John Wesley Powell Student Research Conference

2014, 25th Annual JWP Conference

Apr 12th, 2:00 PM - 3:00 PM

What Color are Purple Butterfly Wings: A Study of Optical Structures

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What Color Are Purple Butterfly Wings: A Study of Optical Structures

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Introduction

The purple color of Morpho butterfly wings is not due to pigment but from the structure of the wing, which reflects the light striking the wing in ways that causes constructive and deconstructive interference. This process creates an effect called iridescence, which can be an evolutionary advantage because it helps the butterflies evade predators (Douma, 2008). Understanding the structure of a butterfly wing can be used pedagogically to teach about the nature of light and to make observations about optical phenomena in the natural world.

Methodology

To study the structure of the wing, we measured the wavelengths and intensity of light reflecting from the butterfly wing at different angles, using the setup shown in *Figure 1*. We also looked at the butterfly wing underneath a Scanning Electron Microscope (SEM) to try to observe the scales and structures in the wing. We created a simple model of the wing to see if our measured results matched expected results, as can be seen in *Figure 3*.

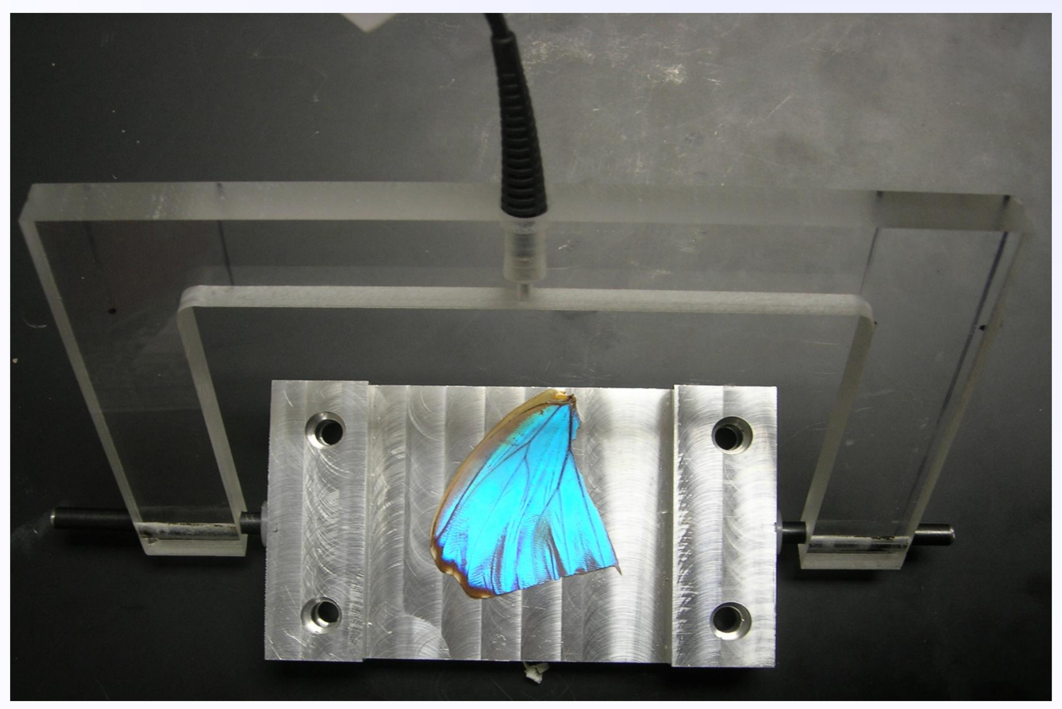

Figure 1: The butterfly wing is placed on the stage under the spectrometer.

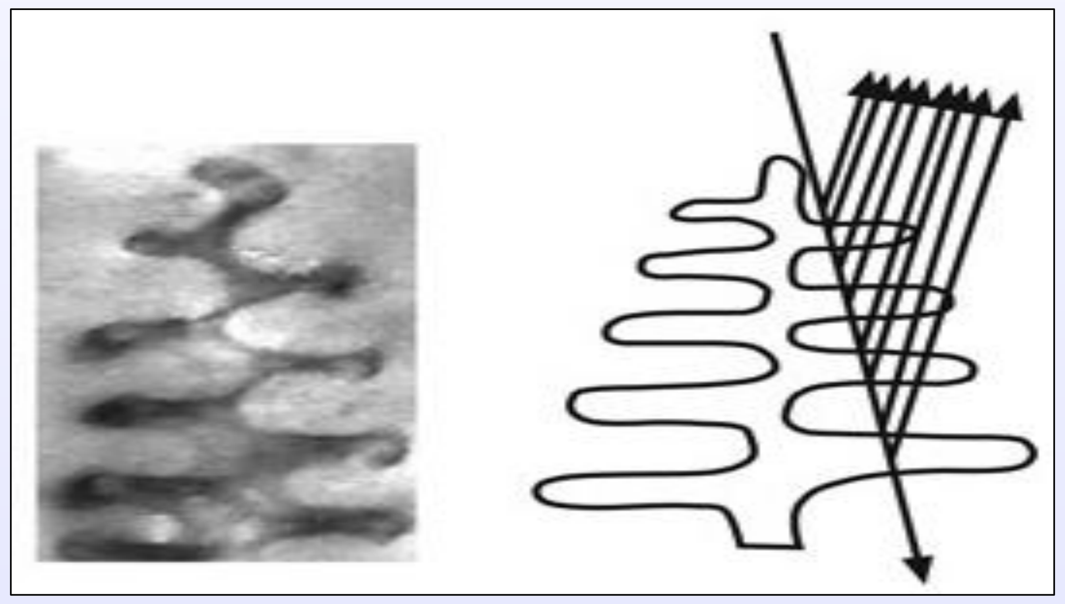

Figure 2: To left is a photo of the structure of a butterfly wing. To the right is a diagram showing how what happens when light strikes the wing (Exeter University, 2005).

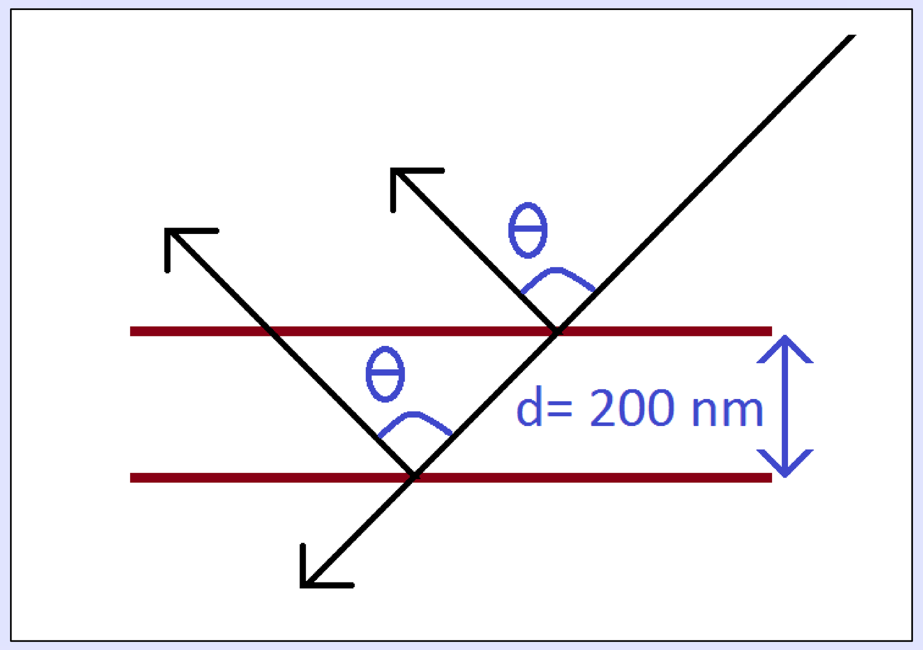

Figure 3: Above is a simplified model of the structure of the butterfly wing. In this model, light is only reflected at two angles from surfaces 200 nm apart.

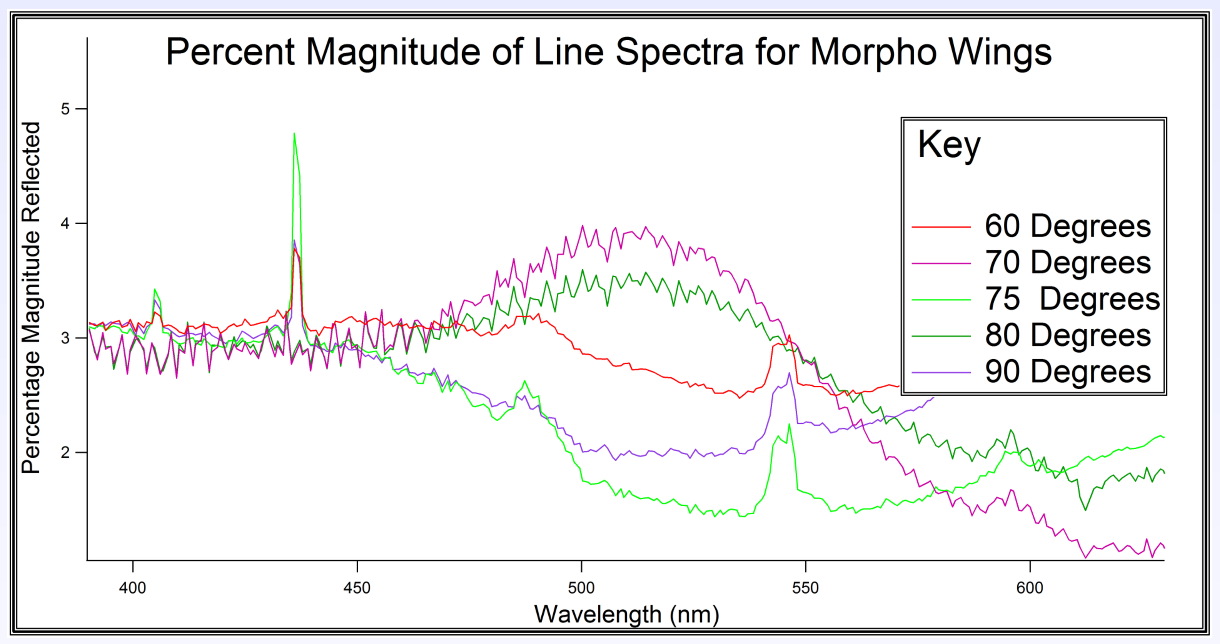

Figure 4: The above graph shows the wavelengths of light reflected at different angles. The intensity of blue light reflected changes depending on the angle of the wing, which is why the color of the wing changes.

Results

Graphs of the reflectance spectrum of the wing were obtained at various angles. *Figure 4* compares these spectrum at different angles. Analysis of this graph shows how the light is reflected with greatest intensely at 440 nm or 550 nm at most angles, which are blue and yellow-green colors. As the intensity of these colors changes, so does how much blue light we see, correlating with the iridescence we observe. The features of the graph also change as the angle changes, likely correlating to the changing transparency of the butterfly wing at different angles. When the wing is more transparent, more features from the back of the wing are seen.

Figure 3 shows a simple model of the effects of the wing, with only two surfaces and no curved surfaces. We used this model to calculate the wavelength of the light reflected at different angles and to calculate what the intensity of this light should be at those angles. In this model, there was only interference between two waves. The intensity of the light reflected by the model had a peak value of 500 nm. The differences between this data and our measured data likely result from how simple this model is when compared to the actual structure of the wing. In the future, we can create more complex models that better predict the reflectance of the wing.

References

Douma, M., curator. (2008). "Why are butterflies colored?". In Cause of Color. Retrieved from webexhibits.org/causesofcolor.

Exeter University (2005). *Interference in multilayers.* Diagram]. Retrieved from http://emps.exeter.ac.uk.