Research Experiences for Teachers (RET)
Center for Pre-College Programs & Newark College of Engineering
New Jersey Institute of Technology

MODULE
Surface Area/Volume Ratio

MODULE TOPIC:
Surface Area/Volume Ratio

RATIONALE:
Because my research was based on nanoparticles and how quickly they are able to dissolve, this topic is fitting for a 9th grade Biology class.

STANDARD(S) & INDICATOR(S): 5.3.12.A.3
(Note: This section should include all standards listed in the lessons.)
5.1.8.B3. Collect, organize, and interpret the data that result from experiments.
5.4.4.C3. Use the design process to identify a problem, look for ideas, and develop and share solutions with others.
5.5.6.A2. Identify and describe the structure and function of cells and cell parts.

OBJECTIVE(S):
(Note: This section should include all objectives listed in the lessons.)
Students will be able to:
Investigate how surface area/volume ratios limit how large a cell can grow.

LIST OF LESSONS:
- Lesson 1: Comparing Surface Area and Volume
- Lesson 2: Cell Races

BACKGROUND INFORMATION:
In the activities students will investigate how surface area and volume are related.

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:
Lab Report will be written after the two labs have been completed.

REFERENCES:
Biology-Miller/Levine, www.explorebiology.com

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LESSON #1
Comparing Surface Area and Volume

LESSON TOPIC:
Comparing Surface Area and Volume

RATIONALE:
Because my research was based on nanoparticles and how quickly they are able to dissolve, this topic is fitting for a 9th grade Biology class.

STANDARD(S) & INDICATOR(S):
5.1.8.B3. Collect, organize, and interpret the data that result from experiments.
5.5.6.A2. Identify and describe the structure and function of cells and cell parts.

OBJECTIVE(S): Students will be able to:
Describe how surface area/volume ratios limit how large a cell can grow.

MATERIALS:
Patterns for 6cm, 5cm, 4cm, and 3cm cubes, scissors, tape, glue

LIST OF HANDOUTS (attach original copies of each handout - teacher & student edition)
Lab- Comparing Surface Area and Volume

CLASSROOM ACTIVITY DESCRIPTION (LABORATORY/EXERCISES/PROBLEMS) including detailed procedures:
In this activity, students will construct a set of paper cubes. The cubes will represent cells at different stages of growth. After the cubes are constructed, the students will calculate the volume, surface area and ration of surface area to volume of each cube.

HOMEWORK ACTIVITY/EXERCISES/PROBLEMS:
Analyze and Conclude questions and Build Science Skill Question

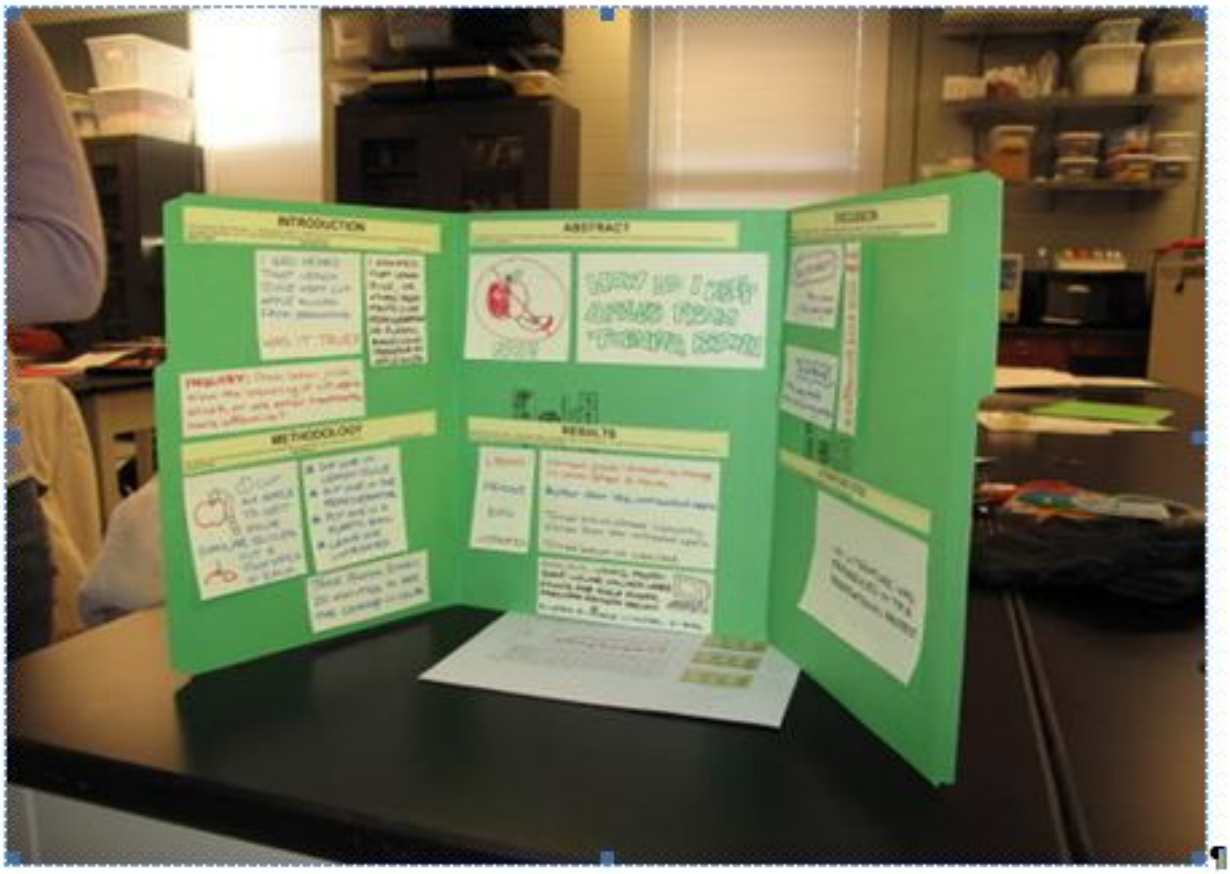
Sample Questions:

Divide the surface area by the volume to find the ratio of surface
Record your results in the data table.¶

Data Table			
Width of Side	Surface Area (cm^2)	Volume (cm^3)	Ratio of Surface Area to Volume
6 cm			
5 cm			
4 cm			
3 cm			

- Describe the function of a cell membrane and its relationship to what happens inside a cell.
- How did the ratio of surface area to volume change as the size of the cubes decreased?
- As a cell grows, what happens to the amount of activity in the cell and the need for materials to be exchanged across the cell membrane?
- How could the growth of a cell affect its ability to survive?

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:
Lab Report and Mini-poster.



REFERENCES:
Miller and Levine Biology 2010

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LESSON #2
Cell Races

LESSON TOPIC:
Cell Races

RATIONALE:
Because my research was based on nanoparticles and how quickly they are able to dissolve, this topic is fitting for a 9th grade Biology class

STANDARD(S) & INDICATOR(S): 5.3.12.A.3
5.4.4.C3. Use the design process to identify a problem, look for ideas, and develop and share solutions with others.
5.5.6.A2. Identify and describe the structure and function of cells and cell parts.

OBJECTIVE(S): Students will be able to:
Describe how surface area/volume ratios limit how large a cell can grow.

MATERIALS:
Agar, water, powdered bromothymol blue, NaOH, ice cube trays, spatula, scalpel, white cups

LIST OF HANDOUTS (attach original copies of each handout - teacher & student edition)
No handouts needed.

BACKGROUND INFORMATION:
In this activity students will design their own cell out of agar. The goal will be to design a cell to maximize volume & mass, but minimize diffusion time

Rules:
- No donut-like holes through the agar cell -- cell membranes cannot sustain that shape.
- No poking, prodding, touching beaker containing agar cell in vinegar.
- Teacher determines when 100% diffusion takes place.
- Students mass agar at conclusion of race...cell must not break when handled. Disqualification if cell breaks upon massing (although you can be a bit lenient here).
- Winner = highest ratio of mass divided by time.

CLASSROOM ACTIVITY DESCRIPTION (LABORATORY/EXERCISES/PROBLEMS) including detailed procedures:
1. Mix 15g agar in 1 liter water.
   This is **AGAR**, not agarose. (Note: 15g is thicker than you would make for growing bacteria, because you want the agar stiffer and tougher for handling.) It is better to use plain agar and not LB agar, so it has less of a chance to grow bacteria.

2. Boil slowly in microwave or hot water bath until agar is melted (granules will disappear). Watch for and avoid boil-over.

3. Remove from heat. Add 0.1 g powdered bromothymol blue and mix. If the mixture is not dark blue, then add more bromothymol blue. If the mixture is green or yellow, you will need to stir in drops of NaOH (or another base) until it turns blue. Wear safety goggles and gloves when handling NaOH.

4. Pour the agar into trays. For the initial lab, I make the agar in rectangular trays, like a wide silverware tray or a square Pyrex dish -- enough to be at least 2cm deep -- and slice chunks for the students to cut from . Make enough for 1-2 ice cubes per student or student group. Let agar harden at room temperature or in refrigerator. Can be made a couple of days in advance. Cover with plastic wrap to keep from drying out and store in refrigerator, otherwise it will get a lot of bacterial growth quickly, especially if you use nutrient agar.

5. From the microcentrifuge trays students cut blocks of specific sizes:
   1cm x 1cm x 1cm
   2cm x 2cm x 2cm
   1cm x 1cm x 8cm

6. Students have to calculate volume, surface area, and SA:V ratio.

7. Students then immerse each block in common household white vinegar either in small beakers or in more tray tops. Agar turns yellow in acid. You can easily see the blue core disappear as diffusion takes place. Students time until blue completely disappears. Helps to put beakers on white paper as a background.
   (You'll notice that 2x2x2 and 1x1x8 have same volume, but different surface area... so students see the comparative effects. You'll be amazed at how long 2x2x2 takes (45-60 minutes)! I usually have them start the 2x2x2 block first since it takes longest and then run others concurrently. You may need multiple stop watches or good records as to when the later blocks were immersed in their separate beakers).

SAMPLE QUESTIONS TO ELICIT CLASS DISCUSSION:

- Which cell design maximized volume & mass, but minimized diffusion time?
- How could you change the design of your cell to meet these requirements?

PARAMETERS TO EVALUATE STUDENT WORK PRODUCTS:

Lab report rubric or mini-poster rubric.

REFERENCES:

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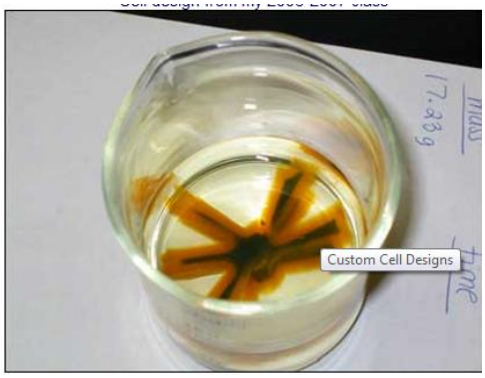
Sample Designs:



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