



Drexel-SDP GK-12 ACTIVITY

Subject Area(s): Life sciences

Associated Unit: None

Associated Lesson: None

Activity Title: Structural Color of Butterflies

Grade Level: 7 and 8 (7-9)

Activity Dependency: None

Time Required: 90 minutes

Group Size: 3-4 students

Expendable Cost per Group: US \$4

Summary

The students are given a basic introduction to the structural color of the Blue Morpho butterfly wing. They also are given an opportunity to use an optical microscopy and introduced to the idea of electron microscopy.

Engineering Connection

Structural color can be used in applications when the used of dyes and pigments cannot be used. This lesson shows how different types of microscopes can be used to show structural color, materials engineers use various microscopes to look at things that they can not see with the naked eye.

Keywords butterfly, structural color, Blue Morpho, microscope, scanning electron microscope, materials engineering, optics, refractive index

Educational Standards

- Science: 3.4.7, 3.1.10, 3.2.10, 3.4.10
- Math: none

Learning Objectives

After this lesson, students should be able to:

- Understand the basic concepts of structural color
- Use a basic microscope

Materials List

Each group needs:

- Microscopy
- Prepared butterfly slide (a section of Blue Morpho (*Morpho Menelaus* or *Morpho peleides* butterfly wing, a glass slide and a full sized cover slip)

To share with the entire class:

- Scanning electron microscopy images to be displayed on projector

Vocabulary / Definitions

Word	Definition
optical light microscope	is a type of microscope which uses light and lenses to magnify images of small samples
Refractive index	a medium is a measure for how much the speed of light (or other waves such as sound waves) is reduced inside the medium.

Procedure

Background

Many things in nature have structural color such as some butterfly wings, some beetles and some feathers. When some is structural color it does not use dyes, pigments or other things we usually associate with the brilliant colors we see in nature on things like the Blue Morpho butterflies.

Mason came up with a list of 7 criteria to determine if something is structurally colored.

Mason's 7 Criteria for Structural Color

1. Color shifts are observed with changes in pressure, distortion, swelling and shrinking of tissue.
2. Color disappears if void spacing in the tissue is filled with a liquid with the same refractive index as the tissue, leading to optical homogeneity.
3. Color is impervious to bleaching agents, and only responds to reagents that cause shrinking, swelling, or other physical changed in the tissue.
4. No chemical pigments (except brown or black pigments, in some cases) are extractable or detectable by chemical means.

5. All components of incident white light are accounted for in reflection, transmission and scattering.
6. Similar coloration can be duplicated using colorless substances, when arranged in a similar pattern.
7. Iridescence is usually observed in some form.

Before the Activity

- Place small sections of the Blue Morph wings between a glass or plastic slide and a cover slide (a full length cover slide works best).
- Place the slides on the microscope stages for the students and coarse focus on the samples, this will save time and frustration for the students. Have all the students start blue side up.

With the Students

1. Have the students look at pictures of a Blue Morpho (or better yet one preserved in glass or plastic), so that they can see that the butterfly is blue on one side and brown on the other.
2. Explain briefly that structural color exists in the Blue Morpho butterflies and briefly explain that structural color depends on how the atoms are arranged and not on dyes and pigments.
3. Have the students look at the blue scales under their microscope and draw what they see on their worksheets.
4. Display the electron microscopy images of the blue scales on the projector and have the students draw what they see.
5. Have the students look at the brown scales under their microscope and draw what they see on their worksheets.
6. Display the electron microscopy images of the blue scales on the projector and have the students draw what they see.
7. Have the students compare the blue and brown scales; you can talk about the differences as a class. You can also talk more in depth about Mason's criteria at this point.

Attachments

Presentation: Structural Color Activity Presentation

Safety Issues

- The glass slides could easily be broken and could be a safety issue, you could also use plastic slides and cover slides if you have those available to lesson the safety issue.

Troubleshooting Tips

There are no common issues with this activity.

Investigating Questions

- What is the difference between the blue and brown scales? Why do you think these features make the scales blue vs. brown?

Assessment

Pre-Activity Assessment

Class Discussion:

- Explain briefly that structural color exists in the Blue Morpho butterflies and briefly explain that structural color depends on how the atoms are arranged and not on dyes and pigments.
 - Color shifts are observed with changes in pressure, distortion, swelling and shrinking of tissue.
 - Color is impervious to bleaching agents, and only responds to reagents that cause shrinking, swelling, or other physical changes in the tissue.
 - Iridescence is usually observed in some form.

Activity Embedded Assessment

Presentation/Handout: Have the students fill out the handout and go through the presentation slides as explained above in the Procedure.

Post-Activity Assessment

Worksheet/Homework: This is a rather long activity, so the last 2 questions on the worksheet could be assigned as a homework assignment.

Activity Scaling

- For upper grades, can talk about the differences between optical and electron microscopes and the magnification differences. Can also look at beetles and feathers in addition to butterflies.

References

Mason, C.W., Structural colors of insects I, *The Journal of Physical Chemistry*. 1926
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Name _____

Date _____

Structural Color

What do the blue scales look like under the optical microscope? (Draw a picture)

What do the blue scales look like on the electron microscopy image? (Draw a picture)

What do the brown scales look like under the optical microscope? (Draw a picture)

What do the brown scales look like on the electron microscopy image? (Draw a picture)

What is different between the blue and brown scales in the optical microscope? (Use words and pictures)

What is different between the blue and brown scales in the electron microscopy images? (Use words and pictures)