Art and the Electromagnetic Spectrum: A Classroom Lesson

National Standards Addressed in this Lesson:

9-12.5 SCIENCE AND TECHNOLOGY
As a result of activities in grades 9-12, all students should develop
Abilities of technological design
Understandings about science and technology

9-12.6 PERSONAL AND SOCIAL PERSPECTIVES
As a result of activities in grades 9-12, all students should develop understanding of
Science and technology in local, national, and global challenges

Overview
This lesson will help students understand applications of electromagnetic radiation in art conservation. In particular, students will learn art conservators use ultraviolet, infrared, visible light, and x-radiation to examine artwork. Properties of each form of radiation and its uses in art conservation will be introduced. Students will then solve problems.

Content Background
Art conservation is not a new field, but very few people are aware it exists. Using different parts of the electromagnetic spectrum allows conservators to learn a great deal about the objects on which they working. Art conservators make practical use of ultraviolet, infrared, and x-radiation on a regular basis to investigate artwork.

Conservators adhere to a very strict code of ethics, which includes prolonging the life of the artwork. Ultraviolet (UV), infrared (IR), and x-radiation can help a conservator determine how an artwork has aged and how it has been damaged.

As part of their code of ethics, conservators use materials that distinguish their work from that of the artist. For example, a conservator may in-paint an area where paint has been lost. The conservator will choose an in-painting material that will be evident under UV, so there is no confusion about what work the conservator has done.

Materials
A computer with Internet access and a projector.
Class set of “Conservator’s Challenge” cards and Conservator’s Recommendations.

Time
This lesson is designed for one session, but it can be broken up or extended depending on the schedule of the class and the chosen activities.

Content Expectation
Successful presentation of this lesson depends upon student understanding of the electromagnetic spectrum. If the spectrum and the concept of waves have not been introduced, they should be covered before proceeding with this lesson.

Procedure

Refresh or present the concept of electromagnetic spectrum. This lesson focuses primarily on UV, visible light, IR and x-radiation.

1. Begin by introducing students to the concept of art conservation by showing them the video at http://americanart.si.edu/lunder/video.cfm?key=9&subkey=1206 (This feature requires the QuickTime Player, a browser plug-in that your technology coordinator can install for you if you do not already have it.)

2. After the video, lead a discussion about art conservation. The profession is an interesting intersection of chemistry, physics, history, and the fine arts. Students may discuss the challenges that conservators might face. Possible discussion questions include the following:
   a. What are the skills that someone would need to be a conservator?
   b. What sort of challenges do you think conservators face?
   c. In the video, the painting conservator said that the materials used for in-painting should be reversible. Why is that?

3. Discuss the uses of different types of radiation. You may either start with visible light (i.e., What could a conservator see with the naked eye that might tell him that materials have aged?) or the UV example given in the movie. (Why is UV radiation able to reveal previous conservation work done on a painting?) This discussion should probe what each wavelength does.

   a. ***X-rays*** are located on the electromagnetic spectrum between ultraviolet and gamma rays. The depth of penetration of x-rays through a material depends on its density. A common use of x-rays in museums is to photograph density variations in composite materials, i.e., to examine painting pigments and sculpture structures.[1] For example, if a ceramic sculpture is suspected of having a crack, an x-ray will be taken to determine the severity of the crack.

   b. ***Ultraviolet radiation*** has waves just a bit shorter than visible light. Ultraviolet radiation, also referred to as ultraviolet light, is used generally in conservation to differentiate types of paints. For example, newer in-painting will appear dark under UV light, making it easier for the conservator to identify. Similarly, some varnishes and pigments will fluoresce or phosphoresce differently depending on the chemical make-up of the substance, thereby helping the conservator identify the material in the artwork.

   c. ***Visible light*** can be seen with the naked eye. Discoloration, pigment change, and structural damage are often first seen this way.

   d. ***Infrared radiation*** can reveal an underdrawing that lies below the paint surface. Conservators will often use infrared reflectography, which is set up as a closed-circuit television system. A light source is directed at the painting, and the camera detects reflected infrared radiation. This signal is converted into a black and white image on a television monitor. Underdrawings executed in infrared-absorbing materials, such as black chalk or bone black, will appear dark on the screen, because they do not reflect infrared light. [2]

4. Now that students have a brief understanding of what tools conservators use, they can meet the challenges that conservators face. Break students into manageable groups (preferably of 3 or 4). Each group will be presented with three "Conservator's Challenge Cards," which present conservation problems. They will then write three recommendations, one for each challenge. (These worksheets are attached.)

5. After all groups have completed their recommendations, share the results (also attached) with the class. Discuss why the correct radiation was the best solutions for each problem.

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[1] CAMEO: Consevation & Art Material Encyclopedia Online
http://cameo.mfa.org/index.asp

[2] Spronk, R. (n.d.) *Investigating the Renaissance.* Retrieved September 9, 2008, from The Fogg Museum's Investigating the Renaissance Site: http://www.artmuseums.harvard.edu/Renaissance/iframes.html

Smithsonian American Art Museum

Lunder CONSERVATION CENTER

Conservator Challenge Card #1

This portrait of Judith Langley has been brought to your conservation lab. There is a heavy coat of varnish on the surface that shows discoloration in visible light. The texture of the surface of the painting and the thickness of the discolored varnish leads you to believe there might be something hidden beneath the layers of varnish in the upper left-hand corner of the portrait. What might you use to find out if there is something underneath?

Judith Langley
n.d.
Attributed to Jan Anthonisz van Ravesteyn
oil on canvas
23 x 19 in. (58.4 x 48.3 cm.)
Smithsonian American Art Museum

Bequest of Mabel Johnson Langhorne

Smithsonian American Art Museum

Lunder Conservation Center

Conservator Challenge Card #2

A group of siblings has graciously offered to donate a family portrait to the museum in memory of their mother. Scholars have confirmed that the painting is by John Smibert, a famous early American colonial portraitist. Examination in visible light makes you think there is discolored varnish on the surface of the painting. You would also like to check more closely for paint loss and previous conservation. What would you use to find out?

A Member of the Livingston Family
1740's
John Smibert
oil on canvas
42 x 30 in. (106.7 x 76.2 cm)
Smithsonian American Art Museum
Gift of the Amirkhan children in memory of their mother, Babette Keeler Amirkhan, Educator, and Livingston Family Descendant

Conservator Challenge Card #3

Museums often loan artwork to other places. In this case, the sculpture *Glory, Glory* pictured left has been requested for a multi-venue loan. That means that it will travel to many places. Before this is packaged and sent, you must be sure that there are no cracks or structural damage that you cannot see. How might you find out?

Glory, Glory
1938
Viktor Schrekengost
modeled and glazed terra cotta with engobe
18 5/8 x 10 3/8 x 9 in. (47.3 x 26.3 x 22.9 cm.)
Smithsonian American Art Museum
Gift of the artist

Smithsonian American Art Museum

Lunder CONSERVATION CENTER

Conservator's Recommendations

What form of electromagnetic radiation would you use to solve each challenge? Be sure to include why that particular radiation will help solve the challenge.

Challenge #	What type of electromagnetic radiation?	How will that type radiation help you?
1.		
2.		
3.		

Conservator's Recommendations

What form of electromagnetic radiation would you use to solve each challenge? Be sure to include why that particular radiation will help solve the challenge.

Challenge #	What type of electromagnetic radiation?	How will that type radiation help you?
1.	Infrared radiation (IR)	IR will allow me to see if there are underlying drawings (underdrawings) beneath the surface of the painting.
2.	Ultraviolet Radiation (UV)	In-painting (or previous conservation) could show up as dark areas under UV light, allowing me to see differences from the original paint.
3.	X-radiation	X-rays will allow me to see if there are any damages to the structure of the sculpture. The x-rays allow me to see the differences in density to find places in the sculpture that need special packing care.

The Results

#1 IR! That's right, infrared radiation helped conservators at the Smithsonian American Art Museum see a coat of arms that was hidden beneath layers of discolored varnish. Check out the pictures!

Before Conservation

Infrared

After Conservation Treatment
(after removal of discolored varnish)

Attributed to Jan Anthonisz van Ravesteyn, (no date), ***Judith Langley,*** oil on canvas, 23 x 19 in. (58.4 x 48.3 cm.), Smithsonian American Art Museum, Bequest of Mabel Johnson Langhorne

The Results

#2 UV! Ultraviolet radiation allowed conservators at the Smithsonian American Art Museum to identify discolored varnish and areas of in-painting.

Before Treatment

Under Ultraviolet

John Smibert, 1740's, ***A Member of the Livingston Family,*** oil on canvas, 42 x 30 in. (106.7 x 76.2 cm), Smithsonian American Art Museum, Gift of the Amirkhan children in memory of their mother, Babette Keeler Amirkhan, Educator, and Livingston Family Descendants

#3 X-ray! X-radiation allowed conservators at the Smithsonian American Art Museum to look for cracks and areas of weakness in the sculpture. Just like in a medical x-ray, the dense places are white and the less dense places are black. The conservators could tell that the heads and arms were hollowed out. The line through the center of the sculpture means that it was created in two pieces. A special crate will be made in order to ship the sculpture.

Viktor Schrekengost, ***Glory, Glory,*** 1938, modeled and glazed terra cotta with engobe, 18 5/8 x 10 3/8 x 9 in. (47.3 x 26.3 x 22.9 cm.), Smithsonian American Art Museum, Gift of the artist