150 YEARS | AMERICAN MUSEUM OF NATURAL HISTORY

EDUCATOR'S GUIDE

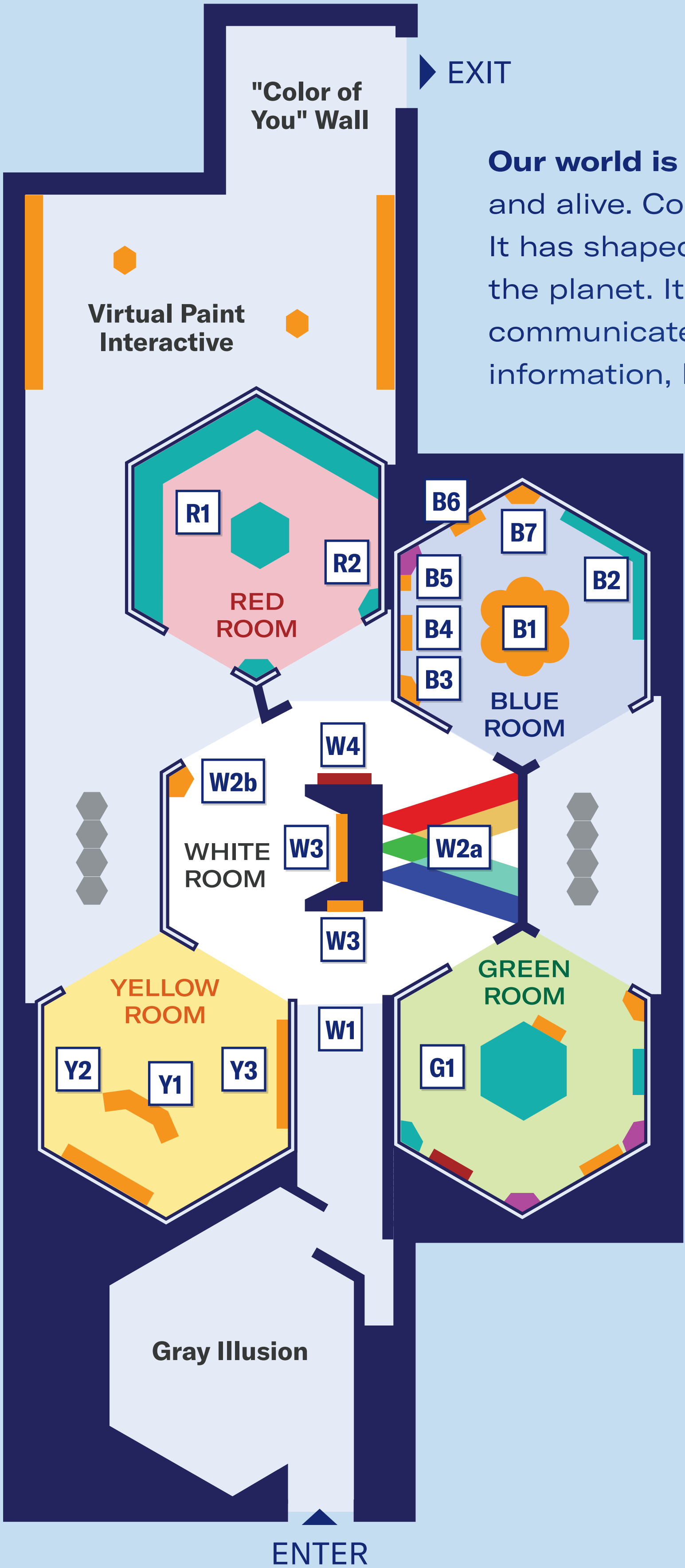
The Nature of COLOR

amnh.org/color-educators

INSIDE

ONLINE

Map of the Exhibition



Our world is awash in color, making it feel vibrant and alive. Color is much more than decoration: It has shaped the evolution of organisms all across the planet. It plays a big role in how we feel and communicate. And it contains vast amounts of information, helping us make sense of the world.

Each section of this exhibition presents a color paired with a theme, using live animals, models, artifacts, artworks, videos, and hands-on experiences to shine light on the astonishing world of color.

MAP KEY

- Interactive
- Live Animals
- Case/Display
- Video

Essential Questions

What is the physics of color?

Light is the visible part of the **electromagnetic spectrum** of energy, and colors are different **wavelengths** of light. There's nothing colorful about them in themselves—it's our brains that interpret them as colors. We perceive objects as having color when light bounces off them and reaches our eyes. When these light waves hit receptor cells in our eyes, they send nerve signals to our brains. Different wavelengths are perceived as different colors. The color of an object depends on the wavelengths of light shining on it, as well as which wavelengths the object reflects. For example, a leaf looks green only when green wavelengths reflect off it and enter our eyes. The leaf looks green in sunlight because it is reflecting the green wavelengths of the sunlight into your eyes and absorbing all the other wavelengths. But if no green light is present—for instance, if you shine a red light onto that green leaf in an otherwise dark room—the leaf will look black. Some objects, such as red-hot glowing coals and **bioluminescent** jellyfish, don't just reflect light—they actually produce their own colors by radiating light.

Why have some animals and plants evolved to display colors?

Colors can help animals blend in with or stand out from their surroundings, both of which can help them survive and reproduce. **Camouflage**, or blending in with the background, can help organisms hide from predators. Likewise, **mimicry**, or looking like another object or organism, allows some animals, like the leaf-mimic katydid, to hide in plain sight. Predators can benefit from mimicry too, disguising themselves as something harmless or even enticing. For example, the orchid mantis tricks its victims by resembling a flower and eating insects that approach it. But sometimes it's good to stand out, and color can help with that. For example, toxic animals can use bright colors to warn predators not to eat them; plants can use color to advertise ripeness so animals will eat their fruit and distribute the seeds in their droppings; flowers can use color to attract pollinators; and animals can use color to attract mates. And sometimes the colors of organisms have nothing to do with how they appear to others. Some colorful chemicals, such as red pigments in leaves, can help protect organisms from damaging ultraviolet rays from the Sun, while green chlorophyll allows plants to capture and use the Sun's energy to grow.

Can you find the organism that uses camouflage and mimicry?

What does color mean to people, and what emotions does it evoke?

Colors can evoke emotional reactions. Some depend on the individual. But many responses are cultural, and different cultures can interpret the same color differently. For example, in the United States many brides wear white, but in much of Asia the color for weddings is red. Pharmaceutical companies make few black pills for the American market because of the color's associations with depression and death, but in India black pills can inspire confidence, helping the pills sell better. And colors can help strengthen group bonds: Think of team colors, flags, and political maps. And colors' cultural meanings can change over time. In the United States today many people associate blue with boys and pink with girls, but that has not always been the case; in 1927 a survey found department stores evenly split about whether pink was for girls or for boys.

Across Asia, red is considered auspicious and plays a role in many celebrations.

Some responses to color may be rooted in biology. People in all cultures tend to perceive shorter wavelengths (violets, blues, and greens) as "cool" colors and longer wavelengths (yellows, oranges, and reds) as "warm" colors. Cool colors like blue and green tend to be calming, perhaps partly because of their association with water and plants, while yellow, orange, and red are more often stimulating; countries around the world use these warm colors on warning signs. Today, marketers use color to evoke consumer responses.

How do people create colorful objects?

From the earliest artists painting cave walls with red and yellow ochres (pigments from clay), people have searched for substances to make our lives more colorful. Color is crucial for art, of course, but it's also important to economic life, from branding and marketing to worldwide trade. Throughout history, **dyes** and **pigments** derived from animals like the cochineal insect (red dye) and the murex snail (purple dye), minerals like lapis lazuli (blue pigment) and cinnabar (red pigment), and plants like indigo and woad (blue dyes) have been traded across the globe. Today, mass-produced, synthetic dyes make bright colors available to almost everyone.

Teaching in the Exhibition

STEAM

STEAM is an educational approach that combines science, technology, engineering, arts and humanities, and mathematics to answer questions and solve problems. This exhibition takes an interdisciplinary approach to understanding color and is a great exhibition for the STEAM classroom.

Look for these icons to see where each element of STEAM is present in the exhibition.

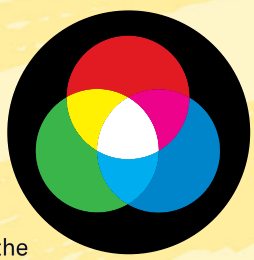
S cience
T echnology
E ngineering
A rts & humanities
M athematics

THE WHITE ROOM

Color and Light

Our perception of colors is alive with surprises and paradoxes. Within the apparent colorlessness of white hides an entire rainbow—and removing colors from white light can yield surprising results. This room explores how different colors of light can be mixed and separated, and how our eyes detect and our brains perceive colors.

W1. Electromagnetic spectrum graphic: Most electromagnetic waves are invisible, but our eyes can detect light with wavelengths in an extremely narrow range between about 400 and 700 nanometers. We perceive different wavelengths in this region as different colors. Students can note various wavelengths on the electromagnetic spectrum and identify those associated with different colors of visible light. S



W2. RGB shadows exploration: In one area (**W2a**), a red light, a green light, and a blue light are shining on a screen; the center looks white because these three "additive primary colors" of light stimulate the three types of cones in our eyes, creating the sensation of white. Students can experiment with blocking the lights with their bodies to see how blocking different combinations of light creates shadows of different colors. On the opposite side of the room (**W2b**), students can explore the same concepts by moving beams of light so they overlap. S

W3. Prism explorations: White light consists of all different colors combined; here, prisms show that the colors can be separated, making each color visible, and combined again into white. Students can also explore the behavior of light by manipulating filters and mirrors attached to magnets. S T E

W4. Color vision animations: In this short video, students will find out how color vision works. Different colors of light stimulate cone cells in the retina to send nerve signals to the brain. The brain decodes these signals to generate a perception of the colors that triggered them. S

THE GREEN ROOM

Color in Nature

Color is an important force in evolution because of the many ways it can affect organisms' ability to survive and reproduce. **Camouflage**, or blending in with the background, can help prey animals escape the notice of predators—and can help predators sneak up on prey. **Mimicry**, or looking like something they're not, can help prey (defensive mimicry); it can help predators, too, by fooling prey into thinking the predator is something harmless like a leaf or a flower (aggressive mimicry). **Aposematism**, or coloration that advertises undesirable characteristics, can help prey survive by alerting hungry hunters and foragers that they're toxic or bad tasting—and it can also help predators survive by warning them away from toxins. Color can help animals reproduce by signalling to potential mates in brilliant **courtship displays**; it can help plants reproduce by attracting **pollinators** to flowers or by tempting animals to eat ripe fruit and **disperse seeds** in their droppings. And colorful pigments can protect organisms from damaging **UV radiation** from the Sun.

G1. Live animals, specimens, models, photos, interactives: Throughout this room, students can look for these animals and plants to explore how they use color to help them survive and reproduce. S

Camouflage:

- Leaf-tailed gecko (live animal)
- Mouse (model)
- Seahorse and other marine species (video)

Mimicry:

- Leaf-mimic katydid (model)
- Orchid mantis (model)
- Various marine species (video)
- Cuckoo egg in a nest (model)

Colorful warning signals help predators avoid eating toxic animals like poison dart frogs, benefiting both predator and prey.

Aposematism:

- Poison dart frogs (live animal)
- Pink dragon millipede (model)
- Ladybug (model)

Courtship:

- Ruby-throated hummingbird (model)
- Damselflies (models)
- Rainbow lorikeet (photo)
- Various marine species (video)

Pollination and seed dispersal:

- Three columbine flowers (purple, white, red) and their specific pollinators (bumblebee, hawkmoth, ruby-throated hummingbird) (models)
- *Quisqualis indica* blossoms (photos)
- Fuchsia blossoms (photos)

UV protection:

- Leaves (lenticular image)

THE BLUE ROOM

Making Color

This room addresses two themes: the technology of making dyes and pigments and the biology and physics of color. One section uses raw pigments, cultural objects, and artworks to explore how humans have discovered, produced, and traded pigments over the millennia to create colorful objects. The other section uses mineral specimens and live animals to explore how color is produced in nature, including the wavelengths of light they reflect, structural coloration (iridescence, pearlescence), and the colored light they produce themselves (from heat, bioluminescence, fluorescence).

B1. Indigo dye interactive: For centuries, indigo was the most valuable, most widely traded dye in the world. Students can virtually dye and print fabrics at a six-player interactive table. Nearby, they can explore the history of this pigment by examining textiles and objects across the globe, including Africa, Mexico, and India. S T E A M

This indigo fabric was made using centuries-old traditional processes in Nigeria.

B2. Other blue pigments: Both natural and synthetic blue pigments have transformed art and commerce throughout history. By examining objects such as pottery and artwork, students can get a sense of how pigments such as cobalt, ultramarine, and Prussian blue were made and used. S T E A M

B3. Color lights exploration: The color of an object depends on the color of light it reflects and the color of light shining on it. Students can push a button to see what happens to the color of the objects under different colors of light. S

B4. True black object: A true black pigment would reflect no light at all; an object colored with such a pigment would have no shadows on it and would therefore look completely flat. Students can examine an object that's close to true black. S

B5. Live iridescent beetles: Some objects appear to have different colors when seen at different angles. Students can observe live beetles and explore iridescent objects such as shells and feathers that produce structural coloration, when microscopic structures alter the light bouncing off of them. S M

B6. Gas tubes: Scientists can identify chemicals from the colors of light they emit. Students can light up gas tubes and examine spectral lines to identify the gases helium and nitrogen. S T E

B7. Fluorescent minerals and bioluminescent organism photos: Reflecting light is not the only way to be colorful. Students can examine minerals under an ultraviolet lamp to see them fluoresce—produce color by absorbing light in one wavelength and emitting it in another. They can also look at pictures of organisms that bioluminesce—produce light by converting chemical energy into colored light. S T E M

THE YELLOW ROOM

Feeling Color

Colors evoke emotional reactions. Some of these are cultural; some are personal; and some may even be biological. This room explores how colors make us feel.

Y1. Game show interactive: Feelings about color—we all have them. In this three-player game (plus an audience who can play by phone at the same time), students can answer questions about their personal reactions to color. A

Y2. Marketing stories: Because colors evoke such strong feelings, they can carry powerful messages that affect human behavior. Students can examine how marketers use color to influence consumer choices. A

Y3. Tile game: Students can arrange colored tiles to represent feelings ranging from warm and cool to energetic and sleepy. A

THE RED ROOM

The Meaning of Color

People ascribe meanings to colors, and those meanings vary across years and cultures. This room looks at how different people have communicated with colors, focusing on the color red.

R1. Clothing and memorabilia: Around the room, students can look for these items of clothing, explore the theme each represents, and examine other objects that illustrate those themes: a couture gown (power, assertiveness), a football uniform (identity, group affiliation), an Indian wedding lengha (auspiciousness, fertility), a cardinal's robe (status, religion), and a man's pink suit (gender, personal expression). T E A

R2. Chinese altar, Christian stained glass windows, cave art: Meanings of color are often culturally specific. Students can examine spiritual objects and read about the symbolic meanings attributed to the colors used. A

Virtual Paint Interactive

Colors can convey important information and evoke serious emotions—but they can also inspire lighthearted play. In this immersive experience, students can use their imaginations and move their bodies to manipulate different colors that are projected on the walls and on the floor. At the kiosks, they can select from four color palettes and brush strokes. A M

"The Color of You" Wall

Students can look at these portraits that explore the diversity of human colors and challenge how people think about skin color and identity. A

Come Prepared Checklist

- ☐ **Plan your visit.** For information about reservations, transportation, and lunchrooms, visit amnh.org/fieldtrips.
- ☐ **Read the Essential Questions** to see how themes in the exhibition connect to your curriculum.
- ☐ **Review the Teaching in the Exhibiton section** for an advance look at what your class will encounter.
- ☐ **Download activities and student worksheets** at amnh.org/color-educators. They are designed for use before, during, and after your visit.
- ☐ **Decide how your class will explore the exhibition:**
  - You and your chaperones can facilitate the visit using the Teaching in the Exhibiton section.
  - Students can use the worksheets and/or maps to explore on their own or in small groups.

Correlation to Standards

A Framework for K-12 Science Education

Scientific and Engineering Practices • Asking Questions • Developing and Using Models • Obtaining, Evaluating, and Communicating Information • Constructing Explanations and Designing Solutions

Crosscutting Concepts • Patterns • Cause and Effect: Mechanisms and Explanations • System and System Models • Structure and Function

Disciplinary Core Ideas • PS3.A: Definitions of Energy • PS3.B: Conservation of Energy and Energy Transfer • PS4.B: Electromagnetic Radiation • LS1.A: Structure and Function • LS2.A: Interdependent Relationships in Ecosystems • LS4.C: Adaptation

National Standards for Social Studies

Standard 9: Global Connections

Glossary

aposematism: an animal signaling to a predator that it is dangerous or unpleasant to eat

bioluminescence: the production and emission of light by a living organism

camouflage: blending in with the background

color: a visual sensation resulting from the wavelengths of light reflected, transmitted, or emitted from an object

courtship display: a set of behaviors or sensory signals, such as colors, sounds, or smells, aimed at attracting a mate

dye: a substance that can impart color to another material by bonding with it chemically

electromagnetic spectrum: the entire range of all electric, magnetic, and visible radiation

fluorescence: a process in which light of shorter wavelength is absorbed and reemitted as longer-wavelength light that changes color, such as from blue to red

mimicry: an organism looking like something it's not

pigment: a substance that can impart color to another material by bonding with it physically

ultraviolet (UV) radiation: electromagnetic radiation with wavelengths shorter than those of visible light and longer than those of X-rays

wavelength: the distance between two successive crests of a wave; different colors of visible light are characterized by their unique wavelengths, as are different types of electromagnetic radiation (e.g. radiowaves, ultraviolet)

Credits

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