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An experimental study on the rate of diffusion of Sodium Hydroxide in different sized Agar Cubes

Aim

The aim of this experiment is to determine if cells with a bigger surface area to volume ratio have a higher efficiency in diffusion of material than cells with a lower ratio.

Introduction

Diffusion is the net movement of molecules from a region of high concentration to an area of lower concentration along a concentration gradient.
Substances as nutrients, oxygen, water and waste products are transported between living cells using this very important process.
In this experiment, agar cubes with phenolphthalein added as an indicator will be used. Phenolphthalein $C_{20}H_{14}O_4$ is an indicator which turns colourless in acidic solutions and pink in basic solutions such as NaOH. As a consequence when Agar cubes will come in contact with Sodium Hydroxide, will turn pink. The NaOH will continue to diffuse through the cube and gradually turn the inside of the cube pink.

Hypothesis

Will the agar cubes with different surface area to volume ratio have divergent rates of diffusion?

Variables

Dependent variables	Independent variables	Controlled variables
Diffusion rate in the agar cubes	Sizes of the agar cubes	Measurement techniques
		Volume of the solution
		Amount of time the cubes are kept inside the solution (10 minutes)
		Solution in which cubes are inserted
		Agar cubes material

Materials

- Agar powder (20g)
- 30 cm ruler (± 0.1 cm)
- Flat blade knife
- Plastic Spoon
- Plastic plate
- 1000 ml baker
- Paper towel
- 400 ml of 0.1M NaOH
- 890 ml of distilled/deionised water
- Timer
- Pipette
- Gloves (safety optional)
- Magnetic stirring bar
- Magnetic heater
- 10/20 ml of 2.0% of Phenolphthalein indicator
- Trays

Figure 1 —> Colourless Agar cubes

Method

The steps to follow are to slowly dissolve 20 grams of Agar powder into 890 ml of deionised water whilst stirring constantly with the magnetic bar. Then bring the solution to boiling point by using the magnetic heater and then let simmer for a few minutes until completely dissolved. When the temperature of the solution gets just under 60°, but not lower than 40°, stir constantly while adding 100 ml of Sodium Hydroxide to the agar solution. Add 10/20 ml of 2.0% of Phenolphthalein indicator quickly whilst stirring until the agar is a deep pink colour. Pour into a shallow tray to a depth of >30mm and allow to set. When solid cut the agar into 1,2 and 3 cm cubes with a flat blade knife. Place the 3 cut Agar cubes inside the NaOH acid (the acid needs to fully cover all 3 cubes) and immediately start a timer of 10.00 minutes. When the 10.00 minutes end remove the 3 cubes from the solution and dry them up with the paper towel. Carefully measure the size of the diffusion of all the agar cuboids.

Results

Observations:

- The baker containing NaOH turned light-pink by the end of the experiment
- All three cuboids immediately changed colour when immersed in the acid

Figure 2 —> Agar cubes in NaOH

After 10 minutes

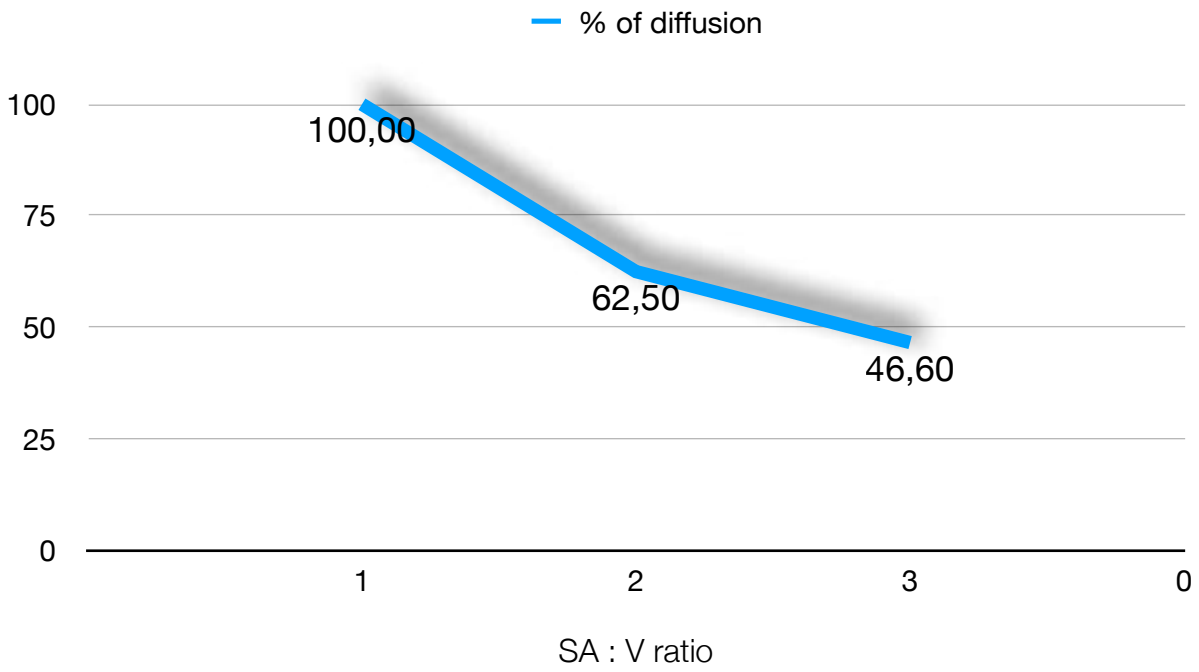
Figure 3 —> Agar cubes in NaOH after 10 minutes

Calculations:

Cuboid size	Cube volume	Cubes' surface area	SA : V
1 cm (± 0.1 mm)	1 x 1 x 1 = 1 cm_3	6 x 1 x 1 = 6 cm2	6 : 1
2 cm (± 0.1 mm)	2 x 2 x 2 = 8 cm_3	6 x 2 x 2 = 24 cm2	3 : 1
3 cm (± 0.1 mm)	3 x 3 x 3 = 27 cm_3	6 x 3 x 3 = 54 cm2	2 : 1

Cuboid size	Not diffused agar	Diffused agar	% of diffusion
1 cm (± 0.1 mm)	0	1	(1/1)*100 = 100%
2 cm (± 0.1 mm)	2 x 2 x 1.25 = 5.00 cm3	8 - 5 = 6 cm3	(5/8)*100 = 62.5%
3 cm (± 0.1 mm)	3 x 3 x 1.6 = 14.4 cm3	27 - 14.4 = 12.6 cm3	(12.6/27)*100 = 46.6%

Graph:



Discussion

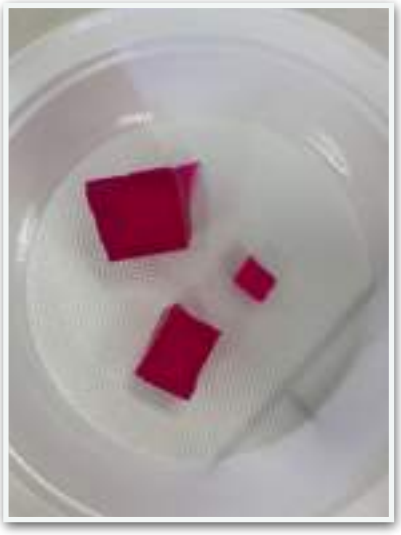


Figure 4 —> Dried Agar cubes after being immersed in NaOH

The results showed that the higher percentage of diffusion was reported when the ratio between surface area and the volume was at its largest, while when there was a lower difference in ratio, the percentage was remarkably inferior.
When the cubes came to contact with the acid solution they immediately turned pink and this meant that diffusion was taking place. As time went by the colour of the agar cubes intensified and expanded proportionally to the time going on. In the smallest cube, 1 cm2, the rate of diffusion was much faster than in the other two cuboids and this was evident since they where immersed in the sodium hydroxide acid.
Diffusion in cells is a very important point for the survival of the cell as if it is not efficient enough, a cell could not be able to meet the necessary intake of materials and the outtake of waste product. This means that smaller cells will work more effectively than large cells so in an organism it is better to have more smaller cells combined than few slow large cells.

Conclusion

The data collected and analysed confirmed the hypothesis which questioned if different sized agar cubes with divergent SA : V ratio would have had non-equivalent rates of diffusion of NaOH. This confirms that smaller cells are considerably more efficient than bigger cells and this is why in nature few cells are of a large dimension.

Evaluation

Overall the experiments' results found are not to take as examples of reliability as all measurements taken were approximate. This happened as while cutting with the knife, the outcomes were not precisely cuboids but some cuts were slightly tilted. This meant that the SA : V ratio values were approximate so the results were as a consequence approximate.
Secondly a decisive point that reduces the trustworthiness is the fact that the lab experiment was not repeated, so the results are based only on a one time trial. Repeating the research would exponentially increase the solidness of the outcome, thus it would boost the accuracy and precision of the data collected reducing the random errors of the study.

References

- figure 1 —> Colourless agar cubes
- figure 2 —> Agar cubes in NaOH
- figure 3 —> Agar cubes in NaOH after 10 minutes
- figure 4 —> Dried Agar cubes after being immersed in NaOH
- Laboratory notes —> Google classroom
- https://www.britannica.com/science/phenolphthalein