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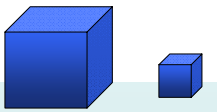
Introduction to the Nanoscale:

Inquiry Into Surface and Volume

This module gives a feel for just how small the nanoscale is and introduces its most basic quality: Surface Area / Volume ratio.

The Big Nano Question: Which cube has the larger ratio of Surface Area / Volume?

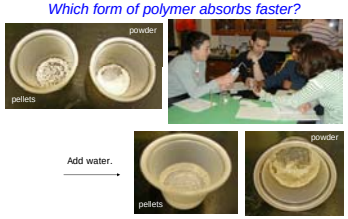


1. Same Material—Different Behavior?

The **physical form** of a solid influences the degree to which it interacts with its environment: the more spread out the solid is, the more readily it interacts.

Which form of steel burns faster?

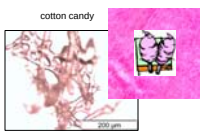
Which form of polymer absorbs faster?



Which form of candy dissolves fastest?

powdered sugar

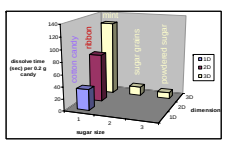
cotton candy



granulated sugar

light microscope image

R. DeWald's AP Chemistry class (Spring 2005)



Learning performances
- Predict the relative rates of dissolving solids having different amounts of surface area.
- Conduct experiments that measure liquid volume, solid mass, and time.
- Induce the relationship between the amount of surface area and the degree of interaction with the environment.
- Discuss how dimensional changes (i.e., 3-D, 2-D, 1-D) can affect this relationship.

2. Powers of 10 and Scale

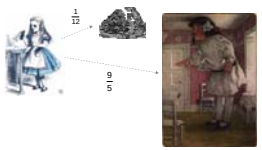
The magnitudes involved with the nanoscale can be represented with powers of 10 and scaling.

How do we describe relative sizes?

1) Measure the dimensional changes of the frog after water is added.

Just add water…

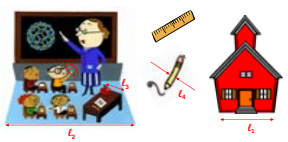
2a) Scale Alice during her adventures in Wonderland.



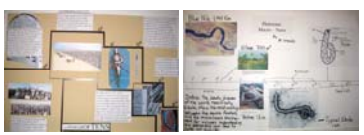
2b) Scale yourself on the globe.

How do we express very large and very small dimensional values?

3) Measure and report a wide range of lengths.



4) Create a poster with a **macro** through **nano** theme.



posters from Renee DeWald's AP Chemistry class Spring 2005

Learning performances
- Measure and express a wide variety of quantities as powers of 10.
- Determine the scale between objects of different sizes as proportions.
- Conceptualize the smallness of the nanoscale relative to the macro.
- Generate own "cognitive tool" to produce a visual representation to relate a wide range of lengths.

3. Surface Area and Volume

The **surface area to volume ratio** changes with the **shape** or **size** of an object. This ratio changes dramatically in the nano scale.

Why are Emperor penguins in Antarctica bigger than Fairy penguins in Australia and New Zealand?

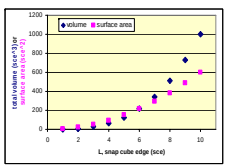
*How do the perimeter, surface area, and volume change as a function of **SHAPE**?*

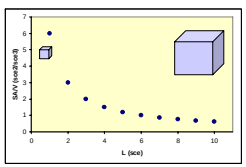
1) Arrange 8 sticks into various ***2-D** shapes* to give different **perimeter / area ratios**.

2) Arrange 8 snap cubes into various ***3-D** shapes* to give different **surface area / volume ratios**.

*How do the surface area and volume change as a function of **SIZE**?*

3) Calculate the **surface area and volume** of cubes of different *lengths*.





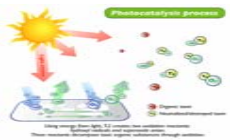
4) Relate how the **SA / V dependence on L** is similar to the candy dissolution activity and penguins.

Learning performances
- Construct physical geometrical models that minimize or maximize the Perimeter / Area ratio in 2D, and the Surface Area / Volume ratio in 3D, as functions of shape.
- Discover the shape for the minimum Surface Area / Volume ratio.
- Show, using calculations and plots, that SA / V is inversely proportional to size.
- Extrapolate from the SA / V vs. L plot why the nano world may differ from the macro world.

DESIGN a System to Clean Water in Outer Space

Challenge: Design and build a prototype for a water-treatment system that will recycle water aboard the International Space Station.

- Identify the basic needs and goals of the design.
- Brainstorm possible solutions with teammates.
- Create and evaluate a prototype.
- Revise / improve the design.



Materials available
- photocatalytic nanoparticles (ZnO)
- organic "pollutant" (methylene blue dye)
- substrates: plastic cylinders & spheres
- catalytic energy source (UV lamp)

Feedback

The students are actively involved in all activities. … Every day as they come in to class, they ask what to do next regarding [this module].

… students apply higher-order thinking skills

… good class discussions of what went right and ways to improve

measured student outcome: improved ability to work as a team member

There is an improvement in [students'] science process skills … and analytical thinking ability.

The module sheds light on how to improve my physics curriculum, especially on the way it should be implemented.

"Students formulate explanations and models—this is the best feature of the module."

Answer: As the object size gets smaller, the surface area to volume ratio becomes larger.