assuming constant length?)

4. Predict the surface/volume ratio for a 400 nm nanofiber.

5. Which group of pretzels has the largest value surface area to volume ratio? What do think this means relative to the size (diameter) of the pretzel?

6. Given the same length and volume, which pretzels do you think have more salt per pretzel? Justify your answer with your data.

7. How does the surface area of a nanoparticle affect something like toxicity in an organism?

Name (s) _____ Date _____

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Extension Activity: Beginning with the websites below, research the following**: Describe how nanofibers might be used in a productive way. Be creative, give some detail and incorporate what you have learned in this lesson in your response.**

Websites: http://www.nanitenews.com/ **,** http://electrospun.blogspot.com/

Share any valuable websites you encounter that may be helpful to your classmates.

Your report should be typed 12 point Times New Roman font and not more than two pages in length. Focus on being concise and thorough. Include your resources and completely document them. Use the rubric below to help guide you as you write your essay. You may work with your partner(s).

This paper is due _____

***Please attach this form to the top of your paper.**

Grading Rubric:

Thoroughness of description and function.	4 Topic well written including description and function.	3 A good description including description and function.	2 Some question(s) as to the description/function	1-0 Description/function is very unclear or missing	Total Points
Connection to lab activity	4 Topic relates very well to principles in lab	3 Some principles in the lab are related.	2 One principle is related.	1-0 Little or no relationship	
Creativity	4 Great idea –you should get a patent!	3 Good idea – others have tried something similar.	-	0 Omitted	
Sources Sited	4 3 or more sources sited properly.	3 3 or more sources but not properly sited.	2 2 sources properly sited.	1-0 1 or no sources…not properly sited.	
Total points					