

### **Investigating the relationship between cell size and rate of diffusion**

**Aim:** To plan and carry out an investigation to show the relationship between volume, surface area, and diffusion; and to demonstrate, using diffusion, why the size of cells is limited.

**Hypothesis:** In this experiment, I expect to find that when the surface area to volume of a cell reaches a certain level, diffusion alone won't be able to supply the cell materials needed, and as single-celled organisms take in and release substances by means of diffusion across the cell membrane, this process limits cell size. I predict that as the rate of diffusion will be too slow to deliver materials to the center of the cell in the larger cells, it could result in cell malfunction.

**Variables:** In this investigation, the variable I am manipulating, the independent variable are the dimensions of surface area to volume ratio of the agar cube. The variable I am observing/recording, the dependent variable, is the rate of diffusion (NaOH turns the agar cube pink as it disperses into it). The controlled variables will be keeping the concentrations of the Sodium Hydroxide constant, to use agar jelly from the same batch (so the type of agar jelly is exactly the same), and to keep the time even for all cubes so the NaOH has the same amount of time to disperse into the cube.

**Apparatus:**

3 agar cubes containing pH indicator  
Sodium Hydroxide solution  
Glass beaker/s  
Clock/ timing device  
Ruler/measuring device  
Safety glasses

**Method:**

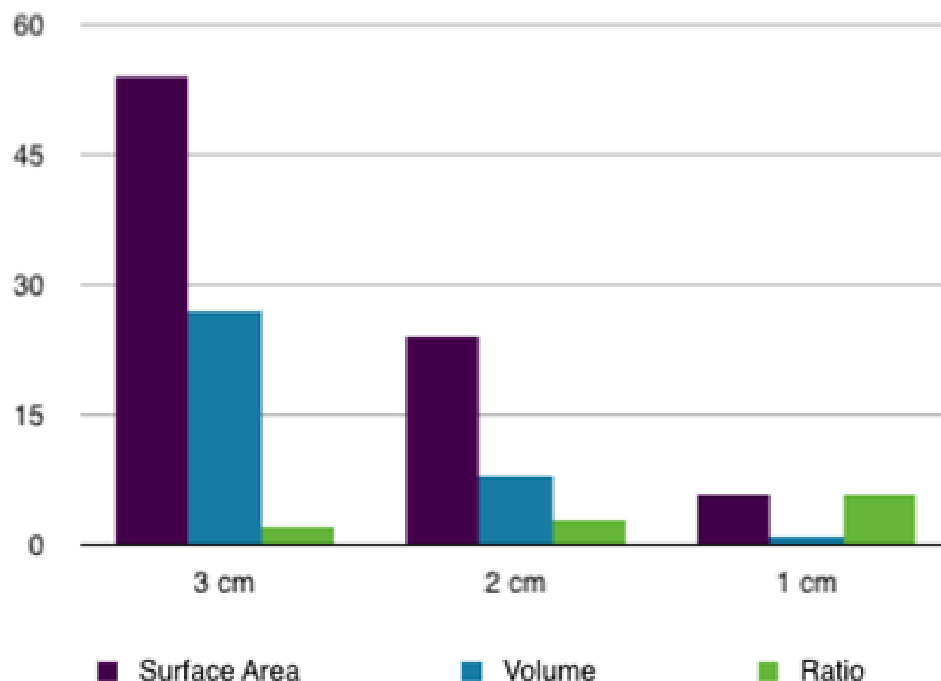
1. Cut out a 1 cm (2x), a 2 cm, and a 3 cm cube from the large piece of agar jelly using a knife.
2. Pour in NaOH into 3 beakers, enough to cover each cube in the solution completely. Immerse all cubes in NaOH at the same time, and record the time.
3. After around 10 mins. cut one of the smaller cubes in half to see if the color has reached the middle of the cube. If it has then stop the investigation, take out all cubes and rinse them in water. If not, allow the investigation to carry on for a reasonable period of time and then stop the investigation.
4. Once all cubes are taken out, cut them all in half and measure the area which has changed pink with a ruler.
5. Record all the data in a raw data table.

**Diagram:****Results:**

We did the experiment twice, as to get a range of data, however we got the same results both times.

	SA (cm <sup>2</sup> )	Volume (cm <sup>3</sup> )	Simplest ratio
3 cm agar cube	$6(3 \times 3) = 54 \text{ cm}^2$	$(3 \times 3 \times 3) = 27 \text{ cm}^3$	2 : 1
2 cm agar cube	$6(2 \times 2) = 24 \text{ cm}^2$	$(2 \times 2 \times 2) = 8 \text{ cm}^3$	3 : 1
1 cm agar cube	$6(1 \times 1) = 6 \text{ cm}^2$	$(1 \times 1 \times 1) = 1 \text{ cm}^3$	6 : 1

### Processed data:



### Discussion:

The hypothesis that the rate of diffusion will slow down as the Surface Area to Volume ratio decreases as the size of the cubes increase was correct. The surface area of the 3 cm cube was 54 cm, while the volume was 27 cm, giving it a 2:1 ratio. Whilst the surface area of the 2 cm cube was 24 cm, the volume 8 cm, producing a 3:1 ratio. And finally, the surface area of the 1 cm square was 6 cm, the volume 1 cm, giving it a 6:1 ratio. Looking at these results it is evident that as the cubes increase in size, the surface area to volume ratio decreases. When cells grow to a certain size, their rate of growth slows down until they have stopped growing completely (restrains cell size). Once a cell has reached its size limit, and when one of the larger cells divide into smaller ones, the rate of growth again increases. So generally, the relationship between the rate of diffusion and cell size is that the rate of diffusion stays the same, but as all the cells are small, diffusion occurs quicker throughout the cells, than in larger cells.

Even though we used agar jelly containing pH indicator to represent a cell and NaOH to represent the state of simple diffusion, this really is the process that occurs millions of thousands of times in our bodies. As the single-celled organisms take in and release substances by means of diffusion across the cell membrane which is important to their successful function, this is the reason that there is a limit to cell size.