SKILL P : Planning and Experimental Procedures	MARK:
NAME: Andy Robertson	Centre Number

INVESTIGATION: An Experiment Study to Test the effects of changes in light intensity on the rate of photosynthesis of small leaf disks cut from Hibiscus plants. And how a change in the rate can be seen.

Research question and how this will determine the investigation.

My research question for this experiment is "The rate of photosynthesis will decrease with a decrease of light intensity". This gives me one thing to vary (a cause) and one thing to measure (an effect). In this case the light intensity is the cause and the rate of photosynthesis is the effect.

Pla
i)

What variables may have an effect on the quantity being measured? Give reasons.

Type Of Variable	Name Of Variable	How The Variable is Made To Act Like It Should
Manipulated Variable	Light Intensity	I varied the light intensity by using a lamp with a 75W bulb in it and when the light intensity needed to be decreased the lamp was moved further away. If the light intensity was needed to be increased the lamp was moved closer to the sample.

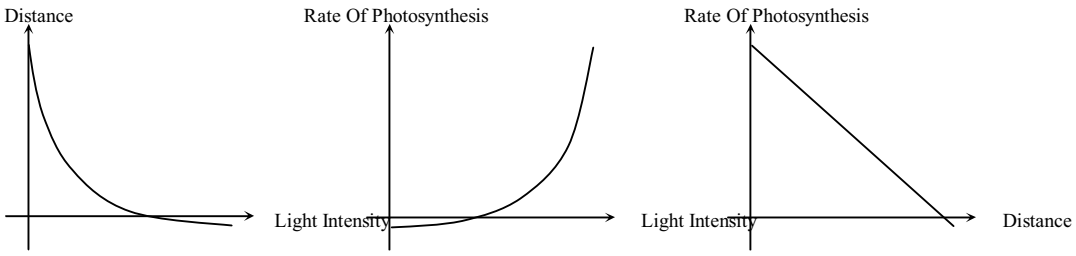
Pla
iii)

Responding Variable	Rate of Photosynthesis (Amount of time for leaf disks to generate enough gas to float)	My responding variable was measured by the amount of time it took the leaf disks to produce enough gas contained inside the disk before it had a sufficient amount of gas to make the disk float. This was done by forcing photosynthesis to occur. More than 1 leaf disk was used (6 in fact) at any one light intensity. Therefore there were 6 results immediately taken from one test and the times at which they rose were recorded to the nearest 1 second.	
Fixed (Controlled) Variables	Temperature	The temperature was incredibly hard to try and control because the light intensity has a direct effect on the temperature and therefore when the light intensity was increased the temperature would increase too. To control this variable the only sufficient solution was to keep the temperature monitored at all times and to ensure that, even when the light intensity decreased, the temperature would still rise at the same rate as it did at the higher light intensity. Therefore this is what I tried to do by keeping a lamp, pointing in the opposite direction of the samples, then moving the back of the lamp, which was still sufficiently hot/warm, closer and nearer to the samples to control the rate in which the temperature rose at.	
	Amount Of Sodium Bicarbonate solution	During the entire of each light intensity test I used the same amount of Sodium Hydrogen Carbonate solution ($NaHCO_3$) (8ml). I used this amount for all areas of the method; creating the gas release from the disks in the syringe, the measurement of the rate of photosynthesis.	
	Method Of Measuring The Rate Of Photosynthesis	I measured the rate of photosynthesis by recording the amount of time it took the disks to float to the surface. This meant that the amount of gas inside the disks itself was sufficient to create enough upthrust so that the leaf could hold up its own weight. I used this method each time I measured the experiments results.	
	Wattage Of Bulb	I kept the wattage of the bulb in my lamp constant. The bulb was not even touch, it was just noted that it was a 75W bulb. Changing the wattage of the bulb would have altered the light intensity to a different degree and it may have also had an effect on temperature.	

Hypothesis

I believe that if I vary the light intensity in which a leaf disk is made to photosynthesise under the rate of photosynthesis will increase indirectly proportionally to the distance at which the lamp is moved away from the sample. However the distance is Inversely Proportional to the Light Intensity, therefore so will the rate of photosynthesis. For instance:

Pla iii)



However these predicted graphs are not entirely true, they are assuming there is an infinite supply of all limiting factors present, and the only factor limiting the rise of the rate of photosynthesis is the light intensity. This means that in actual fact, in real circumstances, when putting this experiment into practice all limiting factors must be eradicated to make the experiment a 'fair test'.

Pla ii)

I would expect these results to occur because of the observations I have made when plants are exposed to high intensities of natural sunlight. In this case the lamp is providing an artificial source of this sunlight. In really high intensities of sunlight the plant however does not follow the normal path of photosynthesis. The plant goes through what is known as the 'Z-Scheme'. This means no gas is used for photosynthesis (only respiration) and so the rate of photosynthesis may be extremely high but the test I am performing would not measure this rate of photosynthesis. A way round this would be to test the amount of ATP present in the leaf disks' themselves. Therefore I believe that if I raised the Light Intensity over a certain value (100W at the same distances I am using for 75W), I believe there would be an increase in the amount of time it took for the disks to rise to the top of the $NaHCO_3$.

In conclusion, I believe that the light intensity change (measured from 5cm to 20cm distance away from samples) will have a direct effect on the rate of photosynthesis (measured by the time it takes the leaf disks to rise to the surface of the $NaHCO_3$). This will be seen after a directly proportional time change in relation to the distance at which the light source (lamp) is from the samples of leaves (disks cut from hibiscus plants). However the time will not increase at a proportional rate indefinitely unless all limiting factors are present and unlimited.

Write a method to say how I am going to do this investigation. State clearly what I will do, what I will measure and how I am going to control it. How will I make sure it is a 'fair test', 'Quantitative' and 'Qualitative'? Include a list of apparatus.

For this experiment I will need to use the following apparatus:

- Stopwatch
- Tweezers
- Hole Punch
- Bench Lamp (with 75W Bulb)
- Thermometer
- 3 Hibiscus Leaves
- 10ml Syringe
- Small 20ml Beaker
- 100ml of Sodium Hydrogen Carbonate solution ($NaHCO_3$)

Plb i)

• White Tile When conducting my experiment I had to plan and follow a certain method. The method I used is shown below: 1) The apparatus is collected and set up as shown in diagram. 2) 6 leaf disks are put into syringe containing 8ml of $NaHCO_3$. 3) Release air gas out of the leaf disks by the following 'sub-steps': • Place thumb or finger over nose of the syringe. • Pull the plunger back to the furthest point possible. • Shake the syringe as violently as possible in order to release all the bubbles, contained within the solution, into the air bubble at the top of the syringe. • Depressurise the syringe by taking your finger/thumb off the nose of the syringe in order to take gasses out of the leaf disks. 4) If the disks sink immediately and do not float on the surface of the solution this part of the procedure is complete. However if any of the disks are floating repeat step 3 entirely until all the disks sink. 5) Then make sure there is still 8ml of $NaHCO_3$ in the syringe, if not add more $NaHCO_3$ until 8ml is reached. Then take the plunger out of the syringe and the solution and disks are poured into the small beaker. 6) The distance at which the lamp is away from the middle of the beaker is set, starting at 5cm away and moving the distance further later. The stopwatch is started and the experiment begins! 7) Steps 2 to 5 are repeated once however during step 6 the distance between the samples in the beaker and the light source is changed to a 5cm increase, per repeat, until 20cm is recorded. 8) All the distances are repeated a minimum of 6 times and all anomalies are repeated again until what is considered to be 'accurate' readings are acquired. 8) Before these results were taken a control was taken in a completely dark cupboard with absolutely no light exposure at all.	Plb ii)

SKILL DC: Data Collection	**MARK:**
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RESULTS (showing all measurements made)

The results I achieved are shown below:

Distance Of Lamp from centre of Beaker (cm)	**Time at which it took the Leaf Disk to float after immediately being put into a beaker of 8ml $NaHCO_3$ solution (Seconds)**						
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Average
0	DNR	DNR	DNR	DNR	DNR	DNR	-
5	326	327	331	331	332	335	330 $^1/_3$
10	617	618	619	619	621	624	619 $^2/_3$
15	RBT	RBT	RBT	RBT	RBT	RBT	-
20	RBT	RBT	RBT	RBT	RBT	RBT	-

DC i)

RBT – 'Restricted By Time'
DNR – 'Did Not Rise' (after 45 minutes in a completely dark cupboard the leaf disks still had not risen.

These results show that as the distance changes from 5ch to 10cm there is a change in the time at which it took the Leaf Disk to float after being put in 8ml of $NaHCO_3$ solution. The change that was made, taken from the averages, was 330 seconds at 5cm and 620 seconds at 10cm. The distances of 15cm and 20cm I would have like to have recorded but unfortunately there was a limiting factor, time! I did, however, manage to receive results from other classmates. However they did not have the same controlled factors as me, so I have to be careful when analysing their results against mine.

DC ii)

The results for a 100W bulb using 20ml of $NaHCO_3$ solution are shown below:

Distance Of Lamp from centre of Beaker (cm)	**Time at which it took the Leaf Disk to float after immediately being put into a beaker of 8ml $NaHCO_3$ solution (Seconds)**						
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Average
0	DNR	DNR	DNR	DNR	DNR	DNR	-
5	468	469	469	469	469	482	471
10	919	920	922	922	924	925	922
10	989	990	990	990	990	1000	991 ½
20	RBT	RBT	RBT	RBT	RBT	RBT	-

Here there are 2 different experiments under the same conditions where 10cm is the distance. The averages are relatively close so an average of these averages can be taken to produce an overall average of 956.75 seconds (957 to 3s.f.).

I also got some results from another classmate. Their conditions were that the bulb was 75W but the volume of $NaHCO_3$ solution was 80ml. Their results are indicated in the table below:

Distance Of Lamp from centre of Beaker (cm)	**Time at which it took the Leaf Disk to float after immediately being put into a beaker of 8ml $NaHCO_3$ solution (Seconds)**						
	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Average

0	DNR	DNR	DNR	DNR	DNR	DNR	-
5	RBT	RBT	RBT	RBT	RBT	RBT	-
10	RBT	RBT	RBT	RBT	RBT	RBT	-
15	RBT	RBT	RBT	RBT	RBT	RBT	-
20	557	557	559	559	560	562	559

This shows me that when the lamp is 20cm away from the beaker there is an average time of 559 seconds before the leaf disks generate enough gas contained within the disk to hold its own weight in $NaHCO_3$ solution.

SKILL DA: Data Analysis	**MARK:**
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PROCESSING of DATA (or plot graphs / charts), CONCLUSION AND EXPLANATION

I can plot some graphs for the results I have obtained. These graphs are shown beneath:

DA
i)

These graphs tell me that my prediction was fairly accurate. I predicted that the amount of time would increase proportionally in accordance to the distance that the lamp is moved from the middle of the beaker. The results I obtained from other classmates also agreed with my prediction. This stated that when there is a high light intensity the process of photosynthesis doesn't produce or use any gas and therefore more time would pass before the Carbon Dioxide produced from respiration would be sufficient to suspend the leaf at the surface of the $NaHCO_3$ solution. This is shown as a perfect example when my classmate's results show that with 80ml of $NaHCO_3$ solution there is more light resistance and therefore the light intensity is lower than if the exact same factors are applied using 8ml of the same $NaHCO_3$ solution. Therefore the disk goes through a very small part of the Z-Scheme that only uses the ETC and uses ADP and Inorganic Phosphorus to produce ATP and excited electrons to loop the process over and over again. However the important thing is that it does not use or produce any gas and would therefore have no effect on the rate at which the disk takes to float. Also the results I personally obtained agree with my prediction because there is less resistance for the light and therefore the light intensity would be greater, I predicted that there would be rise proportionally between the distances changed but I cannot confirm this part of my prediction as I do not have any where near enough results to measure that statement to any degree of accuracy. Concluding, I think my prediction was fairly accurate; I predicted that the distance would have a direct effect on the light intensity and therefore the rate of photosynthesis, measured by the amount of time that it took for the leaf disks to rise to the top of the $NaHCO_3$ solution in the beaker. Also my prediction was confirmed that it would take a longer time if there were less resistance, as the measured aspect was not actually measuring the rate of photosynthesis but actually the amount of gas exchanged inside the leaf disk.	DA ii)