Investigating The Effect of SA:V On The Rate Of Diffusion

Introduction

Agar blocks containing DCPIP are used to represent cells.

Ascorbic acid turns DCPIP colourless.

Blocks of different SA:V are placed in ascorbic acid and the time taken for the blocks to go completely colourless is recorded.

Group results are collated and a graph showing SA:V ratios against time is drawn and a curve of best fit added.

DCPIP

- DCPIP is dichlorophenolindophenol but you can call it DCPIP!
- It is used to test for vitamin C (ascorbic acid).
- Ascorbic acid makes DCPIP change from a dark blue to colourless.

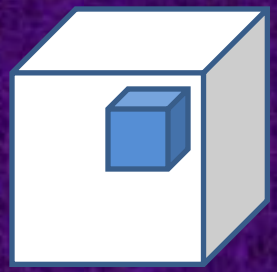
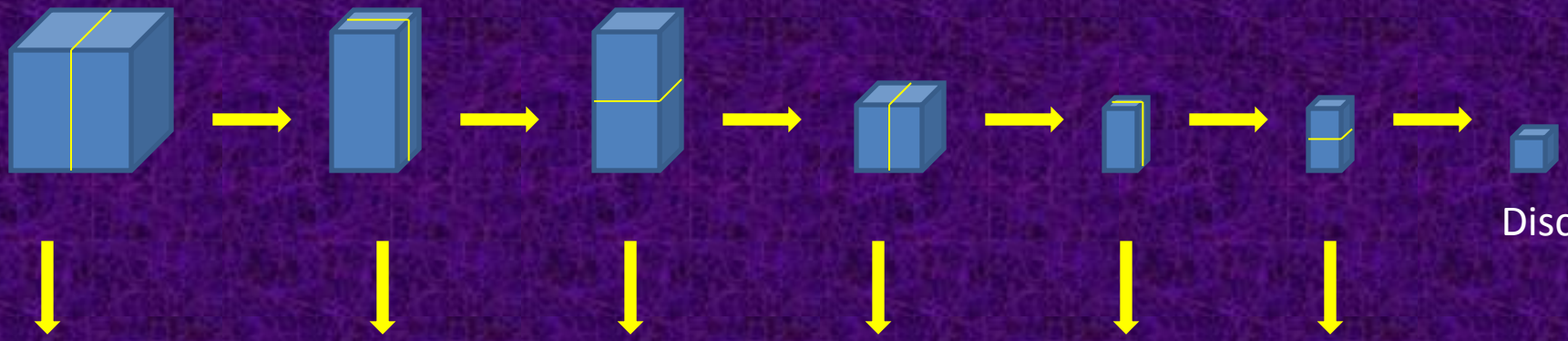


Fig.1 You can see how far the ascorbic acid has diffused and can time how long it takes for the ascorbic acid to diffuse to the centre of the cell.

Method

1. Accurately cut blocks of different sizes to a maximum of 10mm x 10mm x10mm.
2. Place in ascorbic acid.
3. Time how long it takes for the blocks to go colourless.

The Fast Way



10x5x10mm
0.8:1

10x5x5mm
1.0:1

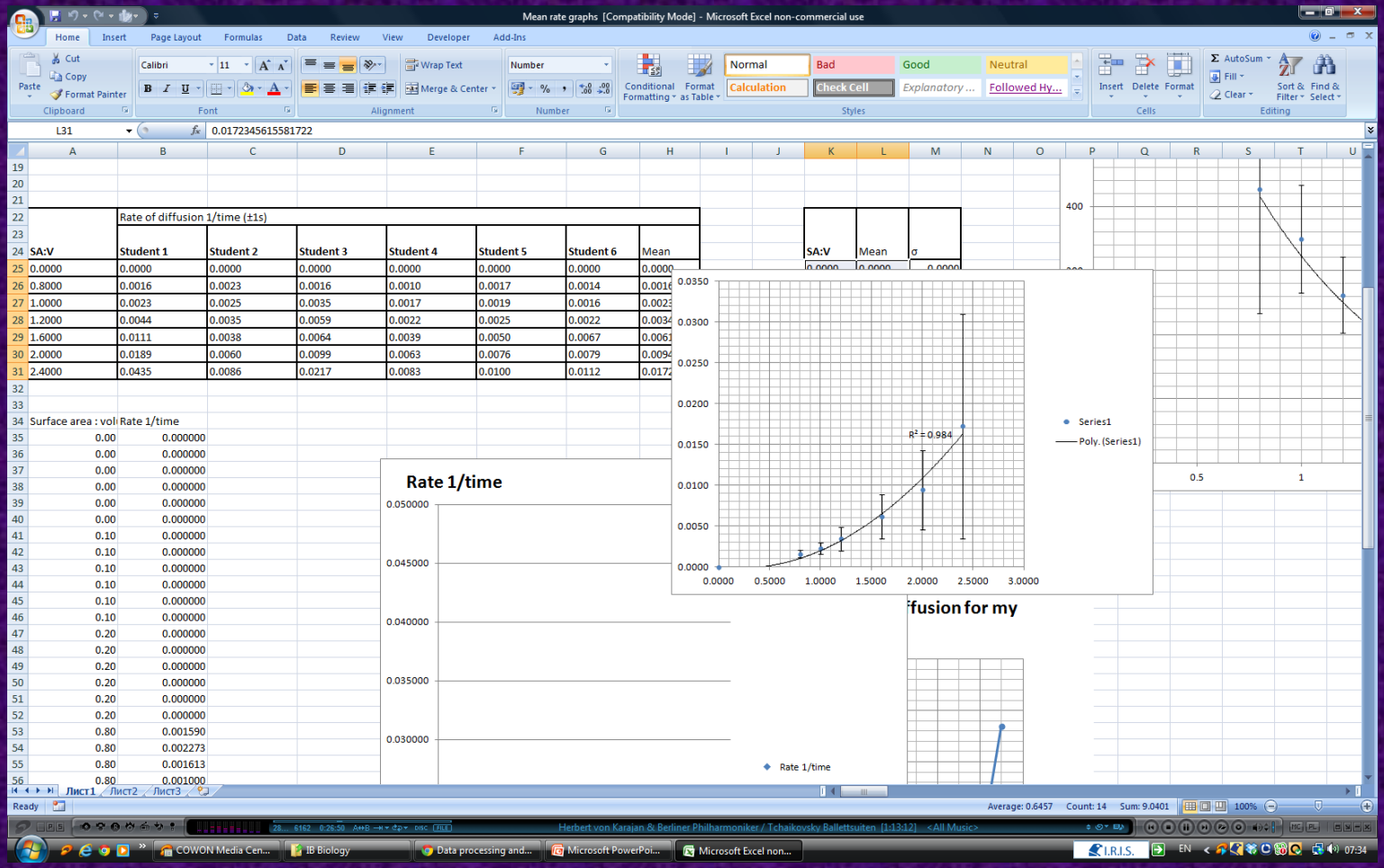
5x5x5mm
1.2:1

5x2.5x5mm
1.6:1

5x2.5x2.5mm
2.0:1

N.B. The blocks are not the same shape – consider this when writing an evaluation

Data Processing and Presentation



Raw Data

SA:V	Time taken for the agar block to go colourless (±1s)					
	Student 1	**Student 2**	**Student 3**	**Student 4**	**Student 5**	**Student 6**
0.80	628	440	620	1000	589	695
1.00	435	394	287	580	520	625
1.20	230	286	170	452	395	460
1.60	90	266	156	255	200	150
2.00	53	166	101	160	132	126
2.40	23	116	46	120	100	89

Processed Data Table 1

SA:V	Mean	σ
0.80	427	313
1.00	349	270
1.20	262	193
1.60	121	84
2.00	85	59
2.40	63	41

Processed Data Table 2

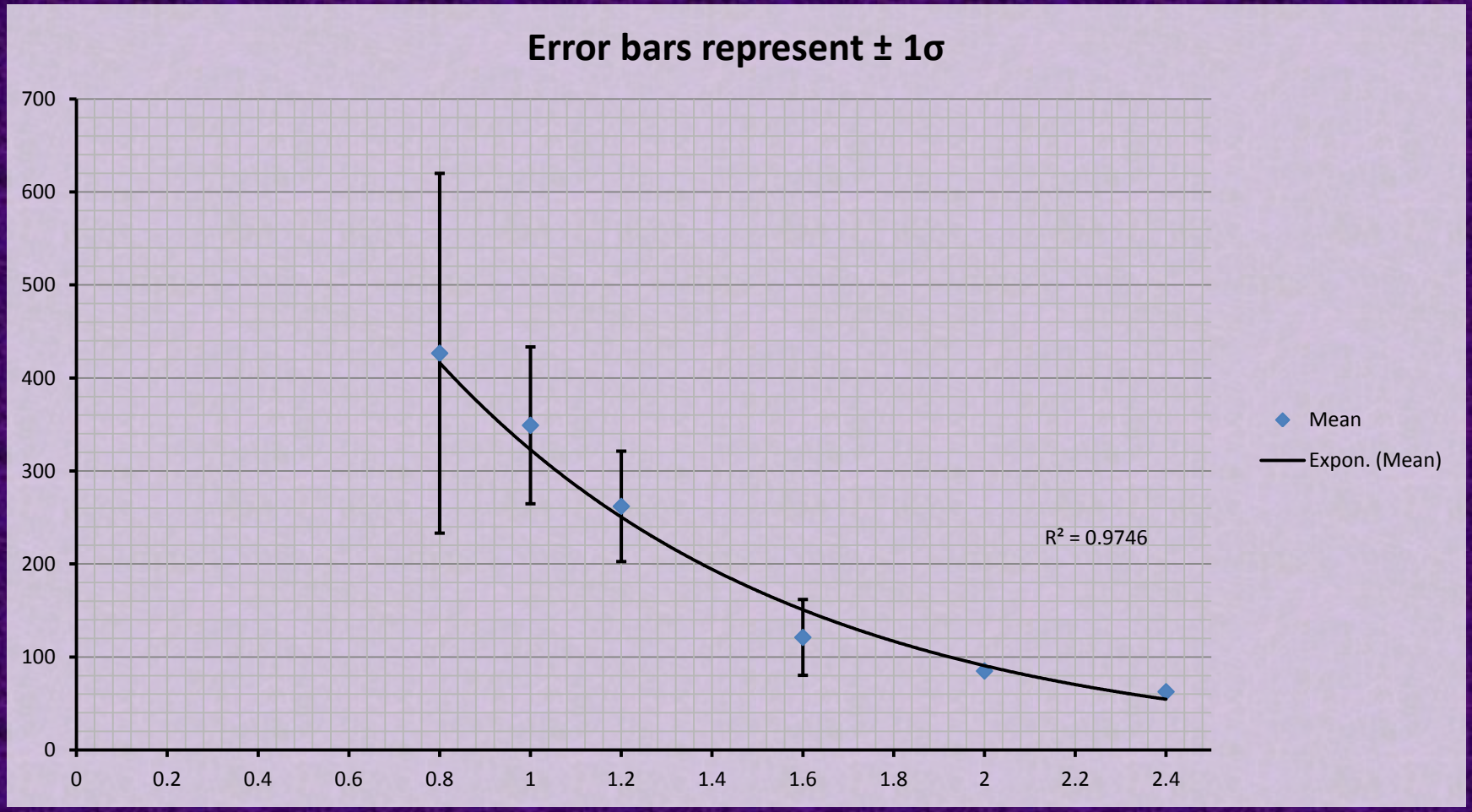
SA:V	Rate of diffusion 1/time (±1s)					
	Student 1	**Student 2**	**Student 3**	**Student 4**	**Student 5**	**Student 6**
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.8000	0.0016	0.0023	0.0016	0.0010	0.0017	0.0014
1.0000	0.0023	0.0025	0.0035	0.0017	0.0019	0.0016
1.2000	0.0044	0.0035	0.0059	0.0022	0.0025	0.0022
1.6000	0.0111	0.0038	0.0064	0.0039	0.0050	0.0067
2.0000	0.0189	0.0060	0.0099	0.0063	0.0076	0.0079
2.4000	0.0435	0.0086	0.0217	0.0083	0.0100	0.0112

N.B. Blocks of SA:V 0.0 were not used but have been included in the data to ensure that the curve in graph 2 has its origins at 0,0.

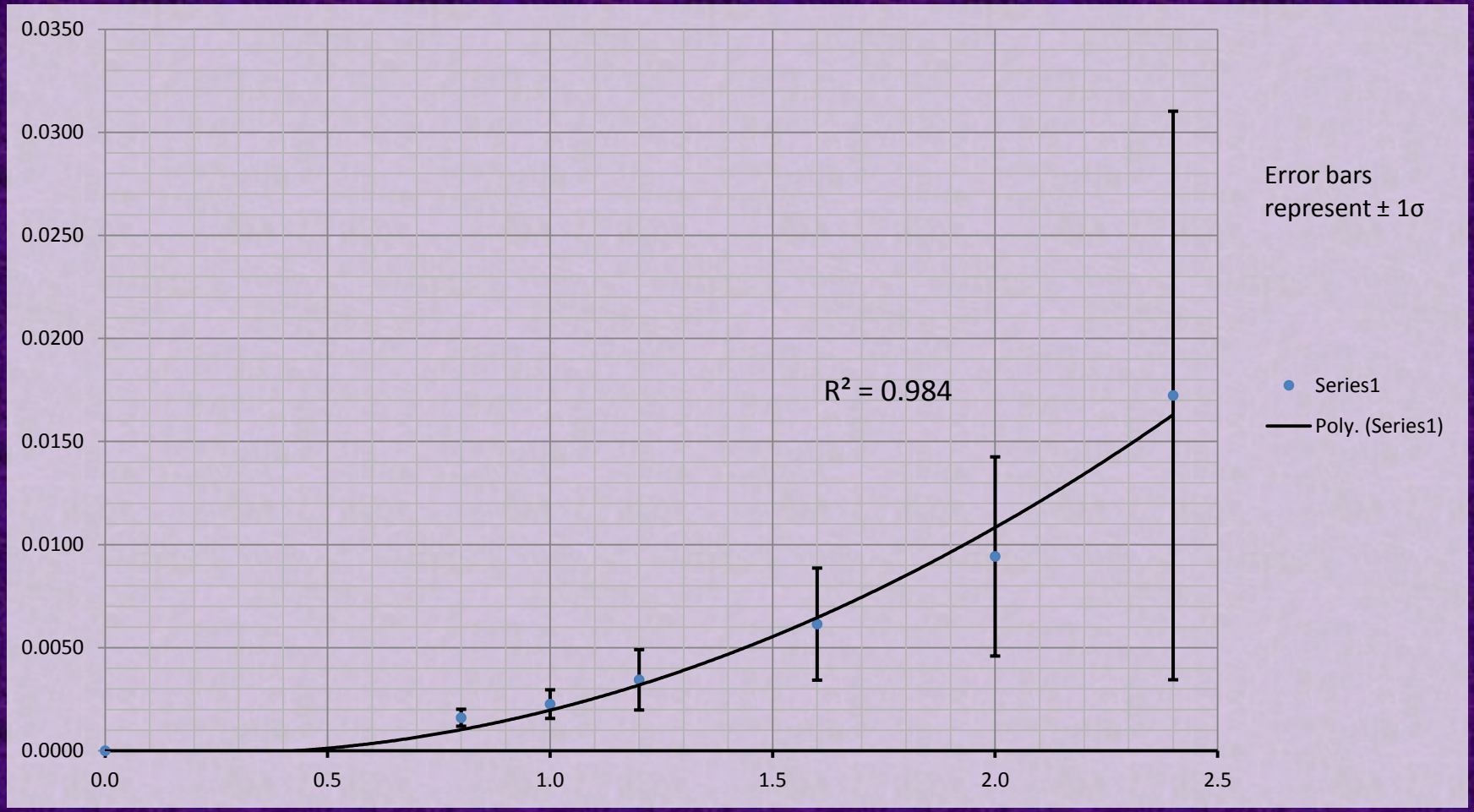
Processed Data Table 3

SA:V	Mean	σ
0.0	0.0000	0.0000
0.8	0.2012	0.0004
1.0	0.2514	0.0007
1.2	0.3020	0.0015
1.6	0.4045	0.0027
2.0	0.5062	0.0048
2.4	0.6096	0.0138

Graph 1 – The effect of SA:V on the time taken for the blocks to go colourless



Graph 2 – The effect of SA:V on the rate of diffusion of ascorbic acid into agar/DCPIP blocks



Conclusion (Aspect 1)

- Graph 1 shows that the time take for the blocks to go completely colourless decreases as the SA:V increases.
- Graph 2 shows that the rate of diffusion increases exponentially with increasing SA:V.
- Doubling the SA:V ratio from 1.0:1 to 2.0:1 resulted in approximately four times the rate of diffusion.
- As each living cell is bathed in extracellular fluid and is closely associated with capillaries, the small size of cells allows sufficient oxygen and glucose to diffuse into cells for the synthesis of ATP by respiration.
- Red blood cells are particularly small and have a biconcave shape, resulting in the rapid diffusion of oxygen into and out of the cells.
- Some invertebrates carry out gaseous exchange through their skin and such taxonomic groups can only reach a certain size (see fig. 2).
- Larger organisms have developed special respiratory surfaces for gaseous exchange such as lungs or gills which provide a much larger surface area.
- Remember to include qualitative observations! All the cubes went from blue to colourless, smallest first and then in order of increasing size.

fig. 2

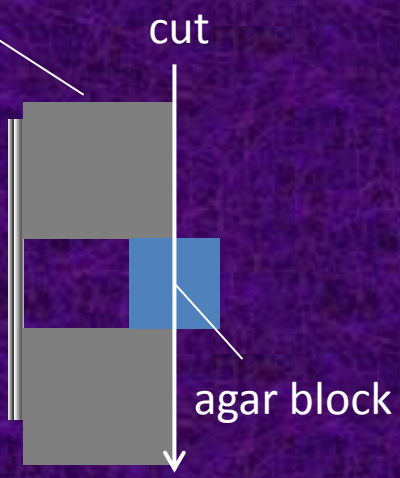
Conclusion (Aspects 2 and 3)

Aspect 2 Evaluating procedure(s)	Aspect 3 Improving the investigation
The blocks were not cut with great accuracy but only ± 0.5mm.	Use a micrometer to measure the dimensions and calculate the SA:V accordingly. See fig. 1
It was difficult to cut the cubes flat and perpendicular ensuring true cuboids.	Using a single edged razor blade (fig. 2) and/or two equally sized metal blocks placed against a vertical surface (fig 3) providing the precision of a guillotine.
It was difficult to determine when the blue DCPIP had completely turned colourless.	Use a white tile, good light source and a magnifying glass.

Fig. 1

Fig. 2

Fig. 3



Conclusion (Aspects 2 and 3)

Aspect 2 Evaluating procedure(s)	Aspect 3 Improving the investigation
The cubes were of different shapes	Either use cubes of square faces only (time consuming) or use a cork borer to cut cylinders which are then cut down such that their length is equal to their diameter (fig4).
The largest cube had a SA:V of 0.8:1 with no data to provide a point nearer to the origins of the axes (0,0).	Use a cube of 10x10x10mm with a SA:V of 0.6:1.
With reference to the smallest block with a SA:V of 2.4:1 student 4 recorded a time approximately 5 times greater than student 1. Perhaps student 1 had poor eyesight and/or student 4 was not looking at his/her apparatus and missed the end point. This possibly accounts for the large error bars.	This does suggest a high degree of human error. In the absence of data logger, students should always remain focused on their experiment. Also asking a friend to start the stopwatch as the ascorbic acid is added will lead to more accurate times.

Fig. 4

Other relevant information

1. The cubes were placed in a test tube that was corked and placed on its side. Only the corners of the cubes were in contact with the glass of the test tube. The tube was gently moved from side to side to make sure that the cubes were not touching.
2. Cells are not cuboids and unlike the agar blocks, are surrounded by a plasma membrane. Water soluble substances can only diffuse through the channel proteins.