



ART &
SCIENCE
COLLIDE

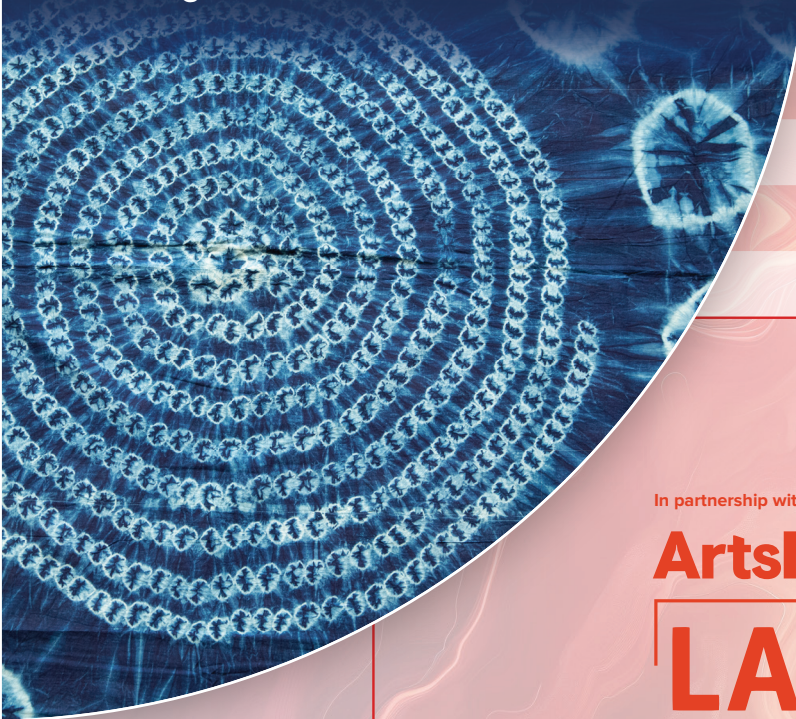
COLOR & PERCEPTION

HIGH SCHOOL | ART & SCIENCE STANDARDS-ALIGNED

ESSENTIAL QUESTION

How do we see and
understand the meaning
of color?

*Blue Gold: The Art and Science of Indigo at
the Mingei International Museum*



*Sangre de Nopal/Blood of the Nopal: Tanya
Aguñiga & Porfirio Gutiérrez en Conversación/
in Conversation by the Fowler Museum at
UCLA and Museum of Contemporary Art Santa
Barbara (MCASB)*



*Color in Motion: Chromatic Explorations of
Cinema at the Academy Museum of Motion
Pictures*



In partnership with

ArtsMatter

LA PROMISE
FUND



ESSENTIAL QUESTION

How do we see and understand the meaning of color?

DISCUSSION

Explore the essential question with students using the exhibition images, descriptions, and student discussion prompts provided for each exhibition.

Then, transition from talking about the exhibitions to connecting them thematically through these prompts:

1. Where do colors come from? How do humans make color?
2. How do you think people transform natural color sources to create pigments and dyes? What chemical reactions are involved? How do you think energy is transferred in that process?
3. Color theory helps us understand how to combine and use colors to create a desired effect. How do you think peoples around the world used the colors they created?
4. Color symbolism is the idea that colors have meaning. Do you think everyone would find the same meaning in the same colors? What factors might inform how people interpret the meaning of a color?
5. How do artists use color to tell a story or communicate a message? What kinds of aesthetic choices do they make? What kinds of physical or chemical processes are involved?

CLASSROOM ACTIVITY

Overview

Working in small groups, students will collaboratively develop a graphic novel that shows the physical, cultural, and aesthetic properties of a color. The resulting graphic novel should tell the story of the sourcing, production, use, and cultural perceptions of color.

Learning Outcomes

As a result of this activity, students will be able to...

- Describe the physical and aesthetic properties of color
- Practice collaborative media production and project management
- Create a graphic novel showing how color pigments are derived from natural sources, used to create human artifacts, and perceived both physically and culturally

Suggested Materials

- Storyboard template
- Design software (e.g., Adobe Express, recommended by LA Promise Fund ArtsMatter)

Instructions

STEP 1: Explore the color's origins, production, use, and meaning. Prompt each group to choose a color (naturally or synthetically derived) and investigate the following:

- **Origins and sources of color.** Where does it come from? What are its physical properties?
- **Production and transformation of color.** How is it transformed from its natural form for use in human artifacts, or how is it synthesized from non-organic materials? What chemical reactions occur in that transformation? How is energy absorbed or released?
- **Human use, perception, and meaning(s) of color.** How do humans use this color? What meaning does it carry in different settings?

STEP 2: Narrative and storyboard. Groups work together to outline and storyboard the narrative of the graphic novel.

- Create a written outline of the narrative, which should synthesize information gathered in Step 1 (color source, color production, human use, perception, and meaning(s) of the color).
- Expanding on this outline, use the storyboarding template (or a piece of paper divided into 6-8 frames with space beneath each frame for a written description) to sketch visual and textual elements of the story.

STEP 3: Delegate roles and self-manage production processes. Once each group has a working storyboard and written narrative, students delegate production roles amongst their teammates. For example, some team members might be responsible for creating the artwork, while others refine the narrative or develop the layout of images and text in the graphic novel.

STEP 4: Finalize for presentation and share. Once groups have made any final adjustments to the graphics, narrative, and layout, invite students to share their graphic novels with their classmates and reflect on the collaborative production process with their teams.

Optional Extensions

To take students' scientific and artistic learning about color even further, consider the following extensions:

- Experience the difference between pigment and light by mixing complementary colors (e.g., red and green) of paint or colored water. Then, compare it to a mixture of those same complementary colors of light filtered from a projector.
- Explore the differences between additive (RGB) and subtractive (CMYK) color models. Discuss the differing definitions of primary and secondary colors in each and uses, benefits, and challenges in digital and print media.

Additional Resources

Title	Source	Description
Color theory	LA Promise Fund ArtsMatter	Slide deck that introduces the basics of color theory.
Adobe Express Cheat Sheets	LA Promise Fund ArtsMatter	ArtsMatter recommends Adobe Express as a graphic design platform. These cheat sheets offer tips to get started once you create a free account.
Storyboard templates	Adobe Express	Use this free template to create storyboards. https://adobesparkpost.app.link/tQ337Vxlxyb Or explore other options here: https://www.adobe.com/express/templates/search?tasks=&tasksx=&phformat=2:3&topics=story-board&q=storyboard
Porfirio Gutiérrez: Ka Duu (Natural Color)	Smithsonian National Museum of the American Indian	Learn more about Porfirio Gutiérrez's work with Zapotec natural dyes and weaving.
Physics in the Arts	University of Wisconsin-Madison Physics Lecture Demonstrations	Professor Pupa Gilbert explains the physics of color in videos 15-29 of this series of 1-2 minute lecture demonstrations.

Assessment Checklist

To assess students' artistic and scientific learning, consider the following questions:

- Does the story clearly identify the natural or synthetic source of the color?
- Does the story describe physical and chemical properties of the color? Does it describe the chemical reactions that occur to create it?
- Does the story describe the process of producing the color, noting any ecological consequences?
- Does the story describe the physical perceptions and cultural meanings of the color?
- Did students effectively delegate roles and manage the production process?
- Do the aesthetic choices demonstrate awareness of expressive intent?

VOCABULARY

Art Terms

Term	Definition
color theory	The study of how colors can be used or combined to create a desired effect.
primary colors	The most basic set of colors that cannot be created by mixing any other colors. In pigment, primary colors are red, blue, and yellow. In light, primary colors could be red, blue, and green in an additive color model or cyan, magenta, and yellow in a subtractive color model.
secondary colors	Colors that are created by combining two primary colors.
additive color model	A method of creating colors by combining wavelengths of light. The primary colors in this method are red, green, and blue (RGB), which can be combined in different intensities to create new colors. This method is usually used for digital media.
subtractive color model	A method of creating colors by removing wavelengths of light by absorbing them from white light. The primary colors in this method are cyan, magenta, and yellow (CMY). Varying their intensities can create new colors. This method is usually used for print media.

Science Terms

Term	Definition
pigment	The natural or synthetic substance that gives color to other materials, including paints, dyes, and inks. When a pigment is struck by light, it absorbs some wavelengths and reflects others. The way a pigment absorbs and reflects light is what gives it its perceived color.

chemical reaction	A process in which two or more chemical substances interact to create a new substance with distinct chemical properties. This occurs by forming or breaking chemical bonds and by absorbing or releasing energy.
light	A type of electromagnetic radiation that is visible to the human eye. Light is made of photons, which travel in waves at different wavelengths.
wavelength	The distance between the high points (peaks) of a wave. Wavelength of light determines its color.
spectrum	The range of wavelengths that a source absorbs or gives off. The spectrum of visible light includes the full range of colors that humans can see.

ART & SCIENCE STANDARDS

California Arts Standards

This **media arts** project aligns with two Anchor Standards.

- **Creating — Anchor Standard 2: Organize and Develop Artistic Ideas and Work** under the process component **Develop**
- **Producing — Anchor Standard 5: Develop and Refine Artistic Techniques and Work for Presentation** under the process component **Practice**

Standard	Description
MA:Cr2	Apply aesthetic criteria in developing, and refining artistic ideas, plans, prototypes, and production processes for media arts productions, considering original inspirations, goals, and presentation context.
MA:Pr5a	Demonstrate progression in artistic, design, technical, and soft skills, as a result of selecting and fulfilling specified roles in the production of a variety of media artworks.

Next Generation Science Standards (NGSS)

This project aligns with standards in **physical science**.

Performance Expectations

Standard	Description
HS-PS1-2	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
HS-PS1-4	Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.
HS-PS3-2	Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
HS-PS4-3	Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Science and Engineering Practices

SEP-2 Developing and Using Models
SEP-6 Constructing Explanations and Designing Solutions
SEP-7 Engaging in Argument from Evidence

Crosscutting Concepts

CCC-1 Patterns
CCC-4 Systems and System Models
CCC-5 Energy and Matter

California Environmental Principles & Concepts (EP&C)

The California Environmental Principles & Concepts (EP&C) build environmental literacy around the relationship between humans and the natural world. The EP&C were developed in 2004 and incorporated into California's Education Code in 2018.

Principle I: The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Human lives, communities, societies, and activities (e.g., agriculture, fisheries, and industry) depend on and benefit from the biodiversity of Earth's natural systems.

The biodiversity of natural systems influences the quality, quantity, and reliability of the ecosystem goods and ecosystem services that human lives, communities, societies, and activities depend on.

The availability and reliability of the ecosystem goods and ecosystem services that natural systems provide humans are directly affected by the size and growth of human populations, and their consumption rates, as well as the operation of human communities.

FEATURED EXHIBITIONS

This resource guide integrates three PST ART exhibitions:

- *Sangre de Nopal/Blood of the Nopal: Tanya Aguiñiga & Porfirio Gutiérrez en Conversación/in Conversation* by the Fowler Museum at UCLA and Museum of Contemporary Art Santa Barbara (MCASB)
- *Blue Gold: The Art and Science of Indigo* at the Mingei International Museum
- *Color in Motion: Chromatic Explorations of Cinema* at the Academy Museum of Motion Pictures

Learn more about these exhibitions in the following pages and at <https://pst.art>.



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Sangre de Nopal/Blood of the Nopal: Tanya Aguiñiga & Porfirio Gutiérrez en Conversación/in Conversation by the Fowler Museum at UCLA and Museum of Contemporary Art Santa Barbara (MCASB)



Artists Porfirio Gutiérrez and Tanya Aguiñiga hold their weavings in front of their faces on a hill near Gutiérrez's hometown in Teotitlán del Valle, Oaxaca. Photo: Javier Lazo Gutiérrez.

About the Exhibition

Sangre de Nopal/Blood of the Nopal: Tanya Aguiñiga & Porfirio Gutiérrez en Conversación/in Conversation examines the intersection of art and science within the Indigenous Oaxacan diaspora. This multivocal exhibition features new and recent work by fiber artists Tanya Aguiñiga and Porfirio Gutiérrez alongside Oaxacan textiles from the Fowler collection. A focus on cochineal, a red dye derived from an insect that lives on the opuntia (prickly pear) cactus and first cultivated by the Zapotec peoples around 500 BC, provides a case study in multi-generational innovation. Aguiñiga and Gutiérrez approach cochineal as a means of engaging with ancestral knowledge, collective memory, and personal experiences with migration and displacement.

The companion exhibition *Sangre de Nopal/Blood of the Nopal: Traditional Ecological Knowledge and Contemporary Art*, is on view at Museum of Contemporary Art Santa Barbara (MCASB) OCT 6, 2024 – JAN 12, 2025. This presentation features the work of Aguiñiga and Gutiérrez, as well as Wendy Cabrera Rubio, Tania Candiani, Edgar Jahir Trujillo, Candace Lin, Andy Medina, Jou Morales, Sandy Rodriguez, Sara Rosalena, Tlacolulokos & Dario Canul, and Dyani White Hawk.



Discussion Prompts for Students

- Cochineal dyeing techniques have been used by the Zapotec peoples for centuries. Why do you think contemporary artists would want or need to find new, innovative methods of producing this dye?
- This project brings together Zapotec ecological knowledge and Western science. How might both of these perspectives contribute to developing new ways of producing this dye?
- Imagine you were responsible for carrying forward a centuries-old tradition of dyeing. How would you decide what traditional elements to keep and which elements to adapt with new technologies?



Blue Gold: The Art and Science of Indigo
at the Mingei International Museum



Prestige Cloth Wrapper, 20th Century. Nigeria, Yoruba people. Cotton, indigo. Collection Mingei International Museum. ©Mingei International Museum.

About the Exhibition

Indigo—both a varied plant family that grows worldwide and the deep-blue dye it produces—has a long and multifaceted history of cultivation, production, and distribution. *Blue Gold* combines science, craft, and history to explore this color's complex past and present. Indigo's beauty and ubiquity have eclipsed the unpleasant realities of its growth and manufacture, including hard labor and pollution, and its association with colonialism and slavery. As a pigment, indigo has been assigned protective properties, healing powers, and dangerous qualities that have shaped its uses in crafts and the arts. The exhibition highlights the roles of botany, chemistry, medicine, ecology, and economics in indigo cultivation. Contemporary craftspeople and artists working with indigo, such as Porfirio Gutiérrez and Laura Kina, address questions about the sustainability of indigo, its problematic legacies, and technological alternatives to manual processing.



Discussion Prompts for Students

- Indigo comes from a plant that has been found to grow on five continents for millennia. It has been thought to have both protective and dangerous properties. Why do you think people around the world have interpreted the meaning of indigo in so many different ways?
- Throughout its long history in human societies, indigo has grown in popularity. What are some possible economic and ecological consequences of its growing popularity?
- How do you think natural and synthetic indigo differ in their physical, chemical properties? How might they differ in their social and cultural meaning?



Color in Motion: Chromatic Explorations of Cinema
at the Academy Museum of Motion Pictures



Academy Museum of Motion Pictures. Photo by Joshua White, JWPictures/© Academy Museum Foundation.

About the Exhibition

From hand-tinted silent films to digital film production, color has always played an essential role in creating cinematic landscapes and narratives. *Color in Motion* explores the power of color as a filmmaking tool, the science and technologies behind it, and its physical and psychological impact on audiences. The story of color is told in high-energy film clips, photographs, posters, production cels, color charts, equipment, and iconic costumes and props such as a costume worn by Kim Novak in *Vertigo*. *Color in Motion* also reveals the many contributions women made to the history of film colors—laboriously hand-coloring and stenciling, working in Disney’s ink and paint department, and serving as the generally white “leader ladies” to whose skin tones film colors were calibrated—raising questions about the role of race and gender in film color development. Immersive spaces and interactive installations include a hands-on “color arcade” that invites visitors to move their bodies to activate colors, allowing them to see, create, and experience color in motion.



Discussion Prompts for Students

- How might color change how the audience experiences a film? How can color communicate an idea or feeling in film?
- What's the difference between the color in paint and the color created by placing a filter over a projector's lens? If you wanted to create a new color, how would you make it by mixing paint? How would you do it using the projector?
- If you were to choose a color that represents who you are, how would you create it using paint or pigment? How would you create that color using light and a projector?

Other Related Exhibitions

In addition to the Featured Exhibitions listed above, check out this PST ART exhibition with related themes:

- *We Live in Painting: The Nature of Color in Mesoamerican Art* at the Los Angeles County Museum of Art (LACMA)

To learn more about these exhibitions and PST ART: *Art & Science Collide*, visit <https://pst.art>.