

Cross-Curricular Discussion

After students have had a chance to review the articles "[Color me dino](#)" and "[Protein paints chipmunks' stripes](#)," lead a classroom discussion based on the questions that follow. You can copy and paste only the questions that apply to your classroom into a different document for your students. [Blackline Master 3](#) is a printable document that contains a chart related to the Physical Sciences Extension Prompt.

BIOLOGICAL SCIENCES

Discussion Questions:

1a. Ask students to think about the purpose of camouflage. What is it and how does it help organisms survive? [*Students might think about camouflage for defense; it can help animals hide in plain sight. Camouflage might be based on color alone or patterns of coloration, such as countershading.*] Ask students to explore different types of camouflage found in nature (they can find images online or take their own) and why the camouflage is useful in each case. This could lead to a discussion about natural selection and how an offspring with beneficial coloration might survive better than others. If environmental conditions change, offspring with different colorations might be selected for, as in the case of the peppered moth. Have your students read the related *Science News* article titled "[Jumping gene turned peppered moths the color of soot](#)," or, depending on their Lexile level, the version at *Science News for Students*, "[How a moth went to the dark side](#)."

What is the purpose of camouflage? How does it help organisms survive? What are some different types of camouflage found in nature? Can you find examples? Explain how each is useful. How might natural selection favor camouflage?

1b. Ask students what they know about human skin and hair pigmentation. Have students watch the Howard Hughes Medical Institute's video titled "[How we get our skin color](#)." The video outlines the physiology of skin pigmentation and defines the purpose and function of melanosomes. Ask your students if their skin or hair varies in color in different situations [*like after being out in the sun*]. After watching the Howard Hughes Medical Institute's video, ask students to explain the role of melanocytes based on information provided in the film. [*Within melanocytes, membrane-bound organelles called melanosomes produce and store melanin pigments.*] Ask students what factors determine overall skin color. [*Some factors that affect overall skin color are: the number of melanosomes, amount of melanin, and type of melanin present.*] How does melanin potentially protect DNA inside skin cells? [*Melanin absorbs specific wavelengths of radiation from sunlight which could decrease the UV radiation hitting DNA inside a nucleus. This radiation can cause mutations in the DNA.*]

What gives human skin or hair a particular color? Does your skin or hair vary in color under certain conditions? How does melanin interact with UV radiation? How can this interaction potentially offer a protective benefit to cells?

Extension Prompt:

1c. Explain that melanocytes come from a special group of cells, known as neural crest cells. Encourage students to research the types of cells that form from neural crest cells [*cartilage and bone of the cranium and face, smooth muscle, and some cells of the nervous system*] or the impact that these cells have on development of an organism. You might want to have students read another *Science News* article, "[Domesticated animals' juvenile appearance tied to embryonic cells](#)," to explore how possible selection for neural crest cells with defects may have led to common physical traits in domesticated animals [*selection for cells with defects may affect coat color, jaw size, facial characteristics and so on*].

Research the group of cells known as neural crest cells. How are they related to melanocytes? What types of cells form from neural crest cells during development? What animals do and don't have neural crest cells and how can the cells help us understand evolution?

PHYSICAL SCIENCES

Discussion Questions:

2a. In "[Protein paints chipmunks' stripes](#)," scientists describe how an increased concentration of a protein appears to interfere with pigment production. Review with students that the molecular mechanisms that drive these changes are unknown to the researchers. Still, this can be a launching point for a discussion about how differing the concentrations of reactants can affect the rate of a chemical reaction. [*Typically, as the concentration of reactants increases, the rate of a reaction increases due to the increased number of reactant collisions per unit time.*] Are there any other substances that generally affect the rate of a chemical reaction? [*Catalysts increase the rate of a chemical reaction by lowering the activation energy. Inhibitors prevent catalysts from interacting properly with reactants and therefore, slow the rate of a reaction.*] Have students draw an energy coordinate diagram for a general exothermic reaction and explain how the shape of the graph changes in the presence of a catalyst. [*The University of Texas outlines an example in the first graph [here](#).*]

How does varying the concentration of reactants in a chemical reaction generally affect the reaction rate? When present, what other substances can affect the rate of a chemical reaction? Explain. Draw an energy coordinate diagram for a general exothermic reaction. Explain how your graph would change in the presence of a catalyst.

2b. Discuss the nature of pigments as substances that absorb light. Ask your students how the absorption of some wavelengths of light relates to the colors that we see. [*The colors that we see are the wavelengths of light that are reflected. Based on a pigment's chemical structure, the molecule absorbs and reflects specific wavelengths of light.*] You might want to review the electromagnetic spectrum. Explain that pigments have unique absorption patterns or spectra. Have students research a pigment. They should determine the molecular structure of one pigment molecule and explain how it allows us to see the color

we see. [Examples of pigments can be found on The WebExhibit by Idea titled "[Pigments through the Ages](#)" (have students find a pigment for which a chemical formula is available). An example of an absorption spectrum of several plant pigments can be found halfway down the page on Estrella Mountain Community College's [page on photosynthesis](#)]. Can students find examples of animals that have an outward color appearance that is not directly related to pigments? [Some animals have structures that scatter light to make them appear a particular color. Peacock feathers, for example, aren't blue because of pigment, but instead their feather structures scatter light to create the blue appearance.]

How would you define a pigment? How do pigments interact with visible light and how does that relate to the colors we see? Research a particular pigment. Draw its molecular structure and determine how it interacts with light. In what plants or animals does this pigment exist? Find an example of an animal that has an outward color that is not directly related to pigment. Explain how the animal's physical structure interacts with light to produce that particular appearance.

Extension Prompt:

2c. Scientists use a variety of techniques to analyze animal pigmentation. Divide students into groups to research the equipment and techniques referenced in the articles (gas chromatography-mass spectrometry, Raman spectroscopy, scanning electron microscope and transmission electron microscope). Ask students to share the information they found about the equipment and the technique. What is each technique most commonly used for? Provide students with a few examples and ask which technique they would use in the given situation. Use the chart on [Blackline Master 3](#) to allow students to organize their responses. [For example, they have a tissue sample from mussels found at the mouth of the harbor. They want to find out if metals coming off of brake pads from vehicles are getting into the water. Which technique would they use to test the mussel tissue samples to look for potential metals? GC-mass spectrometer.]

ENGINEERING AND EXPERIMENTAL DESIGN

Discussion Question:

3a. Have your students ever tried looking at cells under a microscope? If they haven't, they can prepare their own slides using [this simple procedure for onion and cheek cells](#). Can students see and identify any organelles? Ask students why scientists develop more and more powerful tools for looking at specimens. Have students examine the degraded snakeskin images (on Page 25 of "[Color me dino](#)"). According to "Color me dino," how does the transmission electron microscope (TEM) help distinguish between bacteria and melanosomes? [Observing tissue using a TEM produces images in which melanosomes appear dark and bacteria look translucent.]

Prepare your own slides and look at cells under a microscope. What do you see? Can you draw the features of the cells? Which organelles are easy to identify? Why do you think scientists develop more powerful tools for looking at specimens? Examine the degraded snakeskin images on Page 25 of "Color me dino." What parts of the cells can you see? Compare the images. How does the transmission electron microscope help to distinguish between bacteria and melanosomes?

Extension Prompts:

3b. Discuss the idea of making inferences based on deductive and inductive reasoning. [*An inference is a conclusion reached by reasoning through evidence.*] Explain that this exercise will require students to make inferences in order to create and analyze fictional melanosome data. Have students draw or describe a fictional animal focusing on the animal's coloration (encourage them to stick to reddish brown, black or iridescent hues). Along with the animal's coloration, have students hypothesize a likely habitat for the animal. [*For example, a black and gray striped snake that is typically found in forests and marshes.*] Next, give students a small piece of paper (about 3 by 5 inches) to design their animal's "transmission electron microscope (TEM) skin picture" (similar to the picture given in the article). Students should first determine what section of skin is highlighted in their skin picture. Next, they should determine the total number and type of microstructures, as well as the general concentration pattern of microstructures within their skin picture. [*For example, 20 eumelanin melanosomes and 15 bacteria. Eumelanin melanosomes are clustered in the bottom third of the picture and bacteria are scattered throughout.*] Once designed, ask students to draw out their skin picture. Have students switch skin pictures with another student, count melanosomes and bacteria, infer a possible coloration pattern for their classmate's animal, and predict the animal's potential habitat. Students can compare their inferences to their classmates' original ideas.

What is your fictional animal's coloration pattern (stick to reddish brown, black or iridescent hues)?
What is a typical habitat for your animal? Using the melanosome shape, type and color chart on Page 26 of "Color me dino," you will design your own "transmission electron microscope (TEM) skin picture" for your fictional animal. First, answer the following questions: What section of skin is pictured? What type of melanosomes does the skin contain? What are the numbers of melanosomes and bacteria? What is the general distribution of melanosomes and bacteria?

Techniques for Analyzing Pigmentation

Directions: Do research to fill in the portion of the table that relates to your group's assignment.

Equipment	Description	Examples of when to use it
GC-Mass Spectrometer		
Raman Spectrometer or Raman Microscope		
Scanning Electron Microscope		
Transmission Electron Microscope		