

Lesson Plan: *The Electromagnetic Spectrum*

Bruegel's "The Wedding Dance" Revealed



LEARNING TARGET

What is the electromagnetic spectrum (EMS) and how do conservation professionals use it?

How can these imaging techniques show us more about artful objects? In this lesson, students learn about the EMS and apply their skills using the special exhibition *Bruegel's "The Wedding Dance" Revealed*.

STUDENT OUTCOMES

Students will:

- Explore real world applications of the EMS and the tools conservation professional use to answer questions about objects.
- Expand their understanding of the EMS.
- Understand parts of the EMS, particularly focusing on applications related to infrared, ultraviolet, x-Ray radiation and visible light.
- Apply what they learn by analyzing EMS images and drawing evidence-based conclusions.

NGSS STATE STANDARD ALIGNMENT

PS4. B Electromagnetic Radiation

When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.

PS4.A Wave Properties

Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.

PS4.C Information Technologies and Instrumentation

Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.

Lesson Plan: *The Electromagnetic Spectrum*

21st CENTURY LEARNING SKILLS ALIGNMENT

- Critical thinking
- Collaboration
- Communication
- Technology literacy
- Productivity
- Social skills

PRE-VISIT ACTIVITY

The conservation professionals at the DIA include: conservators, a conservation scientist, and an imaging specialist.

Conservation professionals at the Detroit Institute of Arts (DIA) use parts of the electromagnetic spectrum (EMS) to help visualize works of art. Students less familiar with the EMS can review the types of electromagnetic radiation, and the relationship between the EMS, energy and wavelength by engaging with an interactive EMS available here: https://www.sciencelearn.org.nz/image_maps/63-the-electromagnetic-spectrum

After they have explored the website, students engage in a class discussion, which can include the following prompts:

- Which parts of the EMS had you heard of before? Explain.
- What new information about the EMS did you learn today?
- What questions about the EMS do you now have?

SELF-GUIDE ACTIVITIES

This self-guide activity has two parts: 1) a self-guided EMS Notetaker to be completed in the exhibition, and 2) a Gallery Activity working with some DIA conservation department images in which students get to practice what they learned in the exhibition. Ideally, the completed EMS Notetaker will support students in completing the Gallery Activity, but the EMS Notetaker and Gallery Activity can be done separately and do not depend on one-another.

Option 1: EMS Notetaker

Students focus on how conservation professionals use elements of the electromagnetic spectrum (including ultraviolet, infrared, visible light, and x-rays) to examine objects by completing the EMS Notetaker. Students can use this as a support for the Gallery Activity below if completed.

Option 2: Gallery Activity

After exploring the exhibition, students will analyze real EMS images of objects on view at the DIA. Please note: once a field trip is booked, please confirm with your museum contact that all objects in the ARTWORKS document are currently on view.

Before your visit, ensure the artworks in each image packet will be available to students at the museum by 1) posting the files onto a digital platform, such as google classroom or canvas, so that students can see the images on their mobile phones, or 2) print the Image Packets in color, creating one packet for

Lesson Plan: *The Electromagnetic Spectrum*

each pair or small group of students. If the DIA webpage link is shared, note that a Teacher Guide is also posted.

To aid with spreading out large groups across the museum, there are four Image Packets provided, each containing three different EMS images of objects.

Image Packet	Asian and Early Egyptian	European, Medieval, and Renaissance	Modern Art	Scavenger Hunt
Objects	<ul style="list-style-type: none"> • Chinese, <i>Bodhisattva</i> • Indian, <i>Shiva</i> • Egyptian, <i>Head of a Woman</i> 	<ul style="list-style-type: none"> • Jan Provost, <i>The Last Judgment</i> • Luis Salvador Carmona, <i>Virgin and Child</i> • Bartolomeo Manfredi, <i>The Fortune Teller</i> 	<ul style="list-style-type: none"> • Pablo Picasso, <i>Melancholy Woman</i> • George Benjamin Luks, <i>Woman with Macaws</i> • Juan Gris, <i>Still Life</i> 	<ul style="list-style-type: none"> • Peter Paul Rubens, <i>Warrior</i> • John Singleton Copley, <i>Watson and the Shark</i> • José de Mora, <i>Saint Francis of Assisi</i>

Each packet can have three groups of 10 students, or less, that rotate around the three objects. Within their chaperoned groups, students can work in pairs or small groups to use their maps to find the objects they see in their assigned Image Packets, compare the real objects to the EMS images, and complete the EMS Gallery Activity Handout.

Each Image Packet and accompanying questions should take groups 30-45 minutes to complete. If time is a constraint, be aware that two of the Image Packets - the Scavenger Hunt Image Packet and the Asian and Early Egyptian Image Packet –contain images from galleries in different parts of the museum and will require some travel time.

This activity can also be completed in the classroom or given to students if they are absent.

VIRTUAL TIP

If you are unable to come into the museum or this special exhibition is no longer on view, consider using the **Electromagnetic Spectrum Presentation** to help students gain the background knowledge to complete the Self-Guide Activities.

POST-VISIT ACTIVITIES

If teachers would like their students to explore more parts of the electromagnetic spectrum, the history, and the technology connected to it, they can instruct students to read the article [The Electromagnetic Spectrum- Real Life Applications & Technology](#) and complete the Sentence, Phrase, Word graphic organizer. This worksheet can be used to spark a small-group or whole class discussion. Some of the fascinating topics covered in the article include: Microwave communications, medical applications, and the use of radio waves to measure, telemetry, and gamma rays.

This resource was developed by Adina Rubenstein in collaboration with the Education Programs and Conservation teams.

EMS Gallery Activity Handout – Teacher Guide

Asian and Early Egyptian Art

Bodhisattva, 1300-1400, Chinese; paint on clay mixed with straw



In the UV image in the center you can see that the mural was repaired at multiple points in its history. Some materials glow/fluoresce differently under UV light. The mural was cut into smaller sections/squares to remove it from its original location. Under UV light we can see the materials used to repair the joins; they look dark purple (indicated by the yellow lines in the image on the far right). Also, materials used for repairing parts of the paint layer of the mural fluoresce various shades of orange and yellow. (PS. The painting still consists of three separate sections clearly seen in visible light)

EMS Gallery Activity Handout – Teacher Guide

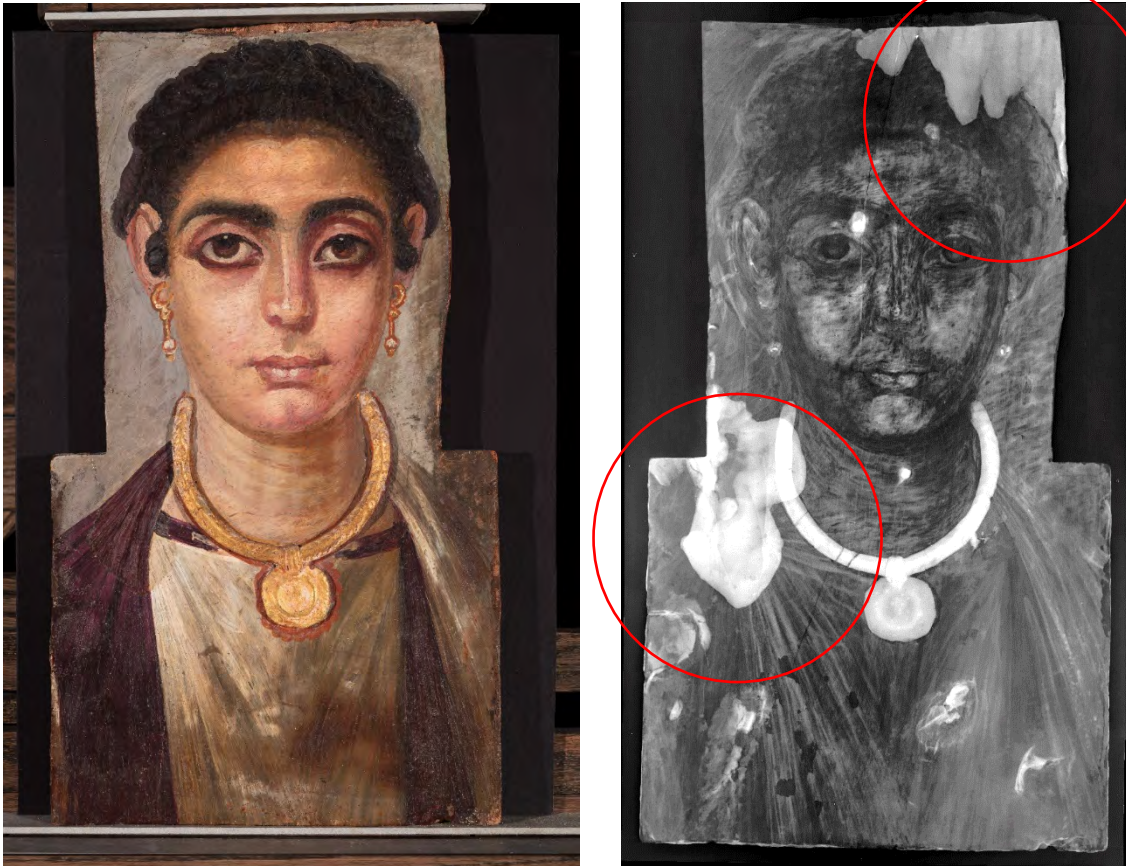
Shiva, late 10th – early 11th century, Indian; granite



In the UV image at the bottom right notice the bright whiteish fluorescing material around the neck of the sculpture. This clearly indicates that the join between body and head was a later repair (P.S. While you can see it in the visible light, the color of the fluorescence can help us identify the material used for the repair).

EMS Gallery Activity Handout – Teacher Guide

Head of a Woman, between 130 and 160 CE, Egyptian; encaustic with gilded stucco on wood panel



In the X-Ray image on the right you can see that the painting was repaired at some point in its history. X-radiography can reveal artist's brushwork, changes to the composition, as well as later repairs. In this case the losses were filled with materials that was denser than the original paint (P.S. Notice that the metal used to make the attached necklace has a similar density as the later repairs).

EMS Gallery Activity Handout – Teacher Guide

European, Medieval, Renaissance Images

The Last Judgment, c. 1525, Jan Provost, Neverlandish; oil on oak panel



In the central area of the infrared image on the right you can clearly see the artist's preparatory drawing was different from the final painted image. The infrared camera can penetrate certain materials (in this case paint) to allow us to see the underdrawing because the materials used for the underdrawing could not be penetrated.

EMS Gallery Activity Handout – Teacher Guide

Virgin and Child, ca. 1750, Luis Salvador Carmona, Spanish; polychrome coniferous wood, glass



In the UV image on the right you can see that the sculpture was repaired at some point in its history. Some materials glow/fluoresce differently under UV light. In this case we can see that the materials used for repairing the damage in the paint layer around the knee and in the blue robe glow/fluoresce differently (dark purple in the robe and light pink in the knee) than the rest of the sculpture (P.S. Conservators purposely choose materials that glow differently so that future conservators can see what they have done).

EMS Gallery Activity Handout – Teacher Guide

The Fortune Teller, ca. 1616-1617, Bartolomeo Manfredi; Italian; oil on canvas

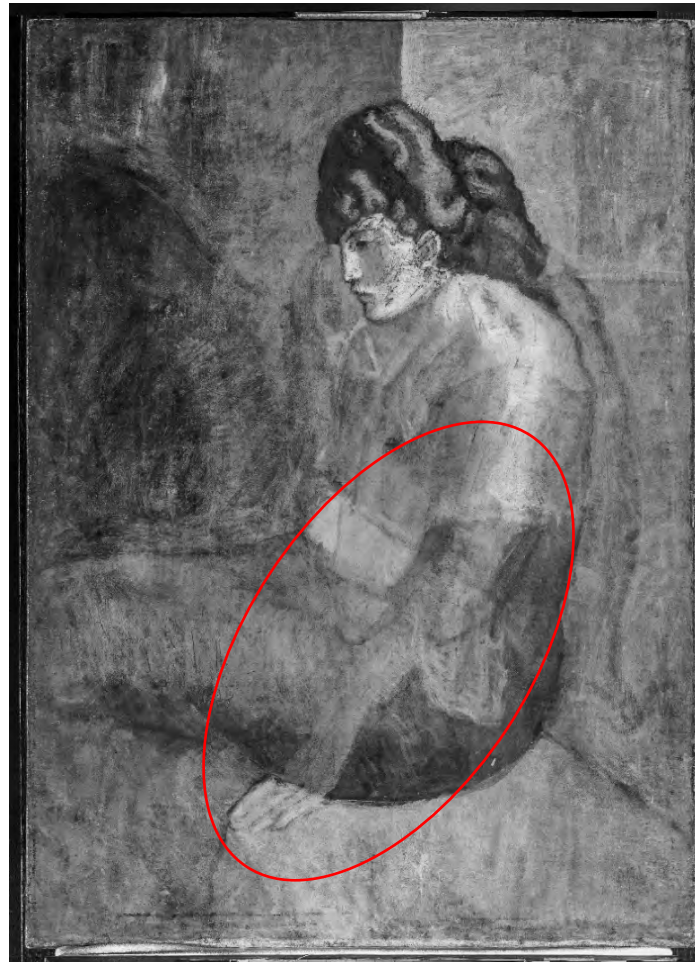


In the X-Ray on the right you can see that the artist changed the positions of the four figures several times before landing on the final composition. X-radiography can reveal artist's brushwork and changes to the composition. In this case the earlier positions of the figures are revealed because the paints used in the initial ideas were denser than the paint covering them.

EMS Gallery Activity Handout – Teacher Guide

Modern Art Images

Melancholy Woman, 1902, Pablo Picasso, Spanish; oil on canvas



In the infrared image on the right you can see how the woman's left arm changed position during the painting process. The infrared camera can penetrate certain materials (in this case paint) to allow us to see earlier stages of the painting.

EMS Gallery Activity Handout – Teacher Guide

Woman with Macaws, 1907 George Benjamin Luks, American; oil on canvas



In the X-Ray on the right you can that see the position of the woman's gaze changed from looking towards the viewer to looking at the large blue macaw. X-radiography can reveal artist's brushwork and changes to the composition. In this case the earlier position of the head is revealed because it's paint was denser than the paint covering it (P.S. The bright white shapes in the corner indicate metal brackets that keep the stretcher tight).

EMS Gallery Activity Handout – Teacher Guide

Still Life, 1916, Juan Gris, Spanish; oil on canvas

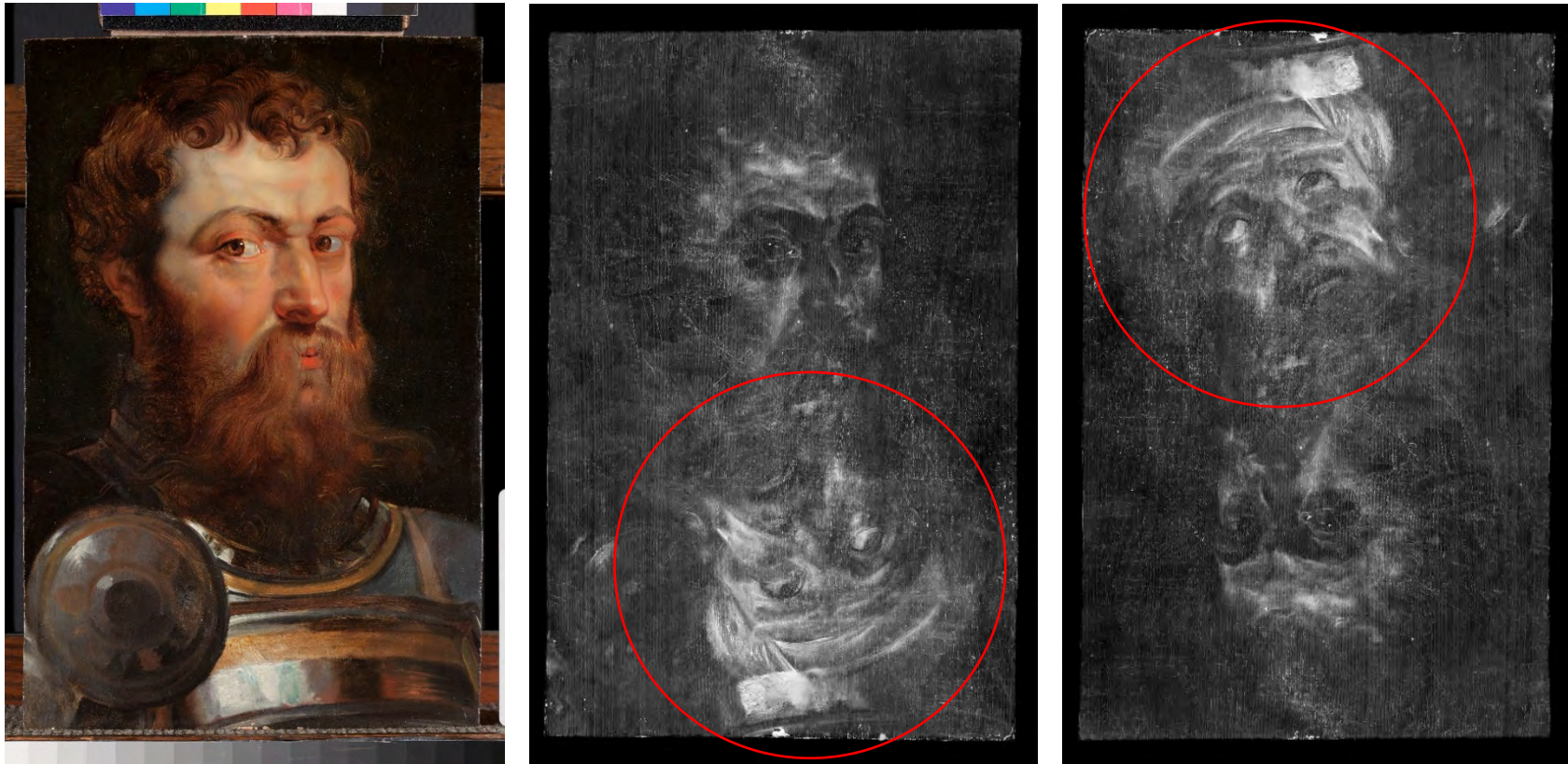


In the UV image on the right you can see that the painting was repaired at some point in its history. Some materials glow/fluoresce differently under UV light. In this case we can see that the materials used for repairing the large tear glow/fluoresce in a dark purplish color, different from the rest of the painting (P.S. Conservators purposely choose materials that glow differently so that future conservators can see what they have done).

EMS Gallery Activity Handout – Teacher Guide

Scavenger Hunt images

Warrior, 1614-1616, Peter Paul Rubens, Flemish; oil on oak panel



In the X-Rays to the right of the painting you can see that the artist painted over the top (and upside down) of a different study of a man wearing a turban. X-radiography can reveal artist's brushwork, changes to the composition, as well as overpainted unrelated compositions. In this case the man wearing a turban is revealed because the materials used to paint him were denser than the paints covering him (P.S. If Rubens had not inverted the panel for his painting of the warrior, the painting would have been much more difficult to decipher as the dense paints in the warrior's face would have interfered with the man with a turban).

EMS Gallery Activity Handout – Teacher Guide

Watson and the Shark, 1782, John Singleton Copley, American; oil on canvas



In the UV image on the right you can see that the painting was repaired at some point in its history. Some materials glow/fluoresce differently under UV light. In this case we can see that the materials used for repairing the losses in the sky glow/fluoresce in a dark purplish color, different from the rest of the painting (P.S. Conservators purposely choose materials that glow differently so that future conservators can see what they have done).

EMS Gallery Activity Handout – Teacher Guide

St. Francis of Assisi, 1680 and 1700, attributed to Jose de Mora, Spanish, polychrome coniferous wood, glass, cord, hair



In the X-Rays on the right notice the different shades of gray which indicate different densities of the materials in the sculpture. Metals often look bright white in an X-Ray as metals are very dense and hard for the X-Rays to pass through. Indicated by red circles you can see some of the metal inside the sculpture, such as nails and a plate on his head where possibly a halo would have been attached.

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ADDITIONAL RESOURCES

In-class Lab Activities:

1. Make your own pigments, paints, and dyes

<https://chavelli.com/blog/making-basic-pigments-from-scratch>

<https://recyclenation.com/2015/04/how-to-make-dyes-paints-from-plants/>

<https://thebeakerlife.com/a-second-life-for-scraps-making-natural-dyes-with-fruits-and-vegetables-b289a125fac2>

2. UV radiation activities using UV beads

Solar UV information, bookmarks, and activities from Stanford: <http://solar-center.stanford.edu/activities/UVBeads/UV-Bead-Instructions.pdf>

UV and sunscreen activities and videos from Steve Spangler Science: <https://www.stevespanglerscience.com/lab/experiments/uv-reactive-beads/>

See DIA conservation professionals in action!

Videos from *Fakes, Forgeries, and Mysteries*, a 2010 DIA exhibition

<https://www.youtube.com/playlist?list=PLE0B4C31D9D509494>

Join PBS and the DIA on a Virtual Field Trip! (Archived from 2016)

<https://www.pbs.org/video/dptv-education-di-virtual-field-trip/>

Lesson plans and video clips: <https://dptv.pbslearningmedia.org/resource/a3c3a89e-de35-4ab8-815f-2a3d3b1ff9dd/dia-virtual-field-trip-science-at-the-museum-steam-unit/>

Additional Conservation Resources

Conservation of a Renaissance work <https://www.youtube.com/watch?v=V--J37806dU>

Art Institute of Chicago's *Conservation and Science* <https://www.artic.edu/about-us/departments/conservation-and-science-2>

The Getty Conservation Institute <http://www.getty.edu/conservation/>

"Becoming a Conservator" guide: <https://www.culturalheritage.org/about-conservation/become-a-conservator#.VzNhGvkrJhE>

The National Center for Preservation Technology and Training <https://www.ncptt.nps.gov/>