Structure of Matter: Activity 2

Butterfly Wings

Winging It

We're Emily and Julie and we love butterflies! We like trying to catch them on our own, but to see as many different colored butterflies as possible, we went to the Magic Wings Butterfly House at the **Museum of Life and Science** in Durham, North Carolina.

Our question:

Why do some butterflies change color when you look at them from different angles?

To help answer our question, we explored soap bubbles, which also have different colors like the wings. We discovered the thickness of the bubble had something to do with the colors we saw. At **Duke University**, we took a close look at the wing of a Blue Morpho butterfly wing and learned how to determine whether colors in butterfly wings are the result of pigment or nanoscale structures. Then, back at home, we put some wings to the test.

Nano Matters

The nanoscale structure of any object has considerable effects on its properties. What do butterfly wings and soap bubbles have in common? Certain butterflies are iridescent, meaning they change color when viewed at different angles. The color does not come from pigment, but is solely based on how light behaves with tiny nanoscale structures in the wing. The thickness of a soap bubble is approximately the same size as these structures and causes a similar effect. The ingredients used to make bubbles are not colored, but the resulting structure has a rainbow appearance. (Keep in mind, the wavelength of visible light is approximately 400–700 nanometers, so nanostructures in this size range can cause interference of light waves.)

Icebreaker

Create some iridescent art.

15 minutes plus drying time

DragonflyTV Skill: Observing

Guide your kids as they

1) Fill the pan with water.
2) Completely submerge the black construction paper in the water.
3) Use the nail polish brush to drip one drop of clear nail polish onto the center of the water—not onto the paper! The nail polish will spread out into a thin film.
4) Lift the paper out of the water and the film will stick.
5) Allow the paper to dry and enjoy your artwork!

You'll need:

- black construction paper
- pan
- water
- clear nail polish

Are you a nano-bit curious?

The nail polish spreads out into a very, very thin film, only a few hundred nanometers thick—similar to a bubble! The thickness isn't always the same throughout the film and when light strikes it, some interesting things happen. White light is a mixture of all colors. Some wavelengths (colors) hit both the top and bottom of the film and remain "in sync" or "in phase" to make really bright colors of pink, blue, etc. This is called constructive interference. Other wavelengths get "out of phase," referred to as destructive interference, and these colors gets canceled out. The result is an iridescent masterpiece!

For other ideas of Icebreaker activities on this topic, visit: pbskids.org/dragonflytv/superdoit/super_bubble.html and pbskids.org/dragonflytv/superdoit/soapbubbles.html.

Investigation

Discover the wonderful world of color!

2 hours

Guide your kids as they

1) Brainstorm objects that you think get their color from either pigment or iridescence. (Some irides-cent objects include: soap bubbles, DVDs and CDs, oil on the surface of water, the inside of an oyster shell, mother-of-pearl and certain butterflies, bird feathers and beetles' wings.)
2) Break into groups and rotate through the following three stations to learn more about iridescent color versus pigment. Take a notebook along to capture observations at each station.
3) For the Bubbles Station, premake the bubble solution (1 cup water, 2 tablespoons glycerin, 4 tablespoons dishwashing liquid). Get a large hoop or bend a coat hanger into a circular shape and use the hook as a handle. Dip this into the bubble solution and hold it up against a black background. Record observations. Using another tool, blow some bubbles and observe the colors on the outside. Then blow them against a piece of white paper. When the bubbles pop, does any color appear on the paper?
4) For the Feathers Station, take a peacock feather and other bird feathers. Predict if they get their color from pigment or structure. Use a dropper to drip water on each feather and record observations. (Be sure to drop the water on the blue-purple eye of the peacock feather.) Do any of the colors change? Check back after they have dried.
5) For the M&M's Station, prepare a shoebox by cutting a small viewing square (about 4" x 3") out of the lid. Place one M&M of each color into the shoebox and put the lid on so you can see the M&M's through the viewing hole. Cover the hole with red cellophane. Can you tell which M&M is which? Replace it with green and then blue cellophane. How do the colors change? Why?

You'll need:

Bubbles Station:

- 1 cup water
- 2 tablespoons glycerin
- 4 tablespoons dishwashing soap
- container for bubble solution
- bubble hoop (or wire coat hanger)
- black background
- white piece of paper
- bubble blowing tools (tea strainer, wands, pipe cleaners, etc.)

Feathers Station:

- peacock feathers (from a craft store)
- other bird feathers
- water
- dropper

M&M's Station:

- multicolored M&M's
- shoebox
- scissors
- colored cellophane (from a party store) or large multicolored holiday lights

nano

See the "Zoom Cab" segment from show 702: Structure of Matter to view a butterfly wing at the nanoscale.

Are you a nano-bit curious?

When we think of color, we usually think of pigment. An M&M is red because it has a pigment—a chemical colorant—that absorbs every color of light EXCEPT red. The red light reflects off of the candy and hits our eye, so the M&M appears red. This is why changing the color of light affects the appearance of each M&M. (See the leaf illustration on the previous page.)

Objects can also have structural color which arises solely from nanostructures and has nothing to do with pigment. These objects are iridescent (the color changes depending on the angle you look at them). The "eye" of the peacock feather is iridescent and changes color when water is added to it. The water "fills in the spaces" of the nanostructures, so the light does not interfere in the same way.

For the bubble, the large film looks colored against a black background. The colors are more intense at the bottom because of the varying thickness of the film. Due to gravity, the film is thin at the top and thick at the bottom. Eventually, the top will get so thin, you will be able to see through to the black background (no color), and then the bubble will pop. Blowing bubbles against a white sheet of paper produces no color on the paper because the color is not a result of pigment.

The wavelength of visible light ranges from about 400–700 nm. The nanostructures in the iridescent feathers, soap bubbles and butterfly wings fall within this range. To see the structures on a butterfly wing, visit the **Image Gallery** on page 66.

DFTV Kids Synthesize
Data and Analysis

Station	Objects	Observations	Pigment, iridescent, or both?
feathers	peacock robin	changed color with water stayed the same	iridescent pigment
bubbles	bubble hoop bubbles popped on paper	More colors at the bottom No color on the paper	iridescent iridescent
M&M's	red light	I saw red, orange and yellow M&M's, but not blue, green and brown	pigment