Investigation into the Effects of Moisture and Light on Pleurococcus Growth

Extended Essay

2003

Contents

Abstract

My research question for this investigation is "Does moisture or light affect Pleurococcus growth more?"

I set about this investigation by approaching a building in my school which was seen to have Pleurococcus growing in varying amounts on its walls, I decided which walls would be appropriate for study and planned a method of collecting and recording my data. I settled upon using the tiles of the walls as quadrats and creating a scheme of a percentage cover scale to represent what I saw on the walls.

I chose to pick three, single, vertical columns of tiles from each side of the building to observe as this gave a good overall projection of the wall as a whole. I looked at each tile and decided in what percentage they were covered with the algae and then recorded this in tables. My tables represented one side/wall each and the three columns were included in one table. From these I was able to create kite diagrams which made analysing what I saw on the walls easier, and was a more digestible representation. I had collected all the data on one day in order to avoid bias and changes in light intensity or the weather. After constructing my tables and kite diagrams I was able to analyse what I had discovered to be the distribution of the Pleurococcus and from closely regarding the surroundings of each wall I could evaluate what I had found to form a conclusion.

I concluded from my investigation that moisture affected Pleurococcus growth more than light.

Research Question:

Does Moisture or Light Affect Pleurococcus Growth more?

Aim:

During the course of my investigation I plan to determine whether the most significant factor effecting Pleurococcus growth is light or moisture by surveying the walls of an L-Shaped building in Sevenoaks School. I aim to find out which of the conditions is more important in terms of inhibiting or encouraging growth.
I realised that on one side of the roof of a boarding house in my school there were large amounts of Pleurococcus growing all over it, yet on the other side there was none. It struck me that there must be a reason for this distribution. It would have been difficult and dangerous to conduct the experiment based on that particular building due to the height and inaccessibility of the roof, so I chose the "L-Block" building, where the algae was present on the walls, to carry out my investigation.

Hypothesis:

I predict that moisture will be the most significant factor in controlling the growth and distribution of Pleurococcus, due to the fact that the algae is made up of single cells which are inadaptable and therefore will not survive in areas lacking in moisture. Light is obviously necessary for photosynthesis but will not be the most influential factor when finding suitable growing conditions for Pleurococcus.

Background Information:

Pleurococcus is a spherical single celled alga, which grows in substantial numbers, sometimes dividing into groups; each cell measures approximately 20micro metres in width.

The cells each contain chloroplasts, containing chlorophyll; here is the site of photosynthesis. Photosynthesis is the process in which energy from sunlight is converted into chemical energy in organic molecules. The products formed through photosynthesis are necessary for the synthesis of proteins, lipids, polysaccharides and nucleic acids which are factors in the structure and function of plant cells like Pleurococcus. (Water is not only needed but is also a product of the reaction).

The element of Photosynthesis particularly relevant to my investigation is the light-dependent stage, the aim of which is to generate ATP, the universal energy source. The ATP is used to convert carbon dioxide into carbohydrate. In photosynthesis water and sunlight are vital components in the light dependent reactions and are needed simultaneously for photosynthesis to occur and thus for the algae to grow. Without the necessary water, there would be no hydrogen ions produced to take part in the production of reduced NADP, necessary for the formation of carbohydrate. Without sunlight there would be no energy for the reaction to occur.

Pleurococcus cells are very vulnerable to changes in environment and are not resistant due to the fact that they are encased only by a thin cellulose cell wall, which offers very slight protection. This factor means that without sufficient water, the cells will dissociate, and no Pleurococcus will be able to grow.

Variables:

I collected all my data on one day within one hour so that my judgement would not be affected. The way in which I chose to measure the amount of

Pleurococcus meant that this was an important issue. At the time I collected the results I knew very little about the sunlight exposure on those walls so as to avoid bias.

The light intensity remained at approximately the same level and the weather conditions did not change because of the short space of time. I wanted to avoid rain or uneven cloud cover as much as possible so that the tiles were not wet and that the colour contrast between the algae and the tiles remained constant.

Method:

My first stage was to examine the walls of the L-Block to be sure of their suitability for my investigation. Some walls were wider than others, which I had to assess and one wall was made up of windows, with no tiles available for studying. I decided upon the walls that I found to be most appropriate for observation and set about designing a method of recording the Pleurococcus distribution.

Due to the fact that Pleurococcus cells are so small, they grow in irregular shape, which could be exceptionally difficult to measure. It soon became apparent that the only way in which I could record what I saw would be to use a method of percentage cover per tile and use the tiles as quadrats in order to determine the distribution. I picked out three vertical columns of tiles from each of the walls which best illustrated the Pleurococcus growth patterns for that wall as a whole. By observing the tiles in this way it provided me with more accurate and widespread data than if I were to take only one column of tiles from the whole wall.

I then drew up tables in which I would record the percentage cover for all three of the columns chosen for each wall. I had taken one column from the left, one from the centre, and one from the right of each side of the building and the percentage cover for each of these columns was to be represented on one sheet.

I chose to use a scale involving five possible options for the percentage cover of each individual tile: 0%, 25%, 50%, 75%, and 100%. Some tiles had a very small amount of Pleurococcus growing underneath the overlap at the very top of them, I counted this as 0% because those areas are not reached by any sunlight which hits the rest of the wall so I did not see them as a portrayal of the wall as a whole. I viewed each tile one by one and decided on how much Pleurococcus was on them and recorded what I saw on my tables. The vertical columns were in a slight zigzag shape due to the layout of the tiles.

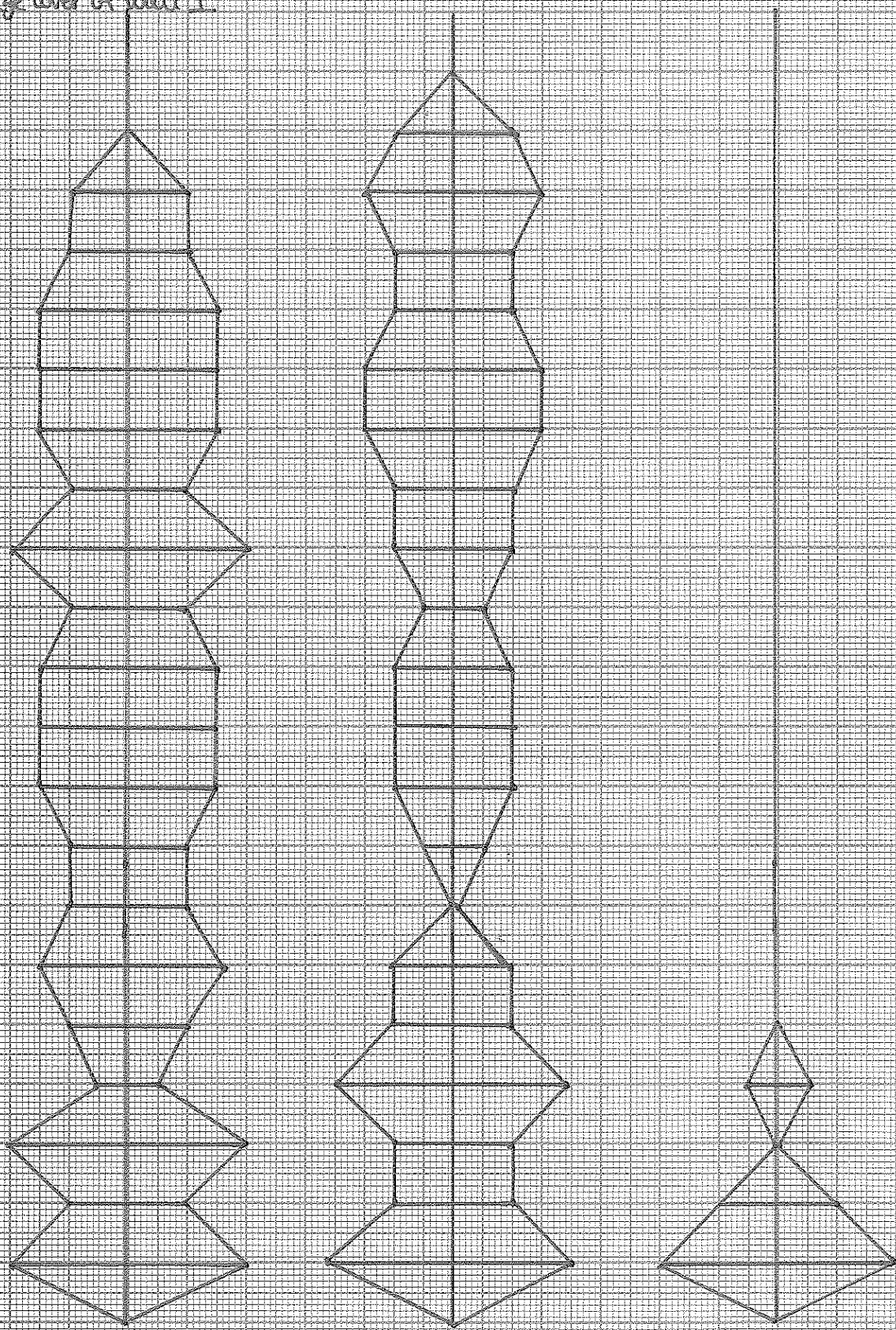
Wall Number: 1

Scale (Percentage cover):
0%, 25%, 50%, 75%, 100%
% Cover

Tile no.	Left		Middle		Right
1	0		0		0
2	0		0		0
3	0		50		0
4	50		75		0
5	50		50		0
6	75		50		0
7	75		75		0
8	75		75		0
9	50		50		0
10	100		50		0
11	50		25		0
12	75		50		0
13	75		50		0
14	75		50		0
15	50		25		0
16	50		0		0
17	75		50		0
18	50		50		0
19	25		100		25
20	100		50		0
21	50		50		50
22	100		100		100
Mean cover	56.818182		48.863636		7.9545455

Kite Diagram to Illustrate Percentage Cover of Wall 1

Wall n° 1



100 75 50 25 0 25 50 75 100

Percentage cover (%)

Wall Number: 2

Scale (Percentage cover):

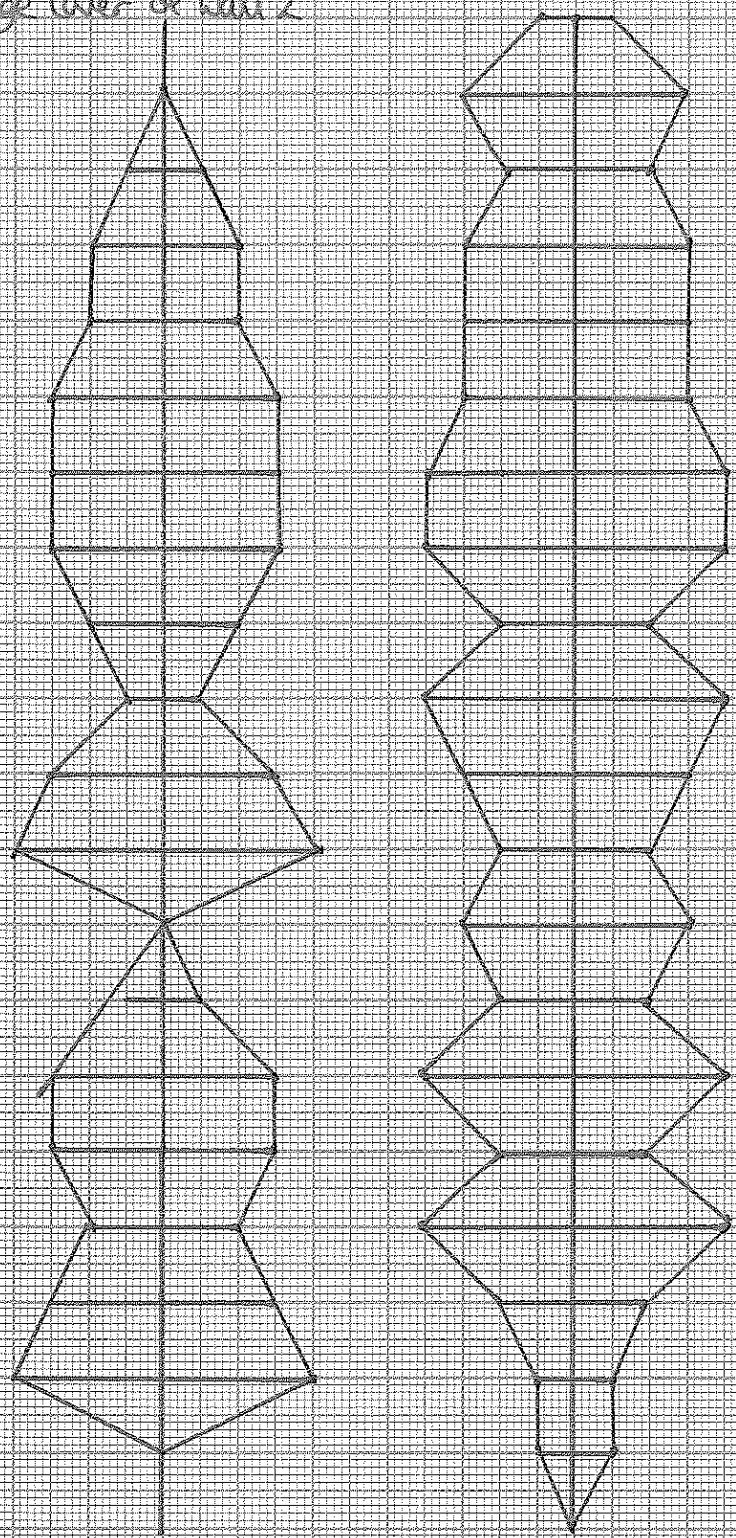
0%, 25%, 50%, 75%, 100%

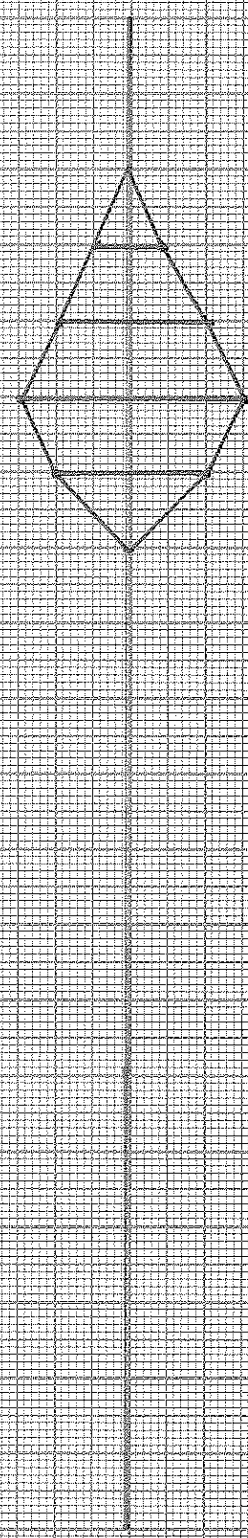
% Cover

Tile no.	Left		Middle		Right
1	0		25		0
2	0		75		0
3	25		50		0
4	50		75		25
5	50		75		50
6	75		75		75
7	75		100		50
8	75		100		0
9	50		50		0
10	25		100		0
11	75		75		0
12	100		50		0
13	0		75		0
14	25		50		0
15	75		100		0
16	75		50		0
17	50		100		0
18	75		50		0
19	100		25		0
20	0		25		0
Mean cover	50		66.25		10

Kite Diagram to Illustrate Percentage Cover of Wall 2

Wall n° 2





100 75 50 25 0 25 50 75 100

Percentage cover %

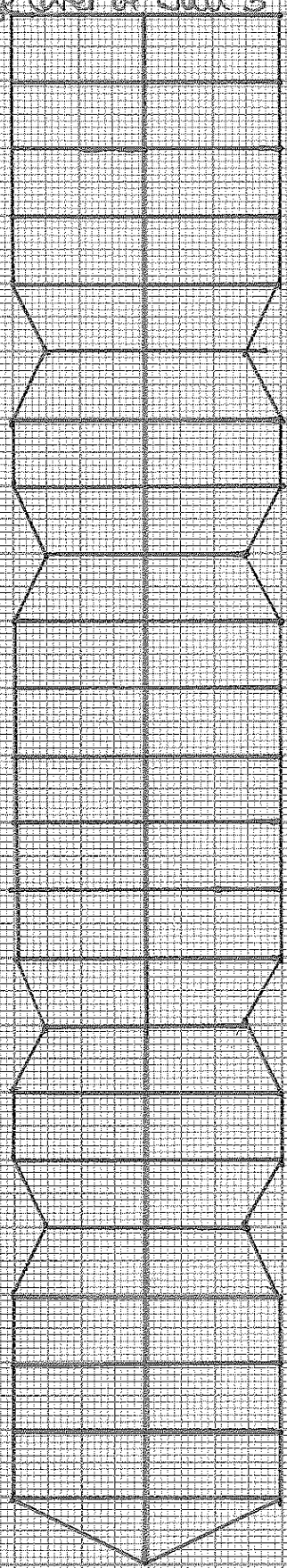
Wall Number: 3

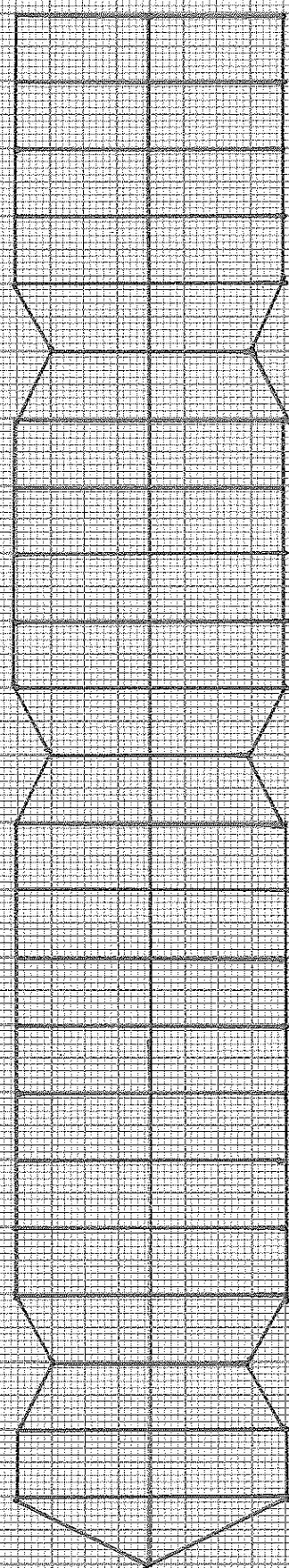
Scale (Percentage cover):
0%, 25%, 50%, 75%, 100%
% Cover

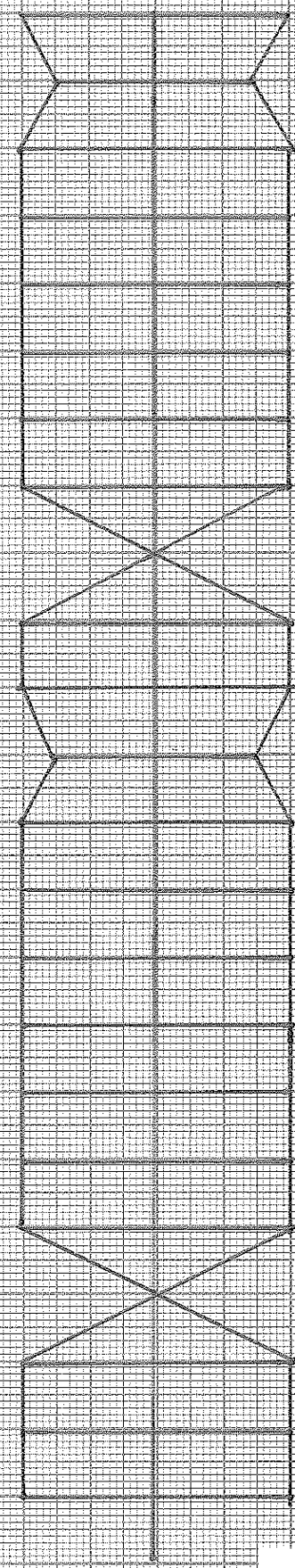
Tile no.	Left		Middle		Right
1	100		100		100
2	100		100		75
3	100		100		100
4	100		100		100
5	100		100		100
6	75		75		100
7	100		100		100
8	100		100		100
9	75		100		0
10	100		100		100
11	100		100		100
12	100		75		75
13	100		100		100
14	100		100		100
15	100		100		100
16	75		100		100
17	100		100		100
18	100		100		100
19	75		100		100
20	100		100		0
21	100		75		100
22	100		100		100
23	100		100		100
Mean cover	95.652174		96.73913		89.130435

Kite Diagram to Illustrate Percentage Cover of Wall 3

Wall n° 3







100 ⅞ ¾ ⅝ ½ ⅜ ¼ ⅛ 100

Percentage cover %

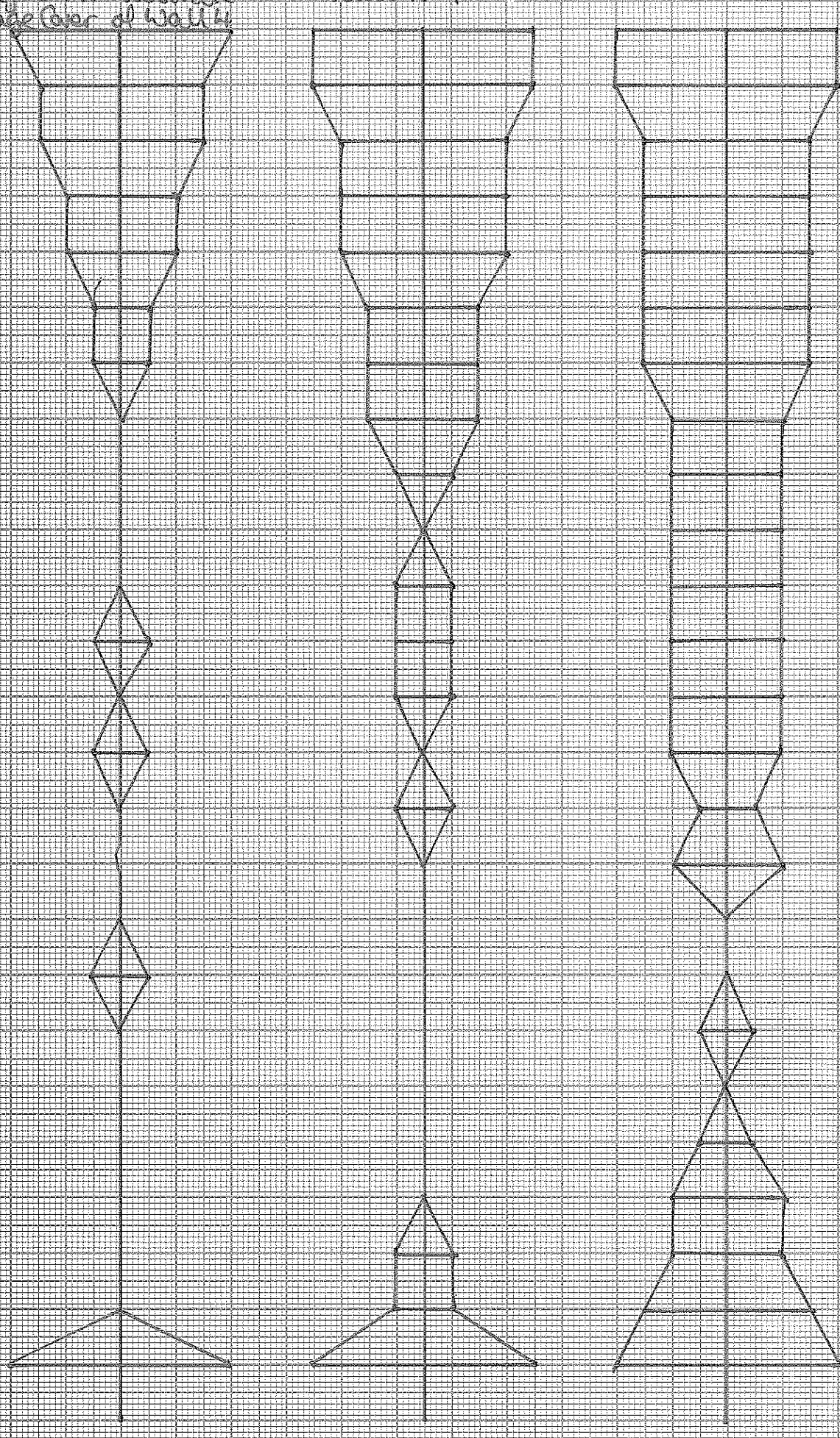
Wall Number: 4

Scale (Percentage cover):
0%, 25%, 50%, 75%, 100%
% Cover

Tile no.	Left		Middle		Right
1	100		100		100
2	75		100		100
3	75		75		75
4	50		75		75
5	50		75		75
6	25		50		75
7	25		50		75
8	0		50		50
9	0		25		50
10	0		0		50
11	0		25		50
12	25		25		50
13	0		25		50
14	25		0		50
15	0		25		25
16	0		0		50
17	0		0		0
18	25		0		0
19	0		0		25
20	0		0		0
21	0		0		25
22	0		0		50
23	0		25		50
24	0		25		75
25	100		100		100
26	100		100		100
Mean cover	25.961538		36.538462		54.807692

Kite Diagram to Illustrate Percentage Cover of Wall 4

Wall n° 4



100 75 50 25 0 25 50 75 100

Percentage cover (%)

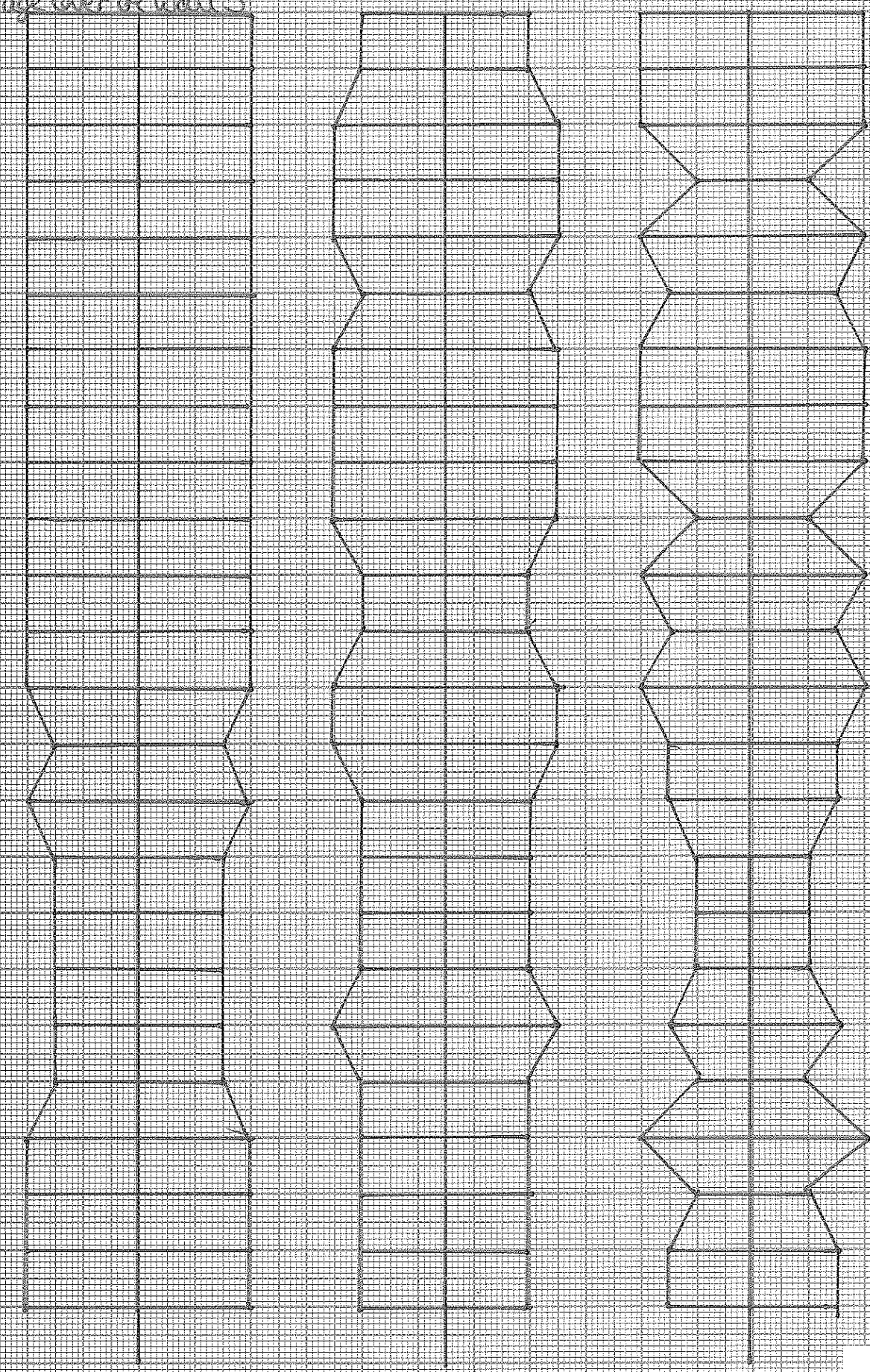
Wall Number: 5

Scale (Percentage cover):
0%, 25%, 50%, 75%, 100%
% Cover

Tile no.	Left		Middle		Right
1	100		75		100
2	100		75		100
3	100		100		100
4	100		100		50
5	100		100		100
6	100		75		75
7	100		100		100
8	100		100		100
9	100		100		100
10	100		100		50
11	100		75		100
12	100		75		75
13	75		100		100
14	100		100		75
15	75		75		75
16	75		75		50
17	75		75		50
18	75		75		50
19	75		100		75
20	100		75		50
21	100		75		100
22	100		75		50
23	100		75		75
24	100		75		75
Mean cover	93.75		85.416667		78.125

Kite Diagram to Illustrate Percentage Cover of Walls

Wall n° 5



100 75 50 25 0 25 50 75 100

Percentage Cover (%)

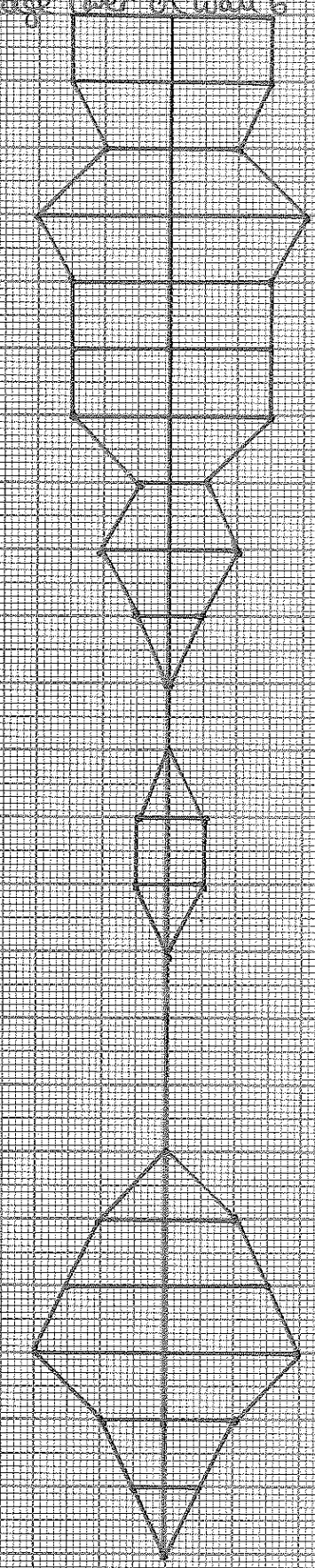
Wall Number: 6

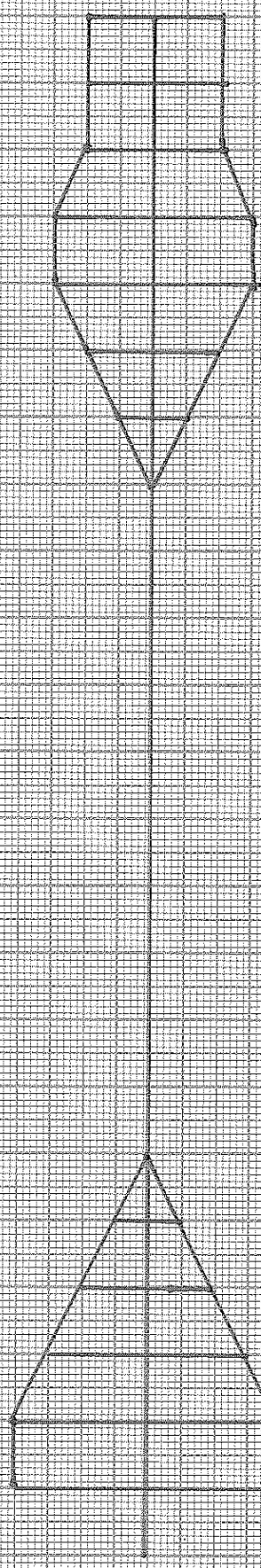
Scale (Percentage cover):
0%, 25%, 50%, 75%, 100%
% Cover

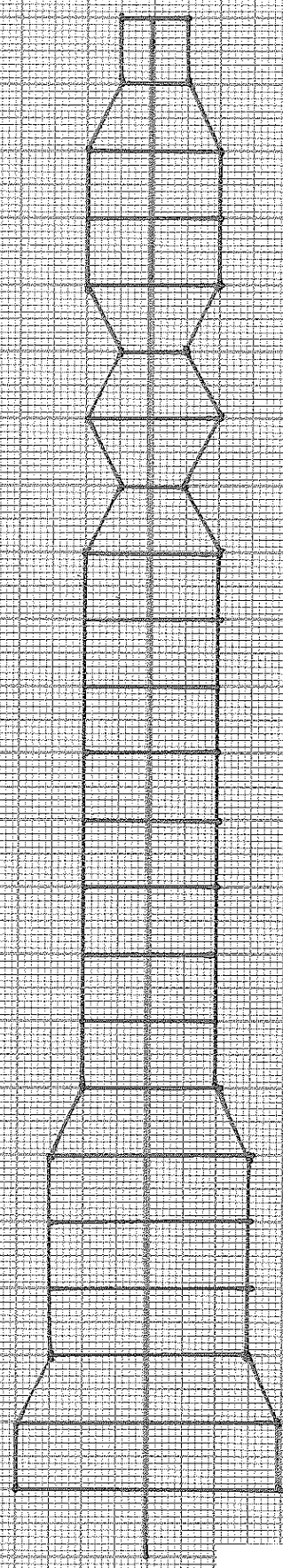
Tile no.	Left		Middle		Right
1	75		50		25
2	75		50		25
3	50		50		50
4	100		75		50
5	75		75		50
6	75		50		25
7	75		25		50
8	25		0		25
9	50		0		50
10	25		0		50
11	0		0		50
12	0		0		50
13	25		0		50
14	25		0		50
15	0		0		50
16	0		0		50
17	0		0		50
18	0		0		75
19	50		25		75
20	75		50		75
21	100		75		75
22	50		100		100
23	25		100		100
Mean cover	42.391304		31.521739		54.347826

Kite Diagram to Illustrate Percentage Cover of Wall 6

Wall n° 6







100 75 50 25 0 25 50 75 100

Percentage Cover (%)

Wall Number: 7

Scale (Percentage cover):

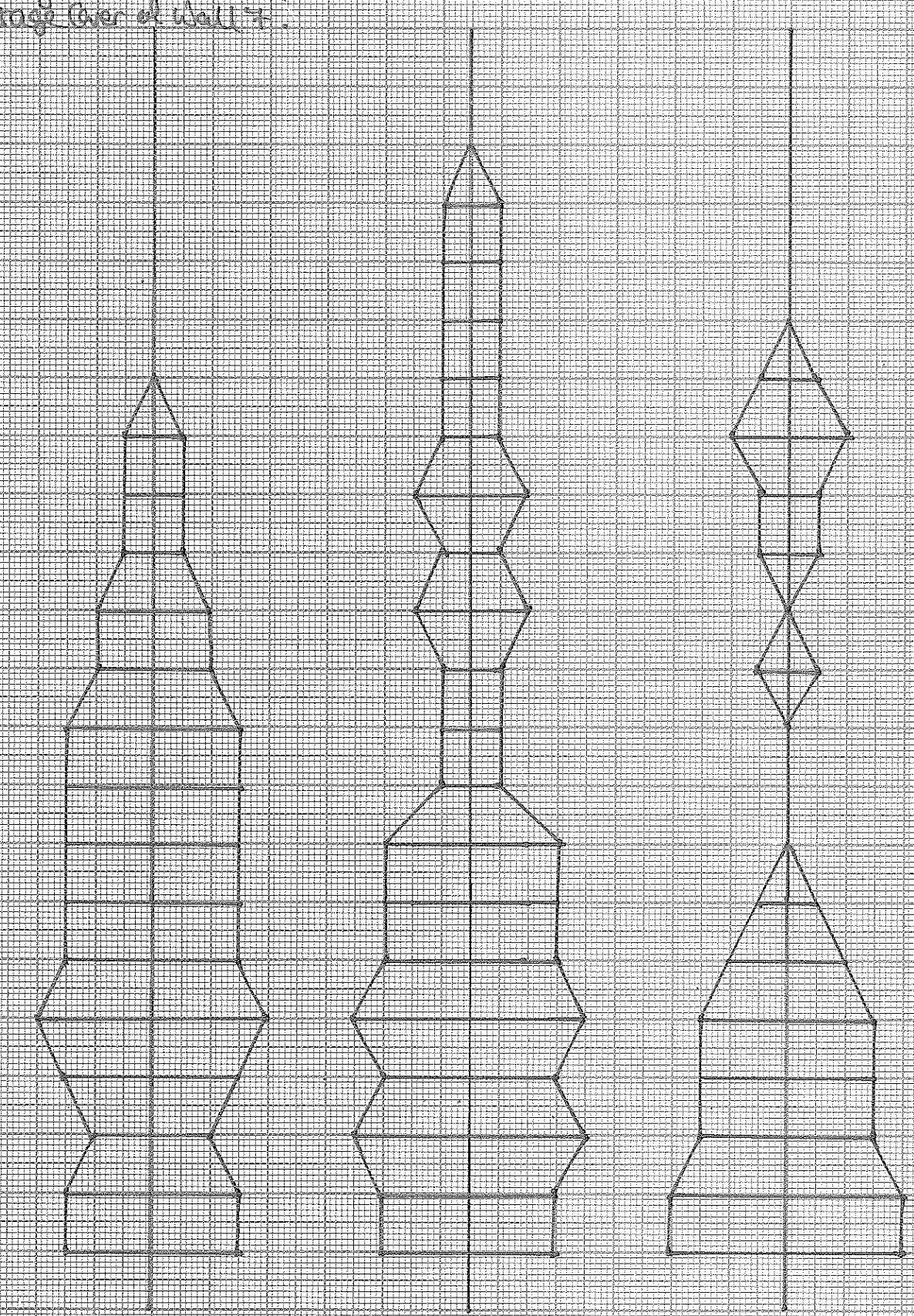
0%, 25%, 50%, 75%, 100%

% Cover

Tile no.	Left		Middle		Right
1	0		0		0
2	0		0		0
3	0		0		0
4	0		25		0
5	0		25		0
6	0		25		0
7	0		25		0
8	25		25		25
9	25		50		50
10	25		25		25
11	50		50		25
12	50		25		0
13	75		25		25
14	75		25		0
15	75		75		0
16	75		75		0
17	75		75		25
18	100		100		50
19	75		75		75
20	50		100		75
21	75		75		100
22	75		75		100
Mean cover	42.045455		44.318182		26.136364

The Diagram to illustrate Percentage Cover of Wall 7.

Wall n° 7.



100 75 50 25 0 25 50 75 100

Percentage Cover (%)

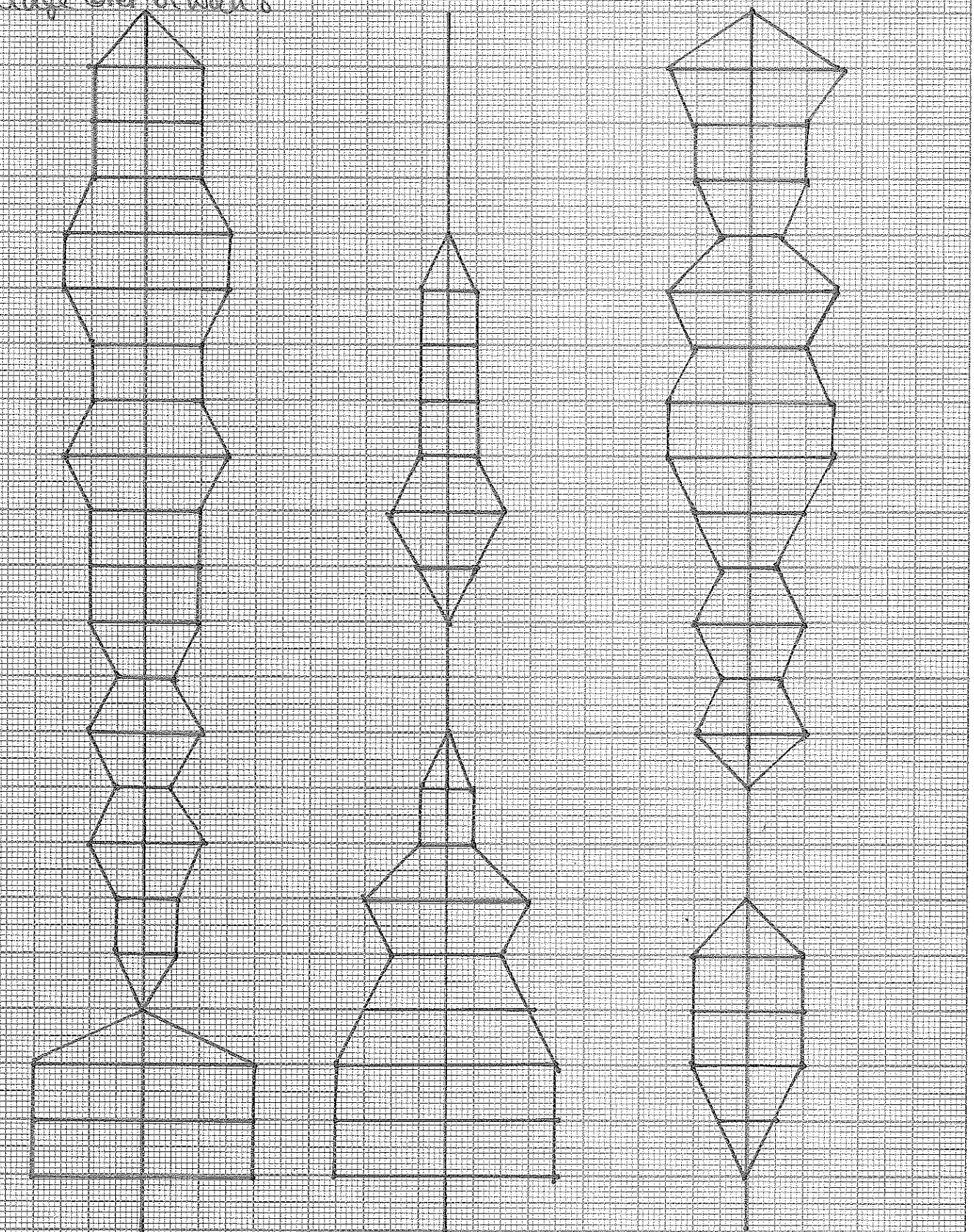
Wall Number: 8

Scale (Percentage cover):
0%, 25%, 50%, 75%, 100%
% Cover

Tile no.	Left		Middle		Right
1	0		0		0
2	50		0		75
3	50		0		50
4	50		0		50
5	75		0		25
6	75		25		75
7	50		25		50
8	50		25		75
9	75		25		75
10	50		50		50
11	50		25		25
12	50		0		50
13	25		0		25
14	50		0		50
15	25		25		0
16	50		25		0
17	25		75		0
18	25		50		50
19	0		75		50
20	100		100		50
21	100		100		25
22	100		100		0
Mean cover	51.136364		32.954545		38.636364

Kite Diagram to Illustrate percentage cover of Wall 8

Wall no 8.



100 75 50 25 0 25 50 75 100

Percentage Cover (%)

Data Analysis:

Side A.

I observed this side of the building to have no Pleurococcus seen to be growing on it at all apart from the section labelled wall 8, which was a special case that I will cover later.

Wall 1.

It is evident from my kite diagram that wall one had much larger quantities growing on it on the left side than the right. From the table, numerically one can seethe extent of this difference. For the top16 tiles observed on the right hand column, I recorded no algae at all.

Wall 2.

Wall number 2 also noticeably has a much higher average percentage cover of Pleurococcus on the left hand side (50% average) and in the middle (66% average) compared to the small amount of Pleurococcus found on the right hand side (10% average). The bottom 13 tiles on the right hand column had no algae appearing on them.

Wall 3.

Wall number 3, was seen to have large amounts of Pleurococcus growing all across it (the average percentages for the three sections had a range of only 6%, with an overall average of 94% cover). This wall clearly exhibits the types of growing conditions suitable for Pleurococcus to grow in.

Wall 4.

This wall has an unusual growth pattern featured on it. There is a diagonal line going from top left to bottom right, below which there is considerably less Pleurococcus growing than above it. This is a clear and unusual pattern, which is

well illustrated by my kite diagram. The tiles at the very top and the very bottom of this wall are all 100% covered with the algae the general pattern further down the column is that the percentage decreases before increasing again at the base of the wall.

Wall 5.

This wall is similar to wall three in that it has an overall large amount of Pleurococcus covering it from left to right, top to bottom, particularly on the left hand side where the average percentage cover is 94%. The top left-hand side of this wall has an especially high density of Pleurococcus.

Wall 6.

The Pleurococcus distribution on this wall is sparse and irregular, the central region shows very little growth, whilst the left hand side, although patchy in the middle, shows areas of hospitable growing areas. The right hand side of this wall shows considerably more consistent growth all the way down it, giving the overall picture of uneven and irregular circumstances surrounding the wall.

Wall 7.

This wall shows very little Pleurococcus in its higher parts, yet has high percentage covers all across the bottom sections of it. There seems to be no trend across the wall (i.e. increase or decrease moving from left to right) and this pattern has not yet been featured on the building.

Wall 8.

This wall had an unusual appearance, the groups of tiles were patchy and irregular, overall the wall was less than half covered, the tiles appearing a greenish

white colour, as yet unseen and very different from the other Pleurococcus observed.

Evaluation:

Side A.

Wall A clearly had no Pleurococcus present growing upon it, apart from one small section, which had special circumstances surrounding it. There is a large exposure to sunlight and, in the areas where there is no vegetation, no Pleurococcus is found. Small patches can be seen behind low plants or shrubs.

Wall 1.

From the kite diagram of Wall 1, it is evident that the Pleurococcus distribution is uneven across the wall. By looking at the bird's eye view of the building in the appendix one can see that there is a large tree near wall 1, which obstructs the line of sunlight, creating a shadow across the left side of the wall. The tiles in the shadowed section of the wall are able to photosynthesise as they retain moisture, because they stay cool and therefore don't dry out, whereas the tiles exposed to large amounts of sunlight on the right hand side of the wall react in the same way as those on wall A, i.e. The conditions are too hostile for any Pleurococcus to grow. The shade brought about by the tree causes the tiles to retain moisture because they are kept cool, whereas the sun can hit the wall on the right hand side and cause the tiles to heat up and then dry out, the lack of water means that considerably less Pleurococcus can grow here. It is noticeable; however, that at the bottom of the wall the percentage cover is 100% because they keep moisture as a result of being near the soil and vegetation on the ground. The air surrounding the tiles is made more humid by the ground and creates a good atmosphere for the Pleurococcus to grow in. The very lowest tiles can actually be kept moist by contact with the soil.

Wall 2.

Wall number 2 noticeably has a much higher average percentage cover on the left hand side (50% average) and in the middle (66% average) compared to the small amount of Pleurococcus found on the right hand side (10% average). I decided that due to vegetation combined with the angle of the sun, the different regions of the wall must receive varying amounts of sunlight exposure and are at different proximities to the vegetation. In the areas where sun reaches the wall through spaces in the vegetation, the tiles tend to be kept dry and the Pleurococcus is not provided with the moisture it needs in order to grow there. However, where the vegetation nearby blocks the direct sunlight from reaching the tiles, the tiles are cooler which causes them to remain damp enough for the Pleurococcus. The bottom tiles of this wall are higher from the ground than those in wall 1 and therefore do not receive moisture from the soil, which could allow for growth.

Wall 3.

Wall number 3, was seen to have large amounts of Pleurococcus growing all across it (the average percentages for the three sections had a range of only 6%, with an overall average of 94% cover) this wall, along with wall 4, is in close proximity to tall and dense vegetation. The vegetation offers a shield from direct sunlight for most of the day, allowing for shade during much of the hours of sunlight. The thick and tall vegetation shades the whole wall, keeping the area moist and the tiles damp enough for the Pleurococcus cells to thrive and grow to their maximum capability. This wall is south facing and one would expect that it would be hot and dry as a result of receiving so much sunlight, however there is more algae present here than on the north facing wall 1 because it is so shaded and moist due to the dense vegetation. This proves that Pleurococcus growth is dependent on conditions rather than solely the direction it faces because the sunlight is obscured by the trees.

Wall 4.

This wall has an unusual growth pattern featured on it. There is a diagonal line going from top left to bottom right, below which there is considerably less Pleurococcus growing than above it. The uneven structure of the nearby vegetation is what I believe to be the cause of this observable fact; the shape of the vegetation means that there is shade provided over the areas where Pleurococcus is growing however the area in question, underneath the line, is mainly in sunlight and is kept very dry. There appeared to be patches of the algae growing with tiles showing approximately 25% cover where the moisture was protected by protruding vegetation and branches. The mean percentage covers for my three observed strips increased from 26.0%, to 36.5%, to 54.8% from left to right, showing further evidence for this. As seen in wall 1, the Pleurococcus grows very well at the bottom of this wall as the tiles receive moisture from the ground immediately below them.

Wall 5.

This second south facing wall is in the direction which would be exposed to the most sunlight, if sunlight was a most needed factor, one would assume that this wall would be likely to have very little Pleurococcus seen growing on it, however this area is surrounded by vegetation and consequently, shade. This means that the large percentage cover of Pleurococcus (average of 85.8 %) would be caused by the **lack** of sunlight reaching the tiles. The tiles are kept from overheating and therefore retain the moisture which is much needed by the Pleurococcus, this results in the wall having such large amounts of the algae growing all across it.

Wall 6.

This wall, although near to vegetation, receives less cover from the trees than in the previous examples of walls 3 and 5, which face the same direction as

number 6. The vegetation is lower, sparser, and further away, resulting in much less Pleurococcus growth here. The sunlight is able to reach wall 6 more readily through spaces and the distance between the wall and the vegetation means that there is much less moisture kept in these tiles than is hospitable for Pleurococcus. The line of vegetation thins considerably around the middle point of this wall, resulting in a large dry patch where there is no Pleurococcus, as can be seen on kite diagram number 6.

Wall 7.

This wall is not directly north facing, in fact, towards the end of the day it receives a lot of sunlight from the north-western direction. This large quantity of sunlight means that the wall is dry and unreceptive towards the Pleurococcus, and in sunlight reaching areas, like the tops of the walls, there is no growth. However, there are creepers growing up across most of the width of the wall, behind which a moist environment is provided for the Pleurococcus to grow comfortably. Also, at the bottom of these columns there are flower beds to supply more moisture for the bottom tiles to host large percentage covers of algae.

Wall 8.

Across the entire building, Pleurococcus appeared in slightly different shades and densities but I chose to treat this wall as a special case due to the fact that this section demonstrated thin Pleurococcus of a grey green shade, noticeably different in appearance.

The Pleurococcus looked like it was faded, which suggests that it had grown and then died. I examined the wall in the winter, when a large nearby tree had no leaves on it. However, in full foliage, the tree would block sunlight from reaching the wall, and the air surrounding the tiles would be more humid due to the added vegetation. The Pleurococcus would be able to grow in these moist conditions, but when the sunlight is allowed through, after the leaves have been

shed from the tree, the Pleurococcus would no longer be able to maintain life after losing water.

Conclusion:

From evaluating my collected data and closely observing the area surrounding the L-Block building I can conclude that moisture is the most important factor affecting Pleurococcus growth and distribution. By studying the moist conditions which I found in this investigation, whether there be light or shade present, I found that Pleurococcus would be likely to grow there. I believe that light, although not the deciding factor, is very important in achieving ideal conditions for Pleurococcus growth. In moist shaded areas, the temperature would be kept low enough for the algae to retain its moisture, so the growth there would be higher than in moist sunlit areas where algae would grow but not as much because of the heat provided by the direct sunlight. The sunlight had a drying effect by raising the temperature and reducing the humidity of those areas. I found that in regions where the walls faced south where much sunlight would be received, shade provided by the vegetation would give enough moisture for the Pleurococcus to grow as in the case of wall 6. The fact that north and south facing walls can have the same growth depending on the conditions surrounding them is also evidence for sunlight not being a determining factor in the growth of this algae. Using wall 7 as an example, one can see that this wall receives a lot of light and yet the amount of Pleurococcus observed increases as you go down the wall as the moisture increases, this strong moisture/growth relationship is also illustrated in walls 1, 4 and 8. Although the light intensity cannot determine the amount of Pleurococcus which can be found, it can have an effect on the amount of moisture available on the tiles, which in turn will determine the Pleurococcus presence i.e. strong light can lead to warmth which can result in dryness causing no Pleurococcus. This is one aspect of my investigation that I would like to have

been able to extend by taking light readings in different areas and also weighing the tiles in order to see how much moisture is retained.

Uncertainties:

From the data that I was able to collect for my investigation it strongly indicated the above conclusion, however, I cannot be certain that I am right. I said many times that vegetation increased the humidity of areas surrounding the tiles, but without measuring the humidity I cannot be sure that some areas of the walls were more humid than others. I did not measure the light intensity at any point in my investigation, yet assumed that in shaded areas it would be lower than exposed regions of the building. When I measured the percentage cover of the tiles I used my own approximation system, it would probably have been more accurate if I had measured the cover with a grid of squares, a ruler, or even removed the algae and weighed it. If I were to have weighed it I would have known more precisely how much Pleurococcus was growing on each tile because in some places the algae grew in thicker patches than in others.

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