Name: _____ Block _____ Date: _____

Cell Size Limited by Surface Area

Why are cells so small? Think about this: even though a whale is much larger than a human and a human is much larger than a tulip, their cells are all roughly the same size. Whales don't have larger cells than humans, just more of them.

There is a very specific reason why cells are the size they are. Anytime this cell interacts with its environment, it does so at its membrane. The more membrane a cell has, the more exchange it can perform with its environment. (This exchange can include activities such as obtaining nutrients or getting rid of wastes.) We refer to the amount of surface that an object has as its surface area (SA).

Once materials get inside the cell, they move via diffusion. Diffusion is the random movement of particles that results in their dispersion in the cytoplasm. Diffusion works best over short distances. Imagine how long it would take food coloring molecules to diffuse in a water glass vs. in a swimming pool. Because the water glass has less volume (V), diffusion is more efficient.

Cells try to **maximize** their surface area (in order to improve exchange) and **minimize** their volume (to make diffusion more efficient). A basketball-sized cell would have lots of surface area (good), but also lots of volume (bad). Think about how long it would take molecules to diffuse from the outer portion of the ball to the center. A pool ball or a marble would be better choices. When we discuss the interplay of these two quantities, we use the ratio of surface area to volume (abbreviated SA/V). Ideal cells have large SA values, but small V values. When a cell reaches a critical surface area to volume ratio, it stops growing or is signaled to divide.

- To establish the relationship between surface area and volume use the formula sheet below to calculate the surface area and volume of the cubes.
- Then, divide the surface area by the volume to get the surface area to volume ratio (SA/V ratio).
- Finally, graph the length of side (cm) vs. the surface area to volume ratios. Note that the surface area to volume ratio does not have a unit since surface area is measured in cm^3 and volume is measured in mL (same as cm^3).

Surface Area and Volume –Formula Sheet

Volume of a Cube (or Square Column)
V = length x width x height

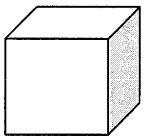
Surface Area of a Cube
A = 6 x area of one side

Cube 1

l = 1cm
w = 1 cm
h = 1 cm

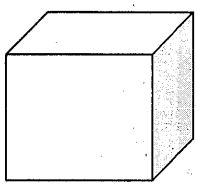
Cube 2

l = 2 cm
w = 2 cm
h = 2 cm



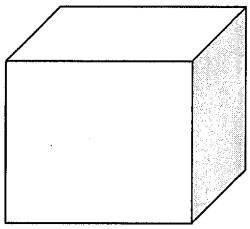
Cube 3

l = 3 cm
w = 3 cm
h = 3 cm



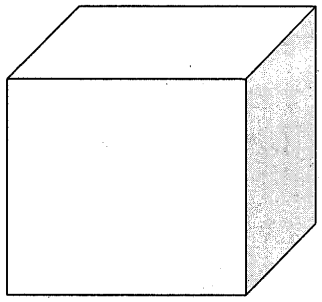
Cube 4

l = 4 cm
w = 4 cm
h = 4 cm



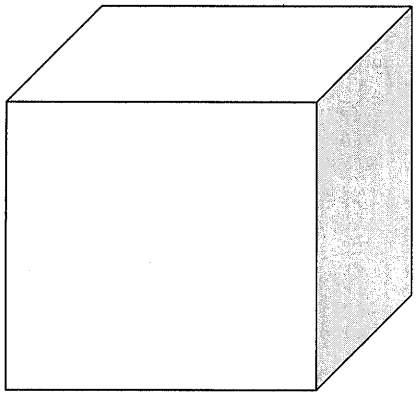
Cube 5

l = 5 cm
w = 5 cm
h = 5 cm



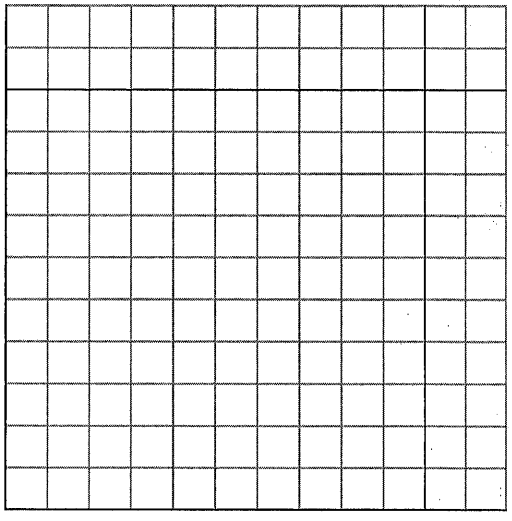
Cube 6

l = 6 cm
w = 6 cm
h = 6 cm



Data Analysis

Length of Cube Side (cm)	SA/V Ratio of Cube



What is the relationship between size and surface area of a cube?

Procedure

1. Put on your safety goggles. Work with your partner to cut out the cell models and fold the models to form a cube. Tape the sides, but leave the top open.
2. Measure the length, width, and height of each model and record the dimensions in Table 1.
3. Calculate the total surface area for each model and enter the result into Table 1
4. Use the funnel to fill each model with sand (or you can use sugar or rice). Use a ruler to level it off
5. Find the volume of sand in each model and enter the data into Table 1
    a. Measure the amount of sand by pouring the sand through the funnel into a graduate cylinder. Read the volume in mL and record into Table 1
    b. Then calculate the volume and record your answer into Table 1.
6. Calculate the surface area to volume ratio for each model.
7. Clean up your sand when you are finished!

Table 1: Model Cell Calculations Surface Area to Volume Comparisons

Cell	Dimensions (cm)	Surface Area (cm^2)	Measured Volume (mL)	Calculated Volume (cm^3)	Surface area to volume ratio
1					
2					
3					
4					

Analysis and Conclusion

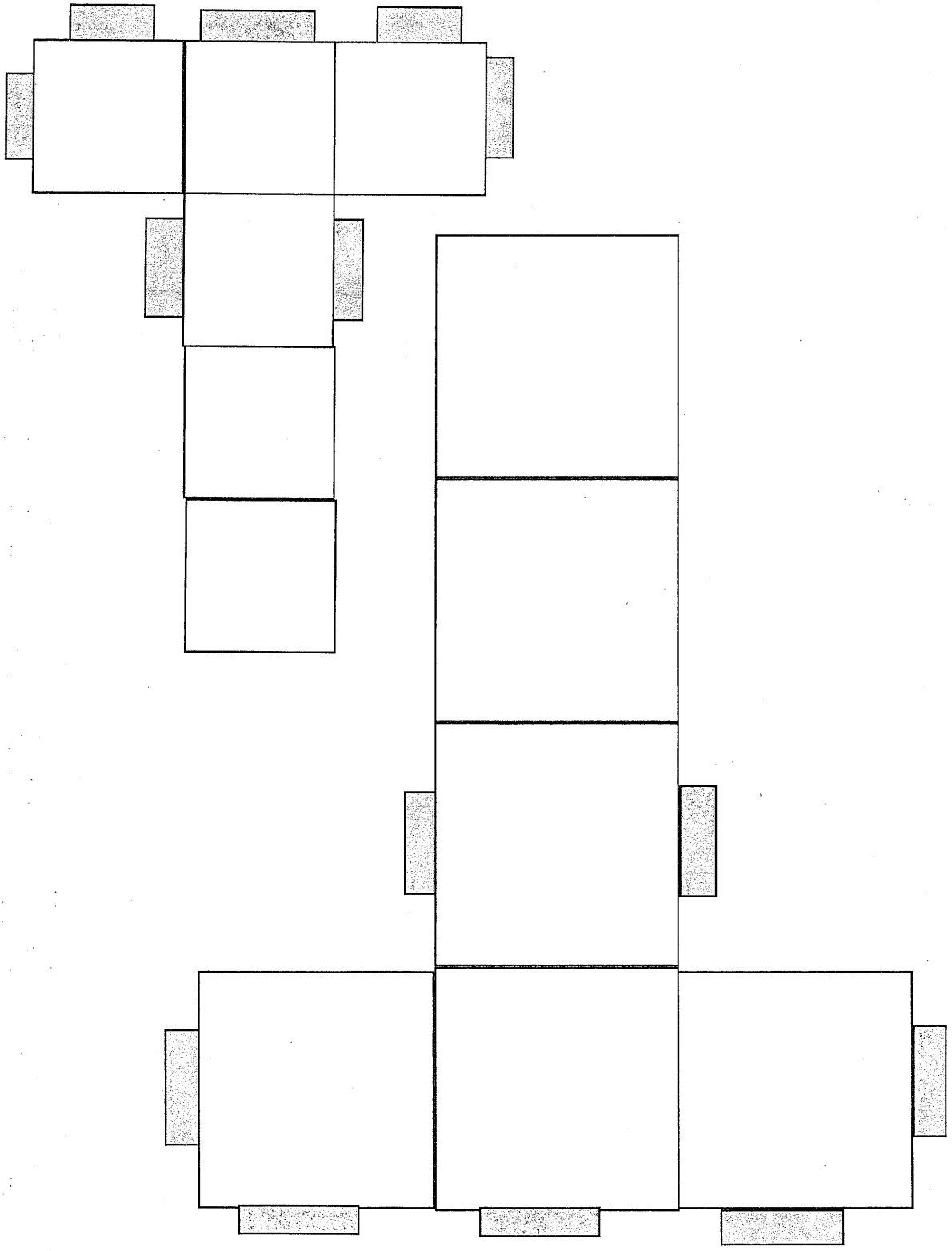
1. Which cell had the largest surface area? _____
2. Which cell had the largest volume? _____
3. Which cell had the largest surface area to volume ratio? _____
4. Which of these model cells is likely to be most efficient at getting nutrients to all of the cell parts? Explain your answer in terms of surface area to volume ratios.

_____

_____

_____

_____



Day