Candidate 2 evidence

The effect of light intensity on photosynthesis in seaweed

Aim

I am going to investigate if changes in light intensity affect the rate of photosynthesis in knotted wrack seaweed. I will also investigate the pigments contained in knotted wrack.

Background environmental science

Seaweeds are classed as green algae, brown algae or red algae. This is because each type contains different pigments that absorb light, and link to light penetration in the ocean. Green algae are found mostly in shallow coastal water, red algae in deep water as far down as 40m, and brown algae are found in between.

All seaweeds contain chlorophyll *a*, a type of chlorophyll that is essential for photosynthesis. In addition to chlorophyll *a*, green algae also contain chlorophyll *b*. These allow green algae to absorb energy from wavelengths between 433 to 666 nm.[1] However, chlorophyll a and b are less efficient in water than on land because these light wavelengths are absorbed rapidly in water. This explains why green algae are mostly found in shallow water.

Brown and red algae have adapted to include other pigments that are more efficient in absorbing energy at other light wavelengths, allowing them to grow at greater depths than green algae. Red algae have a high concentration of phycobilin pigments that absorb light energy in the range of 550 to 630 nm.[2] Brown algae contain a high concentration of fucoxanthin, that absorbs light in the range of 390 to 580 nm.[3] These pigment differences explain why brown and red algae grow in deeper water than green algae.

Experimental procedure

This experiment uses knotted wrack (*Ascophyllum nodosum*), a type of brown algae found on sheltered intertidal rocky shores around Britain and Ireland. It ranges in colour from olive green to brown, depending on the amount of fucoxanthin pigments present.

Hydrogencarbonate indicator solution was placed in five small sample bottle, and small pieces of knotted wrack were placed into four of the bottles. Transmittance filters allowing varying light transmission into the samples were used as shown in the table.

Sample	Indicator	Seaweed	Transmittance filter
1	✓		
2	✓	✓	0%
3	✓	✓	25%
4	✓	✓	50%
5	✓	✓	100%

The bottles were placed under a fluorescent light and left for 30 minutes. A colorimeter was then used to measure light absorbance in each sample.

Data

Data 1:

Three of us worked together in a group. We each prepared our own samples and did the experiment separately using the same materials, equipment and method, and then shared our data.

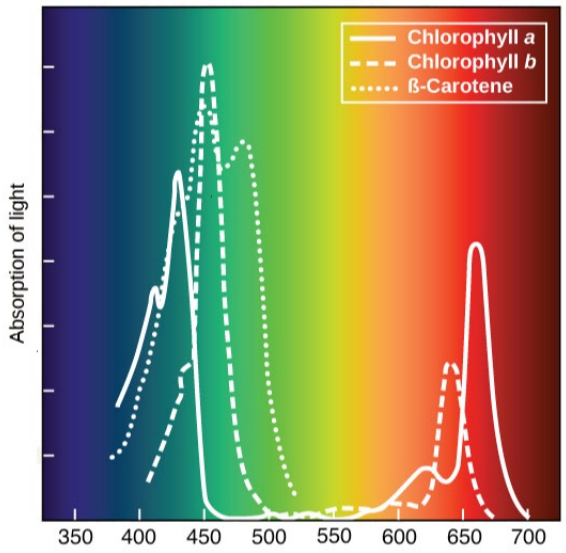
Sample	Light intensity (%)	Light absorbance			
		Test 1	Test 2	Test 3	Mean
1	indicator	0.41	0.41	0.41	0.41
2	0	0.69	0.68	0.71	0.69
3	25	0.75	0.79	0.74	0.76
4	50	0.84	0.96	0.90	0.90
5	100	1.08	1.48	1.32	1.29

The light absorbance value for the indicator (sample 1) was subtracted from the mean values, giving the true absorbance values shown below.

Light intensity (%)	Mean light absorbance
0	0.28
25	0.35
50	0.49
100	0.88

Data 2:

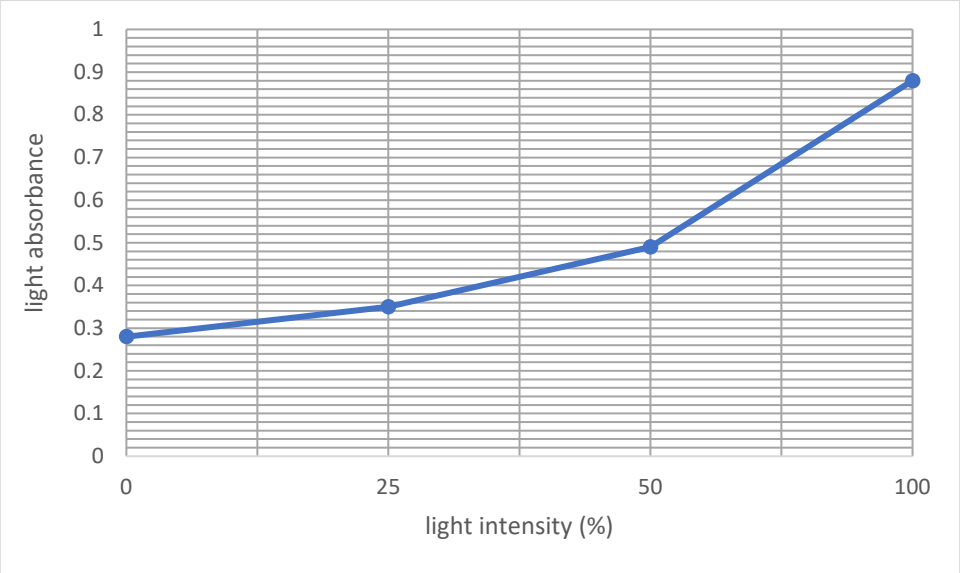
The graph shows the absorption spectra of different types of pigments present in photosynthesising organisms. These pigments absorb only specific wavelengths and reflect others.



Absorption spectra of pigments [4]

Graphical presentation

I plotted the mean light absorbance data from the experiment.



Analysis

In the experiment, the hydrogencarbonate indicator supplied carbon dioxide and the fluorescent tube represented the sun. This allowed the knotted wrack to photosynthesise, using up the carbon dioxide. The transmittance filters controlled the rate of photosynthesis by limiting the amount of light reaching the knotted wrack. The indicator changed colour as photosynthesis increased in response to the light and the amount of carbon dioxide decreased. The colour changes in the samples were measured by the colorimeter.

Conclusion

The results show that light intensity does affect the rate of photosynthesis, with the highest mean light absorbance seen when no filter is in place and light transmission is 100%.

The colorimeter was set for 580 nm. This would have captured colour change due to the chlorophyll *a* and fucoxanthin in the knotted wrack absorbing light in the range of 375 to 700 nm, as shown in the absorption spectra graph.

Evaluation

The knotted wrack was collected several days before we used it. This could have affected the quality of the seaweed and its ability to photosynthesise efficiently.

Everyone in the group measured out 5g of knotted wrack, used the same volume of indicator solution, and left the bottles under the light for the same length of time. This will have improved the validity.

I was part of a team of three. We only had enough equipment to complete the experiment once each, but we all followed the same method, then shared results. This will have improved the reliability of our results.

References

1. ThermoFisher Scientific https://assets.thermofisher.com/TFS-Assets/MSD/Application-Notes/quantify-chlorophyll-a-and-chlorophyll-b-with-custom-method-T141.pdf [accessed July 2019]

2. LibreTexts https://chem.libretexts.org/Bookshelves/Biological_Chemistry/Supplemental_Modules_(Biological_Chemistry)/Photosynthesis/Photosynthesis_overview#:~:text=Visible%20light%20is%20the%20region%20of%20importance%20in,range%20is%20from%20350%20to%20800%20nm%20%28nanometers%29 [accessed July 2019]

3. Wikipedia https://en.wikipedia.org/wiki/Fucoxanthin [accessed July 2019]

4. Khan Academy https://www.khanacademy.org/science/biology/photosynthesis-in-plants/the-light-dependent-reactions-of-photosynthesis/a/light-and-photosynthetic-pigments [accessed July 2019]