WILLIAMS COLLEGE MUSEUM OF ART

Educator's Guide

Photography at the Frontier of Physics and Art

June 5 – December 12, 2010

Elementary, Middle, and High School Levels

WILLIAMS COLLEGE MUSEUM OF ART

encounterart.

Cover image:

Karen Kwitter, Ebenezer Fitch Professor of Astronomy, Williams College
V838 Monocerotis (Light echo)
NASA and The Hubble Heritage Team (STScI/AURA)

Guide developed by:

Caroline O'Connell & Jennifer Oswald
Williams College, Class of 2011

Joann Harnden
Coordinator of Education Programs

Overview

We look forward to your visit at the Williams College Museum of Art (WCMA). We hope this information will help you to integrate your museum experience with your classroom lessons.

The Tour:

Your group will tour the exhibition **Photography at the Frontier of Physics and Art**, which looks at the work of four photographers and two scientists whose work straddles the border between physics and art. The images on display offer "aesthetically informed presentations of data and creative interpretations of the underlying principles governing the universe."[1] Tours will focus on selected examples of the artists' projects that are particularly resonant for different age groups. During the tour, students will discuss the photographers' projects, techniques, and the choices they made, as well as how each image investigates issues of science and art simultaneously.

Students will build an understanding of photography as a tool for scientific research and of the artistic choices photographers make even when they are simply documenting a phenomenon. Students will learn how photographers approach their projects, how different photographic techniques function, and how we "read" photographs — including what we can and can't learn through the visual image.

After looking at and discussing objects from the collection, students will have the opportunity to conduct their own photographic experiments, while using the photography tools of composition, framing, lighting, and point of view. Tours for grades PreK-2 will also include storybook readings.

If you have any questions, concerns, or would like to share creative suggestions, please don't hesitate to contact us. Please let us know if there are any particular areas of interest or special needs to be accommodated during your visit.

Contact the Education Office at (413) 597-2038 or e-mail Joann Harnden, Coordinator of Education Programs, at Joann.Harnden@williams.edu.

[1] *Source: Curatorial text by John Stomberg, Deputy Director/Chief Curator and Lecturer in Art at WCMA.*

Contents

INTRODUCTION TO THE EXHIBITION

Always a child of science and aesthetics, photography combines mechanics, chemistry, and the properties of light with choices about composition, framing, focus and shading. ***Photography at the Frontier of Physics and Art*** presents the work of four artists and two Williams College professors who have used photography to interpret the scientific world. From animal locomotion to flowers in bloom, electricity, speeding bullets, and views of the cosmos, the images on display explore a wide range of physical phenomena and blur the line between science and art. These artworks represent both scientific advancements and aesthetic concerns, and ultimately prompt us to consider the artistry in science and the science in art.

The earliest photographer in the exhibition, **Eadweard Muybridge,** started his photographic career making artistic landscapes. However, he is best known for devising a revolutionary sequential imaging technique that allowed him to photograph the stages of motion and led to the development of cinema. American expatriate **Man Ray** created his portfolio of photogravures, *Electricité*, as an interpretive scheme for understanding the meaning, rather than the function, of electricity. A great documentarian of New York City, **Berenice Abbott** turned to photographing representations of physics late in her career. She argued that physicists needed the aid of an artist to fully explain their work and joined a team at the Massachusetts Institute of Technology (MIT) who wrote the new standard text book for high school physics in the late 1950s. **Harold Edgerton**, a brilliant MIT electrical engineer, pioneered the use of strobe lights in understanding the mechanics of motion.

As a teaching museum rooted on a college campus, we are excited to include the work of two scientists from the faculty of Williams College. Biologist **Joan Edwards's** super slow motion studies of flower blooms have led to new understandings of the entire reproductive cycle of plants. Astrophysicist **Karen Kwitter** works to understand the composition of matter in outer space through studying the light they emit. Edwards and Kwitter demonstrate the ongoing use of photography and creativity in the practice of science.

Source: Adapted from Curatorial Text by John Stomberg

Photography at the Frontier of Physics and Art *was organized by John Stomberg, Deputy Director/Chief Curator and Lecturer in Art at WCMA, with assistance from Nina Cochran, Williams College Class of 2011.*

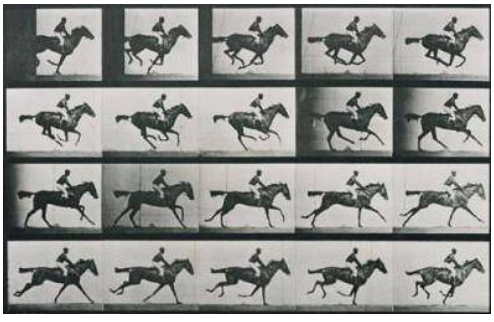
BACKGROUND INFORMATION

The artists' projects on view range across the history of photography and illustrate various technological improvements and aesthetic movements. We see, for example, Muybridge's early collotypes and sequence-of-motion images lead to Edgerton's high-speed stroboscopy and Edwards' videos. Photography has always stood apart as a medium able to capture precise records of the natural world, a quality that has served scientific endeavors well. At the same time, that quality has also been the source of a reluctance to accept photography as a "true" art form. Artists like Man Ray were pioneers in demonstrating that photography could be highly aesthetic, and even abstract. Meanwhile, the work of Abbott and Edgerton helped prove that composition, shapes, and motion were just as important in photography as in media like painting or sculpture.

Students will look at a sampling of the work from each artist to see how photographers throughout time have been interested in exploring the scientific world. The tour will focus on what aspect of science each artist chose to explore, what techniques they used to explore it, and what artistic choices they made to create visually compelling – as well as scientifically informative – images. Tour stops will be selected from the options listed below.

All artist descriptions below are adapted from curatorial text by John. R. Stomberg, Deputy Director/Chief Curator, and Nina Cochran, Williams College Class of 2011.

Eadweard Muybridge, *Animal Locomotion,* 1887, portfolio of collotypes



"Annie G. Galloping" from *Animal Locomotion*

Eadweard Muybridge's (American, born in England, 1830-1904) photos of animal locomotion were a departure from his previous work as a landscape photographer for the U.S. government. Muybridge was a successful commercial photographer by 1872, the year when two acquaintances had a dispute about whether a galloping horse ever lifted all four legs off the ground at once. Muybridge was called in to settle the matter with photography. To do so, he had to invent new technologies to enableextremely fast exposure times. His famous early prints of a galloping horse required a shutter that could operate at only 1/1000th of a

second. This short exposure time necessitated improvements to the **dry-plate developing technique**. Muybridge set up a series of twelve cameras in a row that were either manually or electronically triggered. Their shutter blades were held back with a catch that was operated by an electro-magnet that could release the shutters in quick succession – capturing multiple individual shots of the moving object. All twelve pictures were taken in the space of about half a second. This project led to one of Muybridge's first publications: *The Horse in Motion* (1882). Muybridge's discoveries made it clear that earlier artists had been mistaken in many of their (supposedly realistic) portrayals of animal movement. One artist, Meissonier, even repainted one of his horse pictures based on Muybridge's images. Muybridge continued to take pictures investigating the motion of humans and animals throughout the rest of his life. After his famous experiments capturing a horse in motion, Muybridge moved on to study human motion as well.

The prints on view at WCMA are selections from *Animal Locomotion*, a portfolio of 781 prints published in 1887. In *Animal Locomotion*, we see men and women participating in a variety of activities – walking up stairs, climbing on a stool, throwing a ball, and even swinging a pick axe. Muybridge captured the essence of movement by photographing subjects in quick succession and displaying the resulting images as a series. Viewed together, these pictures communicate the figure's fluid movement through space and time. His work had direct applications in the natural sciences, providing the first objective analysis of animal locomotion. It offered technological advances in photography that led to research in countless fields. He also had enormous influence on artists, correcting their understanding of how animals move (as opposed to how we see them move) and offering concrete visual options for modernist artists interested in the subject of time.

Adapted from curatorial text, with additional sources:

"Eadweard Muybridge: Father of Motion Pictures." Photo-Seminars Website. www.photo-seminars.com/Fame/muybridge.htm. 8/27/10.

Gopnik, Blake. "Frame of Reference: Blake Gopnik on Eadweard Mubridge show 'Helios' at Corcoran." Washington Post. April 10, 2010. www.washingtonpost.com/wp-dyn/content/article/2010/04/09/AR2010040902680.html. 8/25/10.

Man Ray, *Electricité: Dix Rayogrammes,* 1931, photogravure prints

"Le Souffle" from *Electricité*

Man Ray (born Emmanuel Radnitsky, American, 1890-1976) made this series of images as an advertising campaign for a French utilities company. An innovator in terms of technique and content throughout his career, Man Ray captured both the look and the excitement of electricity for a 1931 commission from the Parisian electric company *La Campagnie Parisiene de Distribution d'Electricité* (CPDE). In an effort to spur the domestic use of electricity, the company published a limited edition (500 copies) photogravure portfolio of Man Ray's photographs, entitled simply *Electricité,* which they gave to their wealthier clients. Man Ray had a special affinity for the subject as he lived in the only electrified building in the Montparnasse area of Paris at the time. The electric company selected Man Ray for "certain qualities that he embodied—modernity, invention, pioneering independence, characteristics with which the CPDE wanted to be identified."[2]

During the 1920s, the half-dozen private electricity companies in Paris primarily served the industries and wealthy households. These companies anticipated much greater demand in the future, expecting to expand service to middle and lower-income consumers in the 1930s. New power facilities were created to meet the anticipated increase in demand. However, with the beginning of the Depression in France in around 1930, demand for electricity stagnated, so electric companies began to wage concerted campaigns to encourage households to use more electricity by purchasing and using more electronic appliances.

For many of the images in the portfolio, Man Ray used a camera-less technique in which he placed objects directly on the surface of photographic paper and then exposed it to light, creating a **photogram,** or what he called a "**rayogram**." For other prints he used techniques such as **multiple exposure** and **solarization**. The resulting images evoke the tension between the known and the mysterious – the rational and the irrational – that

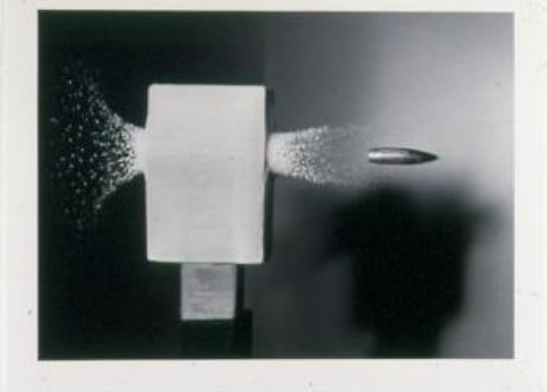
[2] Spray, Stephanie, WCMA Andrew W. Mellon Intern, 1993094. *May Ray: Électricité.* WCMA Exhibition Brochure, October 30, 1993-January 23, 1994.

characterized so much of modern culture during the Machine Age. The photos depict semi-abstracted images of these appliances (like an iron or a toaster), paired with titles such as "Laundry Room," or "Dining Room" to imply the sort of convenience electricity could bring to a home. Many of these portfolios have not survived, so this exhibition offers a rare opportunity to view this unique fusion of the avant-garde and the commercial.[3]

Adapted from curatorial text, with additional source:
Spray, Stephanie, WCMA Andrew W. Mellon Intern, 1993-94. May Ray: Électricité*. WCMA Exhibition Brochure, October 30, 1993-January 23, 1994.*

Harold Edgerton, selected works, 1934-64, gelatin silver prints

Harold Edgerton (1903-1990), or "Doc" as he was known to most people, considered himself a scientist first and foremost. He studied engineering at MIT and became a professor of electrical engineering there in 1934. He was awarded the Medal of Freedom in World War II for advancements in nighttime aerial photography, and helped develop a photographic process that could document a nuclear explosion during the Cold War. He is best known in the art community for his stroboscope images, which seem to freeze super-fast motion on film. His images of tumbling acrobats, spinning fans, and bullets shooting through playing cards and soap are both technologically impressive and artistically striking.



Bullet Through Ivory Soap

Edgerton revolutionized the photography of moving objects, creating images of motion with great precision. He worked with **stroboscopy**, or "strobe-flash," which generates nearly instantaneous bursts of light in repeated succession. He discovered that the flashes of light allowed a camera to record intricate, ultra-high-speed motion that was too fast to be seen by the human eye. For many of his best known images, he held the camera shutter open while using repeated strobe flashes. With this technique he pictured the same object moving through different positions in a single frame. He also used stroboscopy to freeze one incredibly brief moment in the trajectory of exceptionally fast moving objects, such as a bullet. "In the early days of his career, Edgerton's subjects were motors, running water and drops splashing, bats and

[3] Spray.

hummingbirds in flight, golfers and footballers in motion, his children at play. By the time of his death at the age of 86, Edgerton had developed dozens of practical applications for stroboscopy, some that would influence the course of history."[4] His famous images of milk drops and bullets, as well as popular athletes and actresses, introduced the beauty of the scientific world to the popular imagination.

Despite the aesthetic qualities of his iconic photographs, Edgerton remained tethered to science rather than art. An engineer, inventor, and educator at heart, Edgerton focused his work on the advancement of the field of physics through photography. "Don't make me out to be an artist…" Edgerton said, "I am an engineer. I am after facts. Only the facts." Despite this protest, scientists and artists alike have long embraced his work. Indeed, Williams College owns two complete portfolios of his photographs: one in the physics department and one in the art museum.

Adapted from curatorial text with additional source:
"Flashes of Inspiration: The Work of Harold Edgerton." MIT Museum Website.
http://web.mit.edu/museum/exhibitions/edgerton.html. 8/27/10.

Berenice Abbott, *The Science Pictures,* 1982, gelatin silver prints

Collision of Two Balls

Best known for photographing New York City in the 1920s and 1930s, **Berenice Abbott** (1898-1991) turned her camera toward the physical phenomena of complex scientific concepts after 1939. She took her interest in science quite seriously, even taking college courses on electricity and chemistry. With her "science pictures," as she called them, Abbott sought to record the laws of physics on film, noting that "photography is the medium uniquely qualified to unite art with science." Abbott aimed to document physical phenomena by combining visual accuracy with a compositional elegance.

Although photography was largely accepted as art by this time, its full potential as a legitimate tool of modern scientific study had yet to be realized. Everything changed in 1957 when the

[4] "Flashes of Inspiration: The Work of Harold Edgerton." MIT Museum Website. http://web.mit.edu/museum/exhibitions/edgerton.html. 8/27/10.

appearance of the Soviet Union space capsule Sputnik motivated the United States to improve education in science. A renaissance of interest in scientific imagery earned Abbott's "science pictures" a second look. MIT soon hired her to create new images for a new high school physics textbook, *The Attractive Universe: Gravity and the Shape of Space*, published in 1960. Even before she received attention from the scientific community, Abbott associated herself with a group of "objectivist" photographers who worked toward impersonal realism. Abbott believed in making her photographs compositionally strong to represent the beauty of science alongside the facts. *Adapted from curatorial text.*

Karen Kwitter, Williams College Professor of Astronomy

Hubble Telescope Images

V838 Monocerotis (Light echo)
NASA and The Hubble Heritage Team (STScI/AURA)

Astrophysicist **Karen Kwitter**'s research centers on planetary nebulae: glowing gas shells ejected by stars near the end of their lives. Planetary nebulae represent a treasure trove of information about stellar evolution and environment. Their chemical compositions, central stars, morphology and origin have been the focus of her work. Kwitter is currently focusing on chemical abundances in planetary nebulae as a means to understand the formation history of the Milky Way Galaxy and M31 (the Andromeda Galaxy, our neighbor and sibling), an undertaking that requires identifying and obtaining light spectra for newfound nebulae in both galaxies. A planetary nebula is an expanding cloud of gas ejected by a dying star. A galaxy is a large grouping of stars containing up to ten billion stars. The universe may hold as many as ten billion galaxies. Our galaxy is called the Milky Way.

Kwitter works to understand the composition of this matter in outer space by studying the light it emits – her work parallels the interpretive strategies used in the **Hubble Telescope images** on display. To the casual observer, the rich colors and evocative patterns of the nebulae in Kwitter's images are simply beautiful. But for an astronomer like Kwitter, those colors and patterns reveal a wealth of information about the life cycles of stars and the chemical composition of galaxies. Kwitter gathers data in her research by taking the light spectra of different celestial bodies via telescope photographs. Often those photographs result in attractive images like the ones seen

here. Taking color pictures with the Hubble Space Telescope is much more complex than taking color pictures with a traditional camera. The telescope's cameras do not use film, but record different wavelengths of light from the universe with special electronic detectors. These detectors produce images of the cosmos not in color, but in shades of black and white. These black-and-white images are combined and color is added by scientists to create the final image. The hues seen in the prints are not what we would see if we were on a spacecraft. Instead, color is used as a tool to enhance visual detail, to differentiate between different gasses, and to visualize what ordinarily could never be seen by the human eye. In a process that combines science and aesthetics, colors are chosen to augment and inform the black-and-white images in a way that is both appealing and readable to the human eye.

Adapted from curatorial text, Astronomy Faculty Webpage www.williams.edu/Astronomy/people/kkwitter/ and additional sources:

"Cosmology Glossary." Berkeley Cosmology Group Website: http://cosmology.berkeley.edu/Education/IUP/GlossaryP_T.htm. 8/30/10.

"The Meaning of Color in Hubble Images." HubbleSite Webpage: http://hubblesite.org/gallery/behind_the_pictures/meaning_of_color. 8/30/10.

Joan Edwards, Williams College Professor of Biology

Exploding Flowers and Ultra-Fast Plant Movements

Biologist **Joan Edwards'** main research focuses on the evolution of plant-animal interactions. She is particularly interested in how plant behaviors enhance reproductive success. Edwards has devoted several studies to one such behavior: the evolution of "exploding flowers" While we typically think of plants as slow-moving or sedentary, they are actually able to match or surpass the fastest animal movement as they burst open to project their pollen into the air. **Edwards's super slow (ranging from 10,000 to 100,000 frames per second) motion studies** of these flower blooms have led to new understandings of the process involved with the entire reproductive cycle of plants.

Adapted from curatorial text and the Biology Faculty Webpage: www.williams.edu/Biology/Faculty_Staff/jedwards/jedwards.shtml.

Glossary of Photography Terms

It is important to emphasize that photographers make artistic choices when creating, editing, and producing their images in order to share their observations of the world around them. These choices can be said to form the language of photography. They include purely photographic elements such as point of view, framing, cropping, focus and blur, lighting techniques, as well as elements that are common to other art forms such as composition, style, subject, and context. In these exhibitions, the artists' projects share the intention of documenting different natural and scientific processes.

Consider these aspects as you discuss the photographs:

COMPOSITION: Composition is the balance of all the shapes, lines, and patterns, light and shadow, tones, positive and negative space, and how it all works within the picture frame.

FOCUS: Elements are clear or blurry depending on what technique the photographer chooses. Focus creates mood and emphasizes aspects of the image.

FRAMING: The photographer makes choices about what to include and what not to include in the picture frame. Cropping is when the photographer decides to cut out part of the subject, like someone's hat, to make the composition dynamic. Like point of view, framing presents the photographer's frame of reference with regard to the subject.

LIGHTING: Light is the essential ingredient of photography and literally brings the image to life. Photographers pay a lot of attention to the mood created by lighting, and how lighting sculpts forms. Is the lighting bright or dark? Are there any shadows? Is the lighting coming from above, below, or the side? What does the lighting draw your attention to?

POINT OF VIEW: Point of view is where the photographer was standing or positioning him or herself in relation to the subject (From above, below, the side, or an angle). Consider how it affects the way you read the picture. Imagine if the photographer were standing elsewhere or holding the camera differently.

SETTING: Consider what you learn about the subject from the information in back of the subject. Some photographers include the environment to contextualize the subject, and some prefer a plain background to draw your attention to the subject's face or body. Consider the information in front of the subject, too.

SUBJECT: Encourage students to be visual detectives and describe in detail all the things they can see about the subject. What sort of people, animals, or objects can they identify in the image. What are they doing? Can you guess why? What is going on in the image? Why would a photographer be interested in capturing this? Why would a scientist be interested in seeing these images?

TECHNIQUES: What photographic techniques were used? What effects do they have? (High-speed photography? Rayographs? Video?) See **Glossary of Photography Techniques** for more information about the specific techniques used by the artists in this exhibit.

Source: Adapted from Focus on Photography: A Curriculum Guide, *written by Cynthia Way for the International Center of Photography, 2006*.

Glossary of Photography Techniques

The artists featured in this exhibition used a wide variety of photography techniques. In many cases, they invented the techniques themselves. Below is list of the techniques featured in the exhibition, accompanied by a brief explanation of how each method works.

Collotype: The Collotype process was used around the turn of the 20th century. It involves coating a glass plate with sensitized gelatin and exposing it under a negative. The light's passage through the negative hardens the gelatin on the glass plate and the unexposed gelatin absorbs water when washed. The exposed gelatin repels it. The washed glass plate is then coated with ink that adheres to the exposed gelatin and is printed onto paper.[5]

Dry-plate developing technique: Dry-plate developing was inspired by the difficulty of wet-plate developing – a cumbersome process which required high speed and dexterity on the part of the photographer. The dry-plate technique involved using a plate that was chemically treated, but could dry before being used.[6]

Zoopraxiscope: Muybridge's "work in stop-action series photography soon led to his invention of the "**zoopraxiscope**," a primitive motion-picture machine which recreated movement by displaying individual photographs in rapid succession. This machine was demonstrated privately in America as early as 1879."[7]

[5] "Collotype." Victoria & Albert Museum Website. www.vam.ac.uk/vastatic/microsites/photography/processframe.php?processid=pr015. 8/27/10.
[6] Wilson, Lillian. "19th Century Photographic Processes and Formats Represented in 'Captured by the Camera.'" Concord Library Website. www.concordlibrary.org/scollect/Portrait_Exhibit/notes.html. 8/27/10. Pederson, Mark Scholer. "The Silver Gelatin Dry Plate Process." Alternative Photography Website. www.alternativephotography.com/wp/processes/gelatin-silver/silver-gelatin-dry-plate-process. 8/27/10.
[7] "Zoopraxiscope." Digital Arts Institute Website. www.digitalartsinstitute.org/galleries/zoopraxiscope/index.html. 8/27/10.

Photogravures: Photogravures are prints on fine paper that are made from a photographic image that is applied to acid-resist surface on a copper plate, enabling a high-quality reproduction of the image with rich tonal values on paper.[8]

Photogram/rayogram: A photogram, or rayogram (as it was deemed by the artist Man Ray, after his own name), is the term for a form of photography that involves the direct interaction of light and shadow with an object on some sort of photographic surface. The image can be produced without a camera. "The image produced is a negative in the sense that an opaque object blocks light from the film or paper and therefore is not exposed. The areas where no object blocks the light [are] generally black for black and white materials and for color or alternative techniques the background is the color produced by the filter pack or the fully exposed color of the process."[9]

Multiple exposure: Multiple exposure enables a photographer to capture more than one scene in a single frame or image. Images are created by photographing two scenes at reduced-speed exposures onto the same area of film. The reduced speed allows the film to develop a little – but not all the way – before the second image is shot. The two images appear super-imposed on the final photograph.[10]

Solarization: "Print solarization occurs when a photographic print is partially developed, then exposed to white light before the print is completely developed. The effect is a reversal of all or some tones - i.e. some of the image appears to be positive while other portions of it appear to be negative. (Note: Some darkroom technicians obtain the effect by first *completely* developing the print, then exposing it to white light before immersing it in stop bath.) Black and white and color films and papers that are based on silver halide emulsions can also be solarized."[11]

Gelatin silver prints are a form of photographic print where gelatin is applied to the paper and serves as a surface to contain the silver salts that react to light and create the image.[12]

---

[8] Way, Cynthia. *Beyond the Familiar* tour outline. WCMA, 2008.
[9] Rudnick, Les. "Photograms: Introduction." Photograms: Art and Design Website. www.photograms.org/. 8/27/10.
[10] Kulik, Marko. "Multiple Exposure." Photography.CA Website. 2000-2010. www.photography.ca/photography-tips/multiple-exposure/. 8/27/20.
[11] Kulik.
[12] *Beyond the Familiar* tour outline. WCMA. 2008.

Stroboscope: "Stroboscopic photography is a rather more abstract branch of photography, consisting of a flashing strobe light and a camera with an open shutter. Stroboscopic photos must be taken in darkness so that every time the strobe flashes, a still image is taken of a moving object at that instant."[13]

Hubble Telescope images: Launched in 1990, "Hubble is a telescope that orbits Earth. Its position above the atmosphere, which distorts and blocks the light that reaches our planet, gives it a view of the universe that typically far surpasses that of ground-based telescopes."

"Hubble is a type of telescope known as a Cassegrain reflector. Light hits the telescope's main mirror, or primary mirror. It bounces off the primary mirror and encounters a secondary mirror. The secondary mirror focuses the light through a hole in the center of the primary mirror that leads to the telescope's science instruments. People often mistakenly believe that a telescope's power lies in its ability to magnify objects. Telescopes actually work by collecting more light than the human eye can capture on its own. The larger a telescope's mirror, the more light it can collect, and the better its vision. Hubble's primary mirror is 94.5 inches (2.4 m) in diameter. This mirror is small compared with those of current ground-based telescopes, which can be 400 inches (1,000 cm) and up, but Hubble's location beyond the atmosphere gives it remarkable clarity. Once the mirror captures the light, Hubble's science instruments work together or individually to provide the observation. Each instrument is designed to examine the universe in a different way."[14]

Super-slow motion studies: blooming flowers move so slowly that the human eye cannot tell that they are moving at all. Special cameras take thousands of images (10,000-100,000 frames) per second and then play them back at a very fast speed to show the flower's motion.

[13] Peng, Paul (University of Australia, Class of 2012). "Stroboscopic Photography." Penguin's Lab Website. 2007. www.penguinslab.com/Penphotos/strobe.htm. 8/27/10.
[14] Space Telescope Science Institute. HubbleSite. http://hubblesite.org/. 8/27/10.

Making Connections

History

The artists and projects in this exhibition span nearly the entire history of photography – from Muybridge in the late 1800s to Kwitter and Edwards in the present day. The techniques used by the different artists show the development of the technical process of photography, while the subjects of each project are evidence of advancements in scientific knowledge and changes in the concerns of the scientific community. On the tour, students will consider how the featured projects all reflect connections to significant historical events, including the proliferation of electricity, World Wars I and II, the invention of the atomic bomb, and the Cold War.

English/Language Arts

Words and language were an integral part of both Man Ray and Berenice Abbott's projects. Man Ray's photos were part of an advertising campaign, and Abbott's were textbook illustrations. The abstracted images in the *Electricité* series would not have communicated their message so well if they did not have titles to contextualize them, and *The Science Pictures* could not have explained complex physical phenomena without accompanying textbook pages. On the tour, students will reflect on this relationship between words and pictures, considering how both can be used to communicate ideas and discussing how the two can work together to communicate even more clearly.

Visual Arts

Students will have the opportunity to examine photographs from different periods and different technical processes. By comparing and contrasting these works, the students will explore concepts like focus, framing, lighting, composition, subject, and point of view, and how all these elements affect the final image. Students will also consider various uses of visual representations – as documentation, advertisement, illustration and research, as well as decoration.

Science

The images presented connect to many different physics and natural science topics: animal movement, electricity, motion, light, astronomy, and plant growth. The photos on view were all part of scientific endeavors: the result of – or means of proving – various experiments, or a vital tool to teach scientific discoveries to others. Students will consider these experiments, and discuss how photography can be used a scientific as well as an artistic tool.

STANDARDS

The following list presents examples of Massachusetts standards that relate to the material and activities covered in the **Photography at the Frontier of Physics and Art** tour.

Visual Arts Standards: Pre-K–12

1 Methods, Materials, and Techniques. Students will demonstrate knowledge of the methods, materials, and techniques unique to the visual arts.

2 Elements and Principles of Design. Students will demonstrate knowledge of the elements and principles of design.

3 Observation, Abstraction, Invention, and Expression. Students will demonstrate their powers of observation, abstraction, invention, and expression in a variety of media, materials, and techniques.

5 Critical Response. Students will describe and analyze their own work and the work of others using appropriate visual arts vocabulary. When appropriate, students will connect their analysis to interpretation and evaluation.

6 Purposes and Meanings in the Arts: Students will describe the purposes for which works of dance, music, theater, visual arts, and architecture were and are created, and, when appropriate, interpret their meanings.

7 Roles of Artists in Communities. Students will describe the roles of artists, patrons, cultural organizations, and arts institutions in societies of the past and present.

9 Inventions, Technologies, and the Arts. Students will describe and analyze how performing and visual artists use and have used materials, inventions, and technologies in their work.

10 Students will apply their knowledge of the arts to the study of English language arts, foreign languages, health, history and social science, mathematics, and science and technology/engineering.

English/Language Arts: Pre-K–12

1 Students will use agreed-upon rules for informal and formal discussions in small and large groups.

2 Students will pose questions, listen to the ideas of others, and contribute their own information or ideas in group discussions or interviews in order to acquire new knowledge.

History and Social Science

PreK – K Concepts and Skills

2 Use correctly words and phrases related to chronology and time *(now, long ago, before, after; morning, afternoon, night; today, tomorrow, yesterday; last or next week, month, year; and present, past, and future tenses of verbs)*. (H)

4 Use correctly words and phrases that indicate location and direction, such as *up, down, near, far, left, right, straight, back, behind,* and *in front of*. (G)

PreK-K Standards

PreK-K.8

Give examples of different kinds of jobs that people do, including the work they do at home. (E)

Grade 1 Concepts and Skills

1 Use correctly words and phrases related to time and recognize the existence of changing historical periods *(other times, other places).* (H)

Grade 2 Concepts and Skills

2 Use correctly words and phrases related to time *(now, in the past, in the future)*, changing historical periods *(other times, other places),* and causation *(because, reasons).* (H)

Grade 2 Standards

2.10 After reading or listening to a variety of true stories about individuals recognized for their achievements, describe and compare different ways people have achieved great distinction. (H)

Grades 8-12 Concepts and Skills

7 Show connections, causal and otherwise, between particular historical events and ideas and larger social, economic, and political trends and developments. (H, G, C, E)

World History II Learning Standards

WHII.37 Describe how the work of scientists in the 20th century influenced historical events, changed the lives of the general populace, and led to further scientific research. (H)

U.S. History II Learning Standards

USII.30 Describe some of the major economic and social trends of the late 20th century. (H, E)

- **A.** the computer and technological revolution of the 1980s and 1990s
- **B.** scientific and medical discoveries

Science: Pre-K–2

Physical Sciences (Chemistry and Physics) Standards

3 Describe the various ways that objects can move, such as in a straight line, zigzag, back-and-forth, round-and-round, fast, and slow.

Science: Grades 3-5

Earth and Space Science Standards

13 Recognize that the earth is part of a system called the "solar system" that includes the sun (a star), planets, and many moons. The earth is the third planet from the sun in our solar system.

Life Science (Biology) Standards

2 Identify the structures in plants (leaves, roots, flowers, stem, bark, wood) that are responsible for food production, support, water transport, reproduction, growth, and protection.

Physical Sciences (Chemistry and Physics) Standards

4 Identify the basic forms of energy (light, sound, heat, electrical, and magnetic). Recognize that energy is the ability to cause motion or create change.

5 Give examples of how energy can be transferred from one form to another.

7 Identify and classify objects and materials that conduct electricity and objects and materials that are insulators of electricity.

Science: Grades 6-8

Earth and Space Science Standards

12 Recognize that the universe contains many billions of galaxies, and that each galaxy contains many billions of stars.

Physical Sciences (Chemistry and Physics) Standards

11 Explain and give examples of how the motion of an object can be described by its position, direction of motion, and speed.

3 Communication Technologies

Central Concept: Ideas can be communicated though engineering drawings, written reports, and pictures.

3.2 Identify and explain the appropriate tools, machines, and electronic devices (e.g., drawing tools, computer-aided design, and cameras) used to produce and/or reproduce design solutions (e.g., engineering drawings, prototypes, and reports).

Science: High School

Earth and Space Science Standards

4.3 Explain how the Sun, Earth, and solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 billion years ago.

Introductory Physics Standards

5.6 Recognize that moving electric charges produce magnetic forces and moving magnets produce electric forces. Recognize that the interplay of electric and magnetic forces is the basis for electric motors, generators, and other technologies.

PREPARING FOR A VISIT

GOALS

- To prepare students for the museum visit and to make curriculum connections.
- To prompt critical thinking, close observation, and discussion of the ways science and art can connect or be used to inform one other.
- To engender greater awareness of the types of artistic choices a photographer makes when taking a photograph, and how those decisions affect the work.

Pre-Visit Activity: Discussion

Elementary, Middle & High School

Preparation

- Review the description of the exhibition and background material.
- Consider the possible curriculum connections and provide your students with relevant background before your visit.
- Introduce students to what they will see and do at the museum, introducing key concepts through the class discussion activity described below.

Standards

Visual Arts 2, 5, 6, 8, 9, 10. English Language Arts 1, 2.

Materials

A projector and screen or blank wall.

Images by one or more of the photographers featured in the exhibition. Images by Edgerton, Muybridge, and Man Ray from the WCMA collection are available online from the museum's new collection database. Go to www.wcma.org and click on "search the collection."

Procedure

1. Project a single image for the entire class to view and discuss together. Key discussion questions are suggested below.

2. After a class discussion, you may wish to ask students to each select a photograph related to science (from a magazine, newspaper, or classroom textbook). Students can discuss their photograph in small groups or use them in an essay, describing the key features of the photograph and how it relates to science, and addressing the key points below. For older students, this could take the form of a writing assignment that prompts students to describe how the photograph enhances their understanding of the scientific process it depicts.

Discussion Questions: Illustrating Scientific Processes

The term "science" encompasses many different things. It can refer to anything from the simplest observation of nature to the most complex studies of motion or mechanics. Science is not just about content – it is a process of observing, examining, and testing theories about how our world works. Images can provide us a deeper or more nuanced understanding of the process at hand or the subject under study. Many subjects that scientists study are so complex that they are difficult to describe only with words. Sometimes, images can accomplish what words cannot. The photographs in the exhibition are pioneering examples of how the developing technological process of photography could be applied to advance our understanding of science. The questions below are designed to help build visual literacy and observation skills, making students think about how both artistic and scientific elements come into play in various images. What is science, and how do these artistic images address it?

- Action: What is going on in the picture? Can you describe the sequence of events?
- Subject: What do you see in the picture? What details might be most important to a scientist? To an artist? What scientific concept or phenomena is depicted?
- Composition: Describe the composition. Do you see any prominent shapes, diagonals, or other patterns?
- Techniques: Consider the use of lighting and different photographic processes. Do these techniques add to the atmosphere of the picture or affect how much information it provides?
- Point of view: From where did the photographer take the picture? (From above, below, the side, or at an angle?)

- Intention: Why did the photographer take this photo? What might he/she have been trying to illustrate or prove?

- Tone: What is the photographer's attitude toward the subject? What details about the photograph tell you this?

- Science vs. Art: How does the photographer use composition and technique together? How did the photographer use aesthetics to help make his or her scientific point?

- Communication: What ideas/information does this image communicate? What do you think of the artist's choice of title? What would you call this image?

Source: Adapted from Focus on Photography: A Curriculum Guide. *Written by Cynthia Way for the International Center of Photography, 2006.*

Pre-Visit Activity: Capturing Motion

Elementary, Middle & High School

Preparation

Review the images by Muybridge, Edgerton, and Abbott included in this guide.

Standards

Visual Arts 1, 5, 10. English Language Arts 1, 2. Technology/Engineering 1, 2.

Materials

A camera or cameras – either digital or instant.

A well-lit area with enough space for students to move around.

Procedure

Have students partner up and take turns trying to photograph their partner in motion. For example, one student could do a jumping jack, run, wave an arm, give a high-five, etc. while the other student attempts to document this movement clearly and precisely on camera. After each student has had a turn to be both the photographer and the subject, gather all students back together to discuss how the project went. Was their task easy or hard? The students should notice how difficult it is to capture movement on camera. Discuss why this might be difficult and what a photographer might do to try to fix the problem.

Follow-up Discussion

After the students have taken their pictures, consider discussing the following questions:

- Why might a scientist want to capture movement? Why might an artist?
- What can be learned from images of things in motion? What can be learned from the pictures we all took today?
- Compare what the eye can register vs. what a camera can register. Have students reenact their motions while the class observes them, then compare what they saw with what they can see in the photographs.
- What else can we use our resulting photos for? To help draw pictures? To help collect data?

Post-Visit Activities

Goals

- To reinforce concepts introduced during the tour.
- To explore the medium of photography in greater depth, from the perspective of a viewer, a photographer, a scientist, and/or a student of science.
- To use art and writing activities to make curriculum connections.

Post-Visit Activity: Make Your Own Rayograms!

Elementary, Middle & High School

During the tour we discussed many different techniques for making photographs. One of those techniques was called a **rayogram**, which the artist Man Ray named after himself. Rayograms are made by placing objects directly on top of light sensitive paper and then exposing it to light. It is a useful technique for creating a more abstract image. It holds the potential for fun and creative applications and lends itself easily to experimentation.

Objectives

Students will:

- explore different photography techniques.
- gain a better understanding of the process Man Ray used in his *Electricité* series.
- create photographs and explore composition, subject, and light.
- compare and contrast the effects of natural and man-made materials.

Standards

Visual Arts 1, 2, 3, 5, 9. English Language Arts 1, 2.

Materials

Solar-activated photo paper, often called sun print or cyanotype paper

Natural material (leaves, rocks, sticks, etc.)

Man-made material (pencils, paper shapes, lace, buttons, etc.)

Plain white paper

Clipboards

Trays with water for developing images

Blotter or clothesline and pins to dry images

Procedure

1. Explain that students will create a photographic image using the photogram/rayogram technique (the same used by Man Ray to make his *Electricité* series featured on the tour). Describe how the photo paper works – it develops as soon as it is exposed to light, and anything placed on top of it will leave a white silhouette against a blue background. The longer the exposure time, the greater the contrast in the final image.

2. As a class, discuss the types of objects available for use in the rayograms, taking time to differentiate between natural objects and man-made. Give students time to select their objects.

3. Because students will have a limited time to place their objects on the paper once it is exposed to light, it is best if they decide how they would like to place their objects beforehand. Ask students to place the objects on a blank sheet of plain paper on a clipboard and play with different arrangements of objects on the plain paper before using the photo-sensitive paper. Encourage them to consider the difference between natural and man-made objects in their composition.

4. Bring the class outdoors, asking students to carry their compositions outside on their clipboards. Distribute a piece of photo paper to each student and instruct them to arrange their objects on the paper. Leave the paper in the sunlight for the time period designated on the instructions for the sun print paper.

5. Place the sun-exposed paper in a water bath for one minute to develop the image. Hang the print to dry or place in a blotter book.

6. After the rayograms have dried, gather students together to share/talk about their creations and the thinking behind the composition. Reflect upon the effects of the man-made objects and the natural objects. When the images are dry, students can add color (with colored pencils) or text.

Extension

Experiment with multiple exposures. Create one arrangement of objects, expose it to light, then change the arrangement or add different objects, and expose the paper to light a second time.

Background Information: The Science Behind the Sun Print

"The sun sensitive paper is coated with light-sensitive chemicals, which react to light waves and particles when exposed to light. When you place objects on the paper, they block the light and turn white while the paper around them remains blue. Water stops the process and fixes your images on the paper.

In the lab, photosensitive paper is made by coating a sheet of paper with a water-soluble, bluish-green compound called iron (III) hexacyanferrate (III), Fe[Fe(CN)6]. The common name for this chemical is Berlin green - a well-known photosensitive chemical. When exposed to ultraviolet light (UV), a chemical reaction takes place where the water-soluble Berlin green changes into a water-insoluble chemical called iron (III) hexacyanoferrate(II), Fe[Fe4(CN)6]3 The common name for this chemical is Prussian blue. When you rinse your print in water, the water-soluble Berlin Green washes away, but the water-insoluble Prussian Blue remains fixed on the paper. The intensity of the Prussian Blue depends on the amount of time the paper is exposed to the light source and the intensity of the light source. For example, Sun Sensitive Paper doesn't work nearly as well on a cloudy day as it does on a sunny day."

Source: *Steve Spangler Science: Making Science Fun!* Website: http://www.stevespanglerscience.com/experiment/sun-sensitive-paper-experiment

Post-Visit Activity: Motion Studies

Elementary, Middle & High School

What can we learn from photo series like Eadweard Muybridge's locomotion studies? Why would scientists be interested in studying the way people or animals move? How can we use photography to document different actions? In this activity, students will create their own photographic motion studies, exploring the complex steps in simple actions and learning about different methods for capturing movement.

Objectives

Students will:

- work together with classmates to make and test theories about motion, and then capture a series of movements on a camera.
- analyze the reasons for motion studies and discuss what can be learned from them.
- identify the challenges of depicting motion and discuss how different camera settings work to do this.

Standards

Visual Art 1, 2, 3, 5, 6, 9, 10. ELA 1, 2. Technology/Engineering 1, 2, 3. Scientific Inquiry 1.

Materials

- Digital or instant camera/s.
- Computer and/or printer to display images off of camera.
- Space large enough for students to move around.

Procedure

1. Divide students into pairs or small groups. Tell each group to brainstorm several types of motion that would be interesting or informative to document (e.g. walking, dancing, picking up an object). Have students discuss what could be learned from documenting their chosen motion, creating a theory to test or posing a question to answer with pictures.

2. Have students take turns going through those motions while another student photographs them. The person performing the motion should move as if in slow motion,

while the photographer says “freeze” at four or five points where he or she wants to take a picture.

3. After all students have taken turns being both the photographer and the subject, collect the cameras and download the files to a computer. Either print out the images or display them with a PowerPoint presentation. *Note: Putting the pictures in PowerPoint or making a slideshow presentation out of them will allow students to scroll through the images rapidly – creating an interesting flip-book or motion picture effect.*

4. Have students share and discuss their motion studies. What action did they choose and why? Why did they choose to take pictures at one point in the action instead of another? What did they learn from their images? Did they answer their question or prove their theory? If these image series were displayed in a museum, like the Muybridge photos on the tour, what could viewers learn from them?

5. If you have a digital camera with a “sports” or “action” setting on it, try experimenting with that. Compare and contrast the images taken with the action setting to the images taken earlier. Which images are more interesting to look at? Which images tell the most about how an action works?

Post-Visit Activity: Make Your Own "Science Pictures"

Elementary, Middle & High School

Photography at the Frontier of Physics and Art highlights many different ways of capturing scientific concepts and phenomena in photographic images. In this post-visit activity, students will have the opportunity to create their own images, whether through photography, drawing, painting, or collage, that focus on a scientific subject that sparks their interest.

Objectives

Students will:

- revisit a familiar scientific concept that inspires student excitement and curiosity.
- conceptualize and create a visual image to demonstrate a key aspect of that science topic.
- consider strategies for conveying information accurately in an image.
- create a two-dimensional representation of a three- (or four) dimensional reality.

Standards

Visual Art 1, 2, 3, 5, 6, 9, 10. ELA 1, 2. Technology/Engineering 1, 2, 3. Scientific Inquiry 1.

Materials

Options: cameras and/or drawing/ painting/ collage materials

Procedure

1. As a class, review some of the images seen at the museum. Discuss a few specific images, asking students to describe the scientific subject of each image. Then ask students for their ideas about alternate ways to represent those same scientific subjects. For example, what kind of image would they create to epitomize electricity?

2. Explain that students will now have the opportunity to create an image to convey a scientific concept or phenomenon that interests them. Give students time to brainstorm a list of their own individual ideas, and then ask students to share their ideas with one another.

3. Explain that students will have the opportunity to select the medium that they feel is most appropriate to tell the story of their subject. As students develop their artwork, ask them to think about the following process questions:

- What is the scientific subject of your artwork?
- Why did you choose this subject?
- What do you want the viewer to notice or think about when they look at your artwork?
- What medium did you select? Why?
- What is the title? Why?
- What other choices did you make?
- What was the most challenging part of making this picture?
- What was the most rewarding part of making this picture?

Students could write responses to these questions and/or talk about their process during an oral presentation of their work to the rest of the class.

Recommended Resources

Books

Way, Cynthia. *Focus on Photography: A Curriculum Guide.* International Center of Photography, 2006.

Websites

Online Sources for Art Images

The ARTCYCLOPEDIA
www.artcyclopedia.com

WCMA Searchable Collection Database (eMuseum)
http://emuseum.williams.edu:8080/emuseum/

Web Gallery of Art
www.wga.hu

Information on the Photographers:

Eadweard Muybridge

"The Edweard Muybridge Bequest." Royal Kingston Museum Website. www.kingston.gov.uk/browse/leisure/museum/museum_exhibitions/muybridge/machinery_and_equipment/zoopraxiscope.htm.

"Eadweard Muybridge: Father of Motion Pictures." Photo-Seminars Website. www.photo-seminars.com/Fame/muybridge.htm.

Gopnik, Blake. "Frame of Reference: Blake Gopnik on Eadweard Mubridge show 'Helios' at Corcoran." *Washington Post*. April 10, 2010. www.washingtonpost.com/wp-dyn/content/article/2010/04/09/AR2010040902680.html.

"Zoopraxiscope." Digital Arts Institute Website. www.digitalartsinstitute.org/galleries/zoopraxiscope/index.html.

Man Ray

Man Ray Trust Website. www.manraytrust.com.

Rudnick, Les. "Photograms: Introduction." Photograms: Art and Design Website. www.photograms.org/.

Harold Edgerton

"Flashes of Inspiration: The Work of Harold Edgerton." MIT Museum Website. http://web.mit.edu/museum/exhibitions/edgerton.html. 8/27/10.

Peng, Paul (University of Australia, Class of 2012). "Stroboscopic Photography." Penguin's Lab Website. 2007. www.penguinslab.com/Penphotos/strobe.htm. 8/27/10.

Berenice Abbott

"Get the Picture: Berenice Abbott." Minneapolis Institute of Arts Website. www.artsmia.org/get-the-picture/print/abbott.shtml. 8/25/10.

HackelBury Gallery Website. www.hackelbury.co.uk/artists/abbott/abbott.html. 8/27/10.

Technical Information on Photography

"Collotype." Victoria & Albert Museum Website. www.vam.ac.uk/vastatic/microsites/photography/processframe.php?processid=pr015.

"Glossary of Photographic Terms." Photography Tips Website. www.photographytips.com/page.cfm/2088.

Kulik, Marko. "Multiple Exposure." Photography.CA Website. 2000-2010. www.photography.ca/photography-tips/multiple-exposure/.

Pederson, Mark Scholer. "The Silver Gelatin Dry Plate Process." Alternative Photography Website. www.alternativephotography.com/wp/processes/gelatin-silver/silver-gelatin-dry-plate-process.

Peng, Paul (University of Australia, Class of 2012). "Stroboscopic Photography." Penguin's Lab Website. 2007. www.penguinslab.com/Penphotos/strobe.htm.

Rudnick, Les. “Photograms: Introduction.” Photograms: Art and Design Website. www.photograms.org/.

“Zoopraxiscope.” Digital Arts Institute Website. www.digitalartsinstitute.org/galleries/zoopraxiscope/index.html.

Wilson, Lillian. “19th Century Photographic Processes and Formats Represented in ‘Captured by the Camera.’” Concord Library Website. www.concordlibrary.org/scollect/Portrait_Exhibit/notes.html.

Further Background on Related Science Subjects

“Cosmology Glossary.” Berkeley Cosmology Group Website: http://cosmology.berkeley.edu/Education/IUP/GlossaryP_T.htm

Space Telescope Science Institute. HubbleSite. http://hubblesite.org/.

Education Programs

At the Williams College Museum of Art, our Education Programs strive to instill in visitors a love of art and an appreciation for all that a museum can offer.

As a teaching museum, we are committed to finding innovative approaches to teaching and learning through art—making connections across disciplines, building literacy skills, and encouraging the exchange of ideas.

Our programs engage participants in active experiences with art and investigate art history, artistic practices, and the issues that artwork raises. We are always available to discuss ways to tailor our programs and provide support to help you make the most out of your experience with us.

Education programs at the Williams College Museum of Art are made possible by the Eugénie Prendergast Trust.

Staff:

Cynthia Way
Director of Education and Visitor Experience
Cynthia.Way@williams.edu
413.597.2183

Joann Harnden
Coordinator of Education Programs
Joann.Harnden@williams.edu
413.597.2038