Art and Science
Observation and Imagination
(Leonardo Would Have Loved It: Discovering Art & Science Through Phenomenally Acute Observation)

A University of New Mexico Art Museum
Multi-media Education Unit

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Art and Science/Observation and Imagination

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We cannot create observers by saying "observe," but by giving them the power and the means for this observation and these means are procured through education of the senses. Maria Montessori

Introduction:
This is one of a series of publications of the University of New Mexico Art Museum for educators to use in art, humanities, and social studies-oriented instruction. The series highlights artwork from the University Art Museum’s permanent collection. The titles available on-line are:

1) Abstraction
2) Art, Culture, Place: Visual Traditions of the Southwest
3) Architecture: Defining Spaces/Defining Times

Each multi-media curriculum includes:
1) Background text
2) Teacher’s Guide keyed to Elementary and Secondary grades
3) Appendices: Glossary, Bibliography for Students and Teachers
4) Images

Program and Objectives:
Art museums offer opportunities for learning during the school years and beyond. These educational materials are designed to introduce teachers to the unique pedagogical potential of original artwork in museums. The Teacher’s Guide provides instructional strategies designed to increase students’ perceptual skills, to engage them in critical thinking, and to captivate them with creative problem-solving. Use the discussion questions, writing assignments, and art studios to complement a museum visit or as a self-contained unit of study.
Teaching materials support the National and State of New Mexico Standards and Benchmarks.

A group of artists, educators, museum staff and consultants collaborated in a Teaching Institute at the University of New Mexico in June 2006, to infuse these materials with classroom reality. They grappled with the complex issues
represented in the exhibition through discussions, visits to science museums on the UNM campus, and the Rio Grande Nature Center, studio work and field trips to the exhibition with their students. Adventurers included: Michael Certo, Elsie Moses-Hoeg, Sondra Lawson, Debra Novak, Margy O’Brien, Sara Otto-Diniz, Kathy Partch, Susan Wing, and Emily Young. We want to acknowledge the valuable assistance of spirit and inquiry that each participant brought to this project. And, to the thousands of children who continue to show us how to see from their uniquely imaginative perspectives, mil gracias.

**Note to Educators:**
The following teaching materials on art and science, observation and imagination are divided into elementary and secondary sections. Each section includes: Subjects, Time Required, Lesson Overview, Learning Objectives, Vocabulary, References, Topics for Classroom Discussion, Writing Exercises, and Art Studios that are broken down into daily art classes. All students will need an Art Journal (easily made by students with copy paper covered by construction paper and stapled) at each class in which to sketch and write. Be sure to read the entire section thoroughly and adapt it to suit both the needs of your students and your time constraints.

Because the grades 6-12 sections build on those developed for the elementary school, middle and high school teachers are advised to read the elementary sections first. For instance, students in Grades 6-8 will be expected to know and use the vocabulary listed in K-5. Student use of ‘art language’ encourages depth of understanding and fosters more precise communication. Teachers often discover that the art environment can be uniquely conducive to advancing motivation for language acquisition among ESL students. Please reproduce the Glossary in the appendix for older students’ use.

The issues around the exhibition *Art and Science/Observation and Imagination* are complex, multi-layered, and interwoven. To facilitate creative discussions in the classroom, the art gallery and the painting studio, teachers and students may benefit from the playful use of SCAMPER (see Appendix). Please reproduce the SCAMPER sheet as needed.

Trust yourself. With keen observation, imaginative reflection, and thoughtful discussions with students and colleagues, *Art and Science/Observation and Imagination* will transport you and your students to new landscapes of learning.
Art and Science/Observation and Imagination

A Bird’s-eye View

Da Vinci Image, Map of Imola

“Study the science of art.
Study the art of science.
Develop your senses – especially learn how to see.
Realize that everything connects to everything else.”

The artists/scientists in this exhibition not only take Leonardo da Vinci’s advice, but they demonstrate it in their art. And, like da Vinci, many still rely on notebooks in which to record their thoughts and reflections to inspire future works. Margy O’Brien strengthens her watercolor sketches of natural subjects with journal entries recording date, place, weather, smells, sounds, and textures, as well as personal reflections on the experience of a waxing moon. Jo Whaley’s field guides recall the well-worn, pocket-sized guides to trees or birds or mushrooms which accompany every amateur naturalist’s camping trip. All of the artists here introduce us to diverse hidden worlds—the reward for those who are patient enough to observe.

Almost all of the individuals whose works appear in this exhibition have studied science, and many are, in fact, scientists. Though artists and scientists ultimately make sense of the world in different ways, they all begin by active observation, a kind of seeing-thinking which looks for patterns, analogies, connections, and tensions.

In addition to keen powers of observation, the ability to create art—to develop original ideas and concepts—requires imagination and a facility for working across disciplines. These artists and scientists exemplify this gift.

In the 1830s, William Henry Fox Talbot, a true heir of Leonardo de Vinci who had many varied interests, developed a recording system using light sensitive chemicals that could reproduce, on ordinary writing paper, scenes from the world around him. His diligent experiments culminated in a negative/positive photography process still used today, and in the Pencil of Nature, the first photographically illustrated book commercially available to a general audience. Almost as a nod to Fox Talbot, Julie Anand records her landscapes through a vessel of water—a kind of transparent eye—a deceptively simple yet brilliantly conceptual way of seeing the world around her.
Observation and imagination are undeniably linked to the art of science and the science of art. Certainly they depend upon each other for results. Centuries after da Vinci recorded his observations about art and science in his notebooks, Fox Talbot wrote the following about artistic experimentation. This passage from 1841 not only echoes Leonardo da Vinci’s ideas, but also illustrates the continuum which has become his legacy and in which all of these artists work:

> All of this falls within the artist’s province to combine and to regulate; and if, in the course of these manipulations, he… becomes a chemist and an optician, I feel confident that such an alliance of science with art will prove conducive to the improvement of both.

The images on the exhibition texts are reproduced from the following sources:


The UNM Art Museum would like to thank the UNM Fine Arts Library and the Arts and Technology Center in the College of Fine Arts, UNM, for their support for this exhibition.

Special thanks go to Rebecca Mnuk, who graduated from Albuquerque Academy in May 2006. She served as an intern on the *Art and Science/Observation and Imagination* project at the UNM Art Museum during May, as part of the Academy’s Senior Projects Program—a required program for all Academy seniors that takes place during the final five weeks of the senior year. The Senior Projects program allows students to study an area of particular interest within one of four options: internship, mentorship, seminar, and self-directed project. The UNM Art Museum is pleased to host this project.
Botanical Observations

Da Vinci Image: Study of a Star of Bethlehem Plant
“A leaf always turns its upper side towards the sky so that it may better receive on its surface, the dew which drops gently from the atmosphere.”

Centuries after Leonardo da Vinci made this observation scientists have come to understand that leaves actively position themselves towards the sky to aid in photosynthesis, the process by which plants convert energy from the sun, plus water and nutrients into glucose to produce food. Artists/scientists have long created work that is informed by scientific observations and, even, serves science.

British botanist Anna Atkins recorded minute details of plant specimens in cyanotype photograms, an early photographic process, and in so doing pioneered the use of this medium in the service of science. Scientific experiments with sugar beets motivated Edward Skeats to illustrate New Mexico’s wildflowers in watercolor. As Leonardo did, Skeats isolated parts of a plant for closer examination, and painted the same subject from different points of view.

Karl Blossfeldt, however, was first an artist and art educator. With his homemade camera, he isolated images of seed pods, and tendrils against stark backgrounds and presented intimate plant details as magnified, abstract forms. But, it was keen botanical observation that sparked all these artists to engage in their visual dialogues between art and science.
Imagining Zoology

DaVinci Image: "The faculty of imagination is both the rudder and the bridle of the senses."

To choose to enter into the imaginative worlds created by Ian van Coller or Jo Whaley is to experience the serious play that is their art. South African artist Ian van Coller draws inspiration from nineteenth century natural history museum dioramas. He carefully crops and composes his photograph of a museum diorama and digitally montages onto it a “real” image taken from a colonial-era photograph. Against this backdrop, he challenges us to question what we think we see—is it real or an idealized illusion.

Jo Whaley re-imagines insect environments in compositions made of urban refuse—crumpled paper, rusted metal, glass. The compelling focus of her work is the interface between nature and technological culture. For instance, these works raise issues about industrial melanism, an evolutionary theory explaining why moths change color to camouflage against tree trunks blackened by coal-burning facilities.

Both artists transform their observations of the natural world through the “faculty of imagination,” to quote da Vinci, and express truths that partake of both art and science. To paraphrase Hungarian biochemist Albert Szent-Gyorgyi, “[Creativity] consists of seeing what everybody has seen and thinking what nobody has thought.”
Optics

DaVinci Image: “Objects seen with two eyes will appear rounder than if seen with only one.”

Optic Study 2

How do we see? Simply put, light from an object travels in a straight line through our pupil to the lens of our eye. The lens focuses the light rays, and projects them onto the retina which sends an impulse along the optic nerve to the brain. Note this intrinsic connection between the eye and brain—we cannot see without thinking or interpreting what we see. Leonardo da Vinci, who revered sight above all senses, experimented with stereoscopic vision, making observations including the one quoted above.

Julie Anand, a scientist and artist, plays with our eyes and minds by using water as a lens or optical device in which the landscape appears upside down. She then documents the inverted figure against its ground through another lens, that of a camera. What a brilliant way to explore the idea of boundaries between objects and their environments!

To understand the crystal sculptures of Christopher Ries is to enter into the technical world of optics. Light reflects like a mirror or is refracted, or bent, through the faces of his multi-faceted crystals to present projected images which the eye sees, yet which are not inscribed in actuality.

Both artists revel in the imaginative interplay between art and science, and invite their viewers to do so, too.
Bodies in Motion

DaVinci Image: “Weight, force, and casual impulse, together with resistance, are the four external powers in which all the visible actions of mortals have their being and their end.”

Almost from photography’s beginnings, scientists and artists sought ways to accurately record instantaneous movement of objects and the human figure. Photography was first about science—chemistry and optics—and capturing time. Yet early techniques did not allow for the capture of motion. Both Eadweard Muybridge and Harold Edgerton owe a debt to the nineteenth-century English physicist Arthur Mason Worthington, whose experiments in measuring and documenting small time intervals laid the foundation for their own respective investigations.

Muybridge, already an accomplished landscape photographer, successfully took up the task of dissecting, via his multiple camera system, the ordinary movements of humans, animals, and other creatures. Edgerton, an engineer and scientist by training, used his strobe invention to record imperceptible actions—natural and man-made—never before visible, and never before documented.

Both of these men— one a scientist, one an artist—merged their creative impulses with a strong sense of imagination to create innovative works from which future artists and scientists can draw inspiration.
Earth and Sky

Da Vinci Image: “When once you have tasted flight, you will forever walk the earth with your eyes turned skyward, for there you have been, and there you will always long to return.”

Study of Moon from Codex Leicester

Throughout the course of time, our earth and sky, especially cloud formations, have been carefully studied and observed as both a source of creative inspiration and scientific inquiry.

Sir Howard Grubb combined his training as a civil engineer with his interest in optical instruments and supervised the construction of a 48 inch telescope, said to be a masterpiece of engineering in the nineteenth century. From this instrument he made an early photograph of the moon which no doubt provided new information and a view that had not been visible before. In our contemporary world in which men have now walked on the moon, views obtained from the National Aeronautics and Space Administration (NASA), the most advanced in our twenty-first century, likewise afford vast new amounts of data for scientists to study in determining the origins of our planetary systems and for future exploration projects.

Photographer Alison Carey calls herself an alchemist, scientist, and magician. Using modern scientific data together with nineteenth-century photographic techniques, she constructs imaginary landscapes based on what the earth looked like in the prehistoric age. Carey explores her “invented world” in an effort to expand the boundaries of our now very familiar environment and invites us to imagine life in her “primordial world.”

In recording or interpreting their observations, scientists and artists have given us unique and imaginative works that in turn encourage us, as Leonardo does, to always walk with our eyes turned skyward.
Art and Science/Observation and Imagination

Rationale

According to a recent article in Time magazine (February 13, 2006), US students struggle “to keep pace with their international peers” in math and science, and fail to exhibit genuine enthusiasm for those subjects. This can be attributed in part by a lack of quality public school science programs and curricula. Current testing under No Child Left Behind evaluates student performance only in the areas of reading and math, and does not include science, social studies or the arts. Thus, many teachers are forced to teach only these subjects, and science instruction has dropped to an average of 16 minutes per day in elementary school classrooms, and has dwindled to 0 in many schools.

How can we inspire students to be curious and inquisitive thinkers, while nurturing their innate capacity for captivation and sense of wonder? When students are curious, they question, they hypothesize, and they test their theories to draw conclusions. When students are engaged creatively with either science or art, they are observing, thinking, questioning, problem-solving, and displaying the synthesis of their thinking/feeling in works of art or scientific discoveries.

To foster these skills, and to make explicit the relationships between art and science, the University Art Museum has organized the exhibition Art and Science/Observation and Imagination. Artwork informed by science or created in the service of science has been chosen to stimulate the imagination of the visitor. The objective is to engage the visitor in observation of aesthetically potent images in order to further a sense of wonder and to stimulate the viewer to further scientific curiosity and inquiry.
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Grades K-5

“True art and true science”

The fairest thing we can experience is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science.

Albert Einstein

Subjects — language arts, science, visual arts.

Time Required — 6 session unit to be explored during 6 one-hour classes. (Note: Be sure to practice studio work prior to class presentations in order to organize preparation time.)

Unit Overview — This unit is designed to introduce students to modern and contemporary visual art and scientific thought through the unique techniques and strategies of Leonardo da Vinci. Designed as Encounters, the lessons explore several themes of the exhibition Art and Science/Observation and Imagination, such as Bird’s eye View, Botanical Observations, Imagining Zoology, Bodies in Motion, Optics, and Earth and Sky. Students will document their findings and discoveries in art journals, crafted in the first encounter and used in all subsequent ones.

Learning Objectives —

Knowledge Students will learn about the artistic/scientific legacy of Leonardo da Vinci, and that it lives on in the artists and scientists of today who combine skills of observation and imagination in their work.

Skills Students will develop skills of patient observation, hand/eye coordination, drawing, critical looking strategies, and interpretation. They will solve problems both visually and verbally (fabricate an Art Journal, design an educational poster), will conduct research, and will reflect on their learning.

Values This unit seeks to kindle a sense of wonder and to stimulate the intellectual curiosity of students. Students will realize that by developing their skills of observation and utilizing
their imaginations they too can become accomplished scientists and artists. Finally, by witnessing the power of art to support science and vice versa, students will attain a deep understanding of the importance of synthesizing diverse disciplines.

Assessment— The art journal of written observations, sketches and visual thoughts will be a valuable tool to use for assessment and evaluation of student learning. You may choose to use it as the container for a variety of writing assignments, e.g. rich description, reflection, self-evaluation, or out of class research project. We encourage you to involve students in the development of rubrics for each assignment. Thus, you can assess the tasks for completion, accuracy and/or according to the rubrics.

Standards and Benchmarks— New Mexico Content Standards and Benchmarks are provided for each Encounter.
Art and Science/Observation and Imagination

(Leonardo Would Have Loved It: Discovering Art & Science Through Phenomenally Acute Observation)

Encounter 1 — Observing is More Than Seeing
All our knowledge has its origin in our perceptions. Leonardo da Vinci

Overview — Observing requires close looking for understanding and learning. Students will engage in an exercise to develop “phenomenally acute observation.”

Time Required — One 1-hour session.

Vocabulary — Introduce words, write on board, and define as a group.
Art Imagination Observation Science

Learning Experiences —
Materials: Multiples of the same kind and size of leaf, colored pencils, drawing paper for rubbings.

Discuss: Generate a definition of observation through class discussion. Use the following questions to guide your inquiry: What is seeing? What is looking deeply? How do seeing and observing differ? Post the generated definition on the wall to use as a reference throughout the Unit.

Create: Each student will choose a leaf from the leaf pile and observe it carefully for 2 minutes. Then return leaves to the pile and mix together. Students will then find and take out their “own” leaves, based upon their observations. Using 3 colored pencils of the same color family (e.g. various reds, yellows, or greens), students will make multiple rubbings of their leaf on drawing paper. Collect and save the rubbings which will be mounted to serve as the cover of the Art Journal.

Write: Students will reflect on how they observed carefully and noted unique characteristics about their leaves (perhaps a tear on the left top, an insect hole, or a motley color) in order to find them in the pile. Ask them to write what they learned about observation and about themselves in this exercise. Save this entry for inclusion in students’ Art Journals.
Assessment — Observe students during the exercise. Did they follow directions and were they able to find their own leaves again? After the exercise, review the class definition of observation. Is there anything they would change?

Standards
Art: Standard — A, B, C.
Standard 3—B: 1, 2, 3.

Language Arts: Strand I: Standard I: Benchmark I-A.

Science: Strand I: Standard 1: Benchmark I, II.
Strand II: Standard II: Benchmark I, II.
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Encounter 2 — Making an Art Journal
I need to keep a field journal—the words and music—because it keeps alive the delight in discovery. I need to keep my own notes, my own sketches, and my own observations along with digging out facts.

From The Naturalist’s Path by Cathy Johnson

Overview — In this lesson, students will design and create a journal in which to record their observations, questions, and insights throughout the Unit. The observation journal will allow students to find their own voices by opening themselves up to new experiences and engaging in the observation of the natural world around them.

Time Required — One 1-hour session.

Vocabulary — Introduce words, write on board and define as a group.
Binding Documentation Journal

Learning Experiences —
Materials: Out of the many books on nature or art journals, two stand out: Leslie, C. W. and Roth, C. E., Keeping a Nature Journal, and Johnson, C., The Sierra Club Guide to Sketching in Nature (see Bibliography in Appendix). Both books offer ideas about making journals, documenting observations and styles of drawing. Materials will vary according to the kind of journal your class will make but may include: cardstock for front and back covers, leaf rubbings from Encounter 1 to cover the cover, glue, flat craft brushes to spread glue, tissue or rice paper for inside front-cover, paper, hole punch and book rings.

Discuss: How can we use these journals as tools for learning? How will you use your journal to improve your observation skills? What else might your journal contain?

Create: Design the size of the journal you will make and the construction procedure. There are many ways to construct journals, but the basic idea is to have a hard cover on front and back decorated with the leaf rubbing from Encounter 1, tissue or rice paper inside front and back covers, interior pages, and simple binding using book rings through punched holes.
Write: Write an entry in your Art Journal—including date, time, place—as a letter to your journal describing your plans for how you will use it.

Assessment— How did the journals come out? Were the students proud and satisfied? What would they do differently? Let them grade themselves on this assignment.

Standards—
Art: Standard 1—A:1.
Standard 2—A:2.
Standard 4—B:4.

Language Arts: Strand I: Standard I: Benchmark I-A.

Science: Strand I: Standard 1: Benchmark I.
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Encounter 3— Leonardo da Who?
The faculty of imagination is both the rudder and the bridle of the senses.

*Leonardo da Vinci*

**Overview**— Students will learn about Leonardo da Vinci—his art, and his scientific discoveries and inventions. Students will understand how critical the skills of observation and imagination were to his success in both fields.

**Time Required**—Two 1-hour sessions.

**Vocabulary**—Introduce words, write on board, have students write in Art Journals, and define as a group.

<table>
<thead>
<tr>
<th>Artist</th>
<th>Experiment</th>
<th>Leonardo da Vinci</th>
<th>Perspective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renaissance</td>
<td>Scientific Method</td>
<td>Scientist</td>
<td>Sketch</td>
</tr>
</tbody>
</table>

**Learning Experiences**—

**Materials:** Books and web sites about Leonardo da Vinci (see Bibliography in Appendix); ½ sheet of poster board per student pair; scissors; glue; colored construction paper; computer; printer and/or color copy machine; rulers; pencils.
Optional: hole punch; book rings.

**Preparation:** Teacher will read a book about Leonardo da Vinci to the class to give students general background about his life and work. Students will work in pairs to conduct in-depth research on their choice of either a work of art or scientific invention of Leonardo’s. Each pair will present its research as a visual/verbal poster which may be assembled into a large-format book by hole-punching the pages and binding them with book rings. Students and teacher will develop rubrics upon which the posters will be assessed.

**Discuss:** After listening to the book about Leonardo and generating definitions for vocabulary terms, use the following questions to guide discussion. What did Leonardo create or invent that was intriguing to you? What can we learn from him? Why do you think he kept so many journals? Why do people still talk about this person from the past?
Create: Students will collect their information, color copies, computer-generated titles and text. They will lay out the information in an organized and easily read design with main title, sub-headings, text and images. Be sure to have students seek a peer review of their poster **BEFORE** gluing any images in place. Posters may be hung on the walls of the classroom or library or bound into a class book by punching holes and securing with book rings.

Write: Students will write an entry in their Art Journals which answers the following questions:

   a) What did they learn about Leonardo da Vinci?
   b) What did they learn about working with a partner?
   c) What 3 questions would they ask Leonardo if he were still alive?

Assessment—Use the teacher-student generated rubrics to assess each pair’s poster.

Standards—

Art:  
Standard 1—A: 1; C.
Standard 2—A: 1, 2.
Standard 4—A: 1; B: 2, 4.
Standard 6—A.

Language Arts: Strand I: Standard I: Benchmark I-A.

Science: Strand 1: Standard1: Benchmark 1.
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Encounter 4 — Looking In/Looking Out—Botany and Illustration

For in the true nature of things, if we rightly consider, every green tree is far more glorious than if it were made of gold and silver.

Dr. Martin Luther King, Jr.

Earth and sky, woods and fields, lakes and rivers, the mountain and the sea, are excellent schoolmasters, and teach some of us more than we can ever learn from books.

Sir John Lubbock

**Overview**— This encounter introduces students to scientific illustrations. They will reflect on the roles played by both art and science in botanical illustration. Students will study a variety of drawings, and will create their own through observations of plant specimens in the classroom as well as in a natural environment either on your school’s campus or at a nearby park. It is important that students understand that artists and scientists document their observations in different ways—plants as specimens (e.g. Edward Skeats and Karl Blossfeldt) or as part of the larger context (Eliot Porter and Margey O’Brien).

**Time Required**—Two 1-hour sessions.

**Vocabulary**—Introduce words, write on board, have students write in Art Journals, and define as a group.

Botany  Contour drawing  Diagrammatic drawing (optional)
Illustration  Memory drawing

**Learning Experiences**—

**Materials:** Art Journal, drawing pencils, colored pencils, erasers, fine black India ink pens, plant specimen for each student, jeweler’s loupes or magnifying glasses, field guides to wildflowers, mushrooms, trees, etc., nature journals or scientific books on plants (see Bibliography in Appendix) which represent different styles and techniques of scientific illustration, selection of plant materials.

**Discuss:** Let each student choose a field guide, nature journal or scientific book. Give them time to silently study the illustrations before facilitating a class seminar discussion on “Is it art or science?” The following questions may guide
your inquiry: What kind of information does the drawing present? What parts are scientific/artistic? How might such an illustration be useful to scientists/artists? Why might a scientist draw a plant? (Clue: Remember the steps in the scientific method.) What might a scientist learn through the process of drawing? Why might an artist draw a plant? What drawing skills can you learn from these illustrations to use in your own drawings?

Create A: Let each student choose a plant specimen to draw. Give them time to silently observe the plant and identify its basic shapes. Use jeweler’s loupes or magnifying glasses for closer observation. Each student will complete a contour drawing, memory drawing and diagrammatic drawing (optional) in his/her Art Journal. Generate a set of rubrics with the class on which to base your assessment of both the process and product of their drawings.

Contour drawing—First, follow the contour or outline of your plant specimen VERY SLOWLY with your eyes. Then, pretend that your pencil is simply tracing the route of a lady bug as it walks along the edge. Don’t look at your drawing or lift your pencil—just focus on the “lady bug” walking along the contour.

Memory drawing—First, carefully observe your plant specimen noting shapes and relationships of parts to whole. Then, put it away and draw it with as many details about the form and shape as possible. When you’re finished, check your drawing against the specimen.

Diagrammatic drawing—Draw the object as fully as possible—add shading for dimension, texture, color, labels to identify pistil, stamen, etc., and measurements.

Create B: The second class session involves observation of a plant in its natural environment. Observation of nature in its element has no peer—the natural lighting alters our perceptions, more of our senses are engaged when out of doors, and studying the plant within its context informs us of its relationship within its ecosystem. After exploring for several minutes, students will choose a place from which to make acute observations of a single plant. They will complete the same three types of drawings in their Art Journals as they did above. They may then explore and draw independently to finish 5-8 drawings which reflect their observational skills.

Write: Ask students to imagine that they are their pencils. Write the following questions on the board to jump-start their thinking: How are they
held? How do they move across the page—fast, slow, fluidly, choppyly, serenely, frantically? What path do they leave behind? Ask them to write a paragraph from the point of view of the pencil.

**Assessment**—Use the rubric developed above to assess both the process and product of student drawings.

**Standards**—

**Art:**
- Standard 1—A: 1, 2; B: 1, 2; C: 1.
- Standard 2—A: 2.
- Standard 3—B: 3.
- Standard 4—B: 1, 2, 3, 4.
- Standard 5—C: 1, 2.

**Language Arts:**
- Standard I: Benchmark I-A, I-B, I-C
- Standard II: Benchmark II-A, II-B, II-C

**Science:**
- Strand I: Standard I: Benchmark I, II.
- Strand II: Standard II: Benchmark I, II.
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Encounter 5— Let there be light!

Look at light and consider its beauty. Blink your eye and look at it again. The light which you see was not there at first, and that which was there is no more.

Leonardo da Vinci

Overview—Light and how it travels through glass, is reflected by mirrors, and refracted by water or a prism into the color spectrum intrigued Leonardo and Julie Anand, an artist in the exhibition. In this encounter, students will investigate what happens when light passes through soap bubbles, and will conduct a science experiment with glass, water, food coloring, plastic fish, and light.

Time Required—One 1-hour session.

Vocabulary—Introduce words, have students record in art journals, and define as a group.

Color    Lens    Light    Prism    Spectrum

Learning Experiences—

Materials: For Encounter 1, see these web sites on bubbles and bubble activities: www.bubbles.org, and http://www.exploratorium.edu/ronh/bubbles. They provide information on bubble formulae, bubble colors, color waves, how we see them with our eyes, and other advanced bubble-ology activities. Include the following materials in your encounter with bubbles: water, dish washing liquid detergent, bubble wands, straws, observation journals, pencils, other tools for experimentation.

For Encounter 2, you will need: round glass fish bowls (one for each group of 4 students), water, liquid food coloring (one light color and one dark color), plastic fish.

Encounter 1: Take students outside to mix bubble formula with water and dish washing liquid detergent. Invite students to blow bubbles with bubble wands, straws, and variously-shaped tools for experimentation. Encourage them to observe the shapes and colors of the bubbles, as well as bubble behavior. After
exploring and playing for 15-20 minutes, sit on the grass and discuss what they observed. Students may record their thoughts and sketches in their Art Journals.

**Encounter 2:** View and discuss Julie Anand’s photograph, “Fountain Hills Country Club, AZ, 2003.” Why do we see what we see? Be sure to use the vocabulary for this lesson and discuss how light passes through air and water, and how the water in the curved bowl functions as a lens (the camera has a lens, and our eyes have lenses, also). Divide students into groups of 4, and distribute materials listed above to each group. Students will use the scientific method to decide on hypotheses, and conduct their experiments.

**Write:** Students will write up their science experiments in their Art Journals under the categories:
   a) Hypothesis—what do they predict will happen?
   b) Experiment—what did they do to test their hypothesis?
   c) Results—what was the outcome of the experiment?
   d) Future research—what would they like to do next?

**Assessment**—Teachers will assess the science experiment documented in the students’ Art Journals according to science standards and benchmarks.

**Standards**—

**Art:**
Standard 1: A: 1,2  B: 1, 2  C: 1
Standard 2: A: 2  B: 2

**Language Arts:**

**Science:**
Strand I: Standard I: Benchmark I, II, III.
Strand II: Standard I: Benchmark I.
Art and Science/Observation and Imagination
(Leonardo Would Have Loved It: Discovering Art and Science Through Phenomenally Acute Observation)

Grades 6-12

“True art and true science”

The fairest thing we can experience is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science.

Albert Einstein

Subjects — language arts, science, visual arts.

Time Required — 6 lesson unit to be explored during 6 one-hour classes, with an optional 7th hour of class. (Note: Because the grades 6-12 unit builds on that developed for grades K-5, we suggest that teachers read the elementary unit first and incorporate elements of those lessons as needed. Be sure to practice studio work prior to class presentations in order to organize preparation time.)

Unit Overview — This unit is designed to introduce students to modern and contemporary visual art and scientific thought through Leonardo da Vinci’s strategies of observation and imagination. Designed as Encounters, the lessons explore several themes of the exhibition Art and Science/Observation and Imagination, such as Bird’s eye View, Botanical Observations, Imagining Zoology, Bodies in Motion, Optics, and Earth and Sky. Students will document their findings and discoveries in art journals, purchased or self-crafted in the first encounter, and used in all subsequent ones.

Learning Objectives —

Knowledge Students will learn about the artistic/scientific life of Leonardo da Vinci, and that his legacy lives on in the artists and scientists of today who combine skills of observation and imagination in their work.

Skills Students will develop skills of patient observation, hand/eye coordination, drawing, critical looking strategies, and interpretation. They will solve problems both visually and verbally, will conduct research, and will reflect on their learning.
**Values**

This unit seeks to kindle a sense of wonder in and to stimulate the intellectual curiosity of students. They will realize that by developing their skills of observation and utilizing their imaginations they too can become interdisciplinary artists/scientists. Finally, by witnessing the power of art to support science and vice versa, students will comprehend the value of synthesizing diverse disciplines.

**Assessment** — The art journal of written observations, sketches and visual thoughts will be a valuable tool to use for assessment and evaluation of student learning. You may choose to use it as the container for a variety of writing assignments, e.g. rich description, reflection, self-evaluation, or an out of class research project. We encourage you to involve students in the development of rubrics for each assignment. Thus, you can assess the tasks for completion, accuracy and/or according to the rubrics.

**Standards and Benchmarks** — Each Encounter is aligned to New Mexico Content Standards and Benchmarks, as noted.
Art and Science/Observation and Imagination
(Leonardo Would Have Loved It: Discovering Art and Science Through Phenomenally Acute Observation)

Encounter 1— Making an Art Journal (Optional)
I need to keep a field journal—the words and music—because it keeps alive the delight in discovery. I need to keep my own notes, my own sketches, and my own observations along with digging out facts.

From The Naturalist’s Path by Cathy Johnson

Overview—In this lesson, students will design and create a journal in which to record their observations, questions, and insights throughout the Unit. Skip this encounter if you plan for your students to purchase journals which should lie flat and have hard covers. The art journal will provide a place for students to find their own voices by documenting and reflecting upon their experiences.

Time Required—One 1-hr class.

Vocabulary—Introduce words, have students record in art journals, and define as a group. (Review vocabulary in K-5 Encounter 2 as needed.)

Reflection

Learning Experiences—
Materials: Out of the many books on nature or art journals, two stand out: Leslie, C. W. and Roth, C. E., Keeping a Nature Journal, and Johnson, C., The Sierra Club Guide to Sketching in Nature (see Bibliography in Appendix for full citation). Both books offer ideas about making journals and documenting observations, and suggest ways of drawing. Materials will vary according to the kind of journal your class will make, but may include: cardstock or matte board for front and back covers, glue, flat craft brushes to spread glue, tissue or rice paper for inside front-cover, paper, hole punch and book rings.

Discuss: Brainstorm reasons that an artist or a scientist would use an observation journal. Suggest ways that you may use your journal. How will your journal be a tool for learning?

Create: Introduce the objectives for making/having & using an observation journal. It is important to mention this was a critical component of Leonardo da Vinci’s artistic and scientific process, he obsessively documented his
observations. The students will also be documenting their observations and discoveries like Leonardo.

**Write:** Write a reflective entry in your Art Journal—including date, time, place—as a personal letter to your journal introducing yourself, your interests in art and science, and describing your plans for how you will use it to become a more proficient artist and scientist.

**Assessment**—Ask students to list 3 things they did well in creating their Art Journals, and 3 things they would do differently the next time. Let them grade themselves on this assignment.

**Standards**—

**Art:**
- Standard 1—A: 1.
- Standard 2—A: 2.
- Standard 4—B: 4.

**Language Arts:** Strand I: Standard I: Benchmark I-A.

**Science:** Strand 1: Standard 1: Benchmark 1.
Art and Science/Observation and Imagination

(Leonardo Would Have Loved It: Discovering Art and Science Through Phenomenally Acute Observation)

Encounter 2— Naked Eye Moon Observations
Now do you not see that the eye embraces the beauty of the whole world? Leonardo da Vinci

Overview — Students will develop their looking/drawing skills through multiple observations of the moon. Like Leonardo, they will view the moon with their naked eyes. Note: An exceptional curriculum on the Archaeo-astronomy of the Southwest—including earth science, New Mexico history, and trigonometry— can be found at: http://www.unm.edu/~abqteach/index/science_index.htm.

Time Required — One 1-hour class and twelve evenings of observation homework.

Vocabulary — Introduce words, write on board, have students write in Art Journals, and define as a group.
Circle  Compass  Cycle  Diameter  Orbit  Lunar
Moon  Revolution  Rotation

Learning Experiences —
Materials:  3 x 5 cards, pencils, compasses, NASA photograph of the moon (from the Solar System Lithograph Set at www.nasa.gov), copies of NASA information sheet on the moon, map of the moon identifying land forms (see National Geographic or Smithsonian).

Preparation:  Distribute twelve 3 x 5 cards and the NASA information sheet on the moon to each student.

Discuss:  Have students read the NASA information sheet prior to discussion. Observe the photograph of the moon and identify the land forms. Review theories about the moon’s origin, facts about its physical relationship to the earth (size, distance, geology) and the history of human interaction with the moon.

Create:  Have students make an initial sketch of the moon from the NASA photograph or the Sir Howard Grubb photograph in their Art Journals. Demonstrate how to draw a 2 in. diameter circle with a compass on the right half
of the unlined side of a 3 x 5 card. Have students draw circles in the same place on each of 12 cards. Three nights a week for the next four weeks at the same time each night, students will observe the moon and draw it in detail on one of the cards. They should write the date and time on the lower left corner. Each moon observation should last at least 15 minutes.

Write: Students will write weekly entries in their Art Journals reflecting on their moon observations—what do they think about while looking at the moon?

Assessment—Assess students on the number of their observations and Journal entries, and the level of details in their moon drawings.

Standards—
Art: Standard 1—A: 1, 2.

Language Arts: Standard II—Benchmark II-A, II-C.

Science: Strand I—Standard I: Benchmark I, II.
    Strand II—Standard III: Benchmark I, II.
Art and Science/Observation and Imagination
*(Leonardo Would Have Loved It: Discovering Art and Science Through Phenomenally Acute Observation)*

Encounter 3— Leonardo da Who?

The faculty of imagination is both the rudder and the bridle of the senses.

*Leonardo da Vinci*

**Overview**— Students will learn about Leonardo da Vinci—his art, and his scientific discoveries and inventions—by conducting research and writing an illustrated report on one aspect of his life. Students will understand how critical the skills of observation and imagination were to his success in both art and science.

**Time Required**— Two 1-hour classes.

**Vocabulary**— Introduce words, write on board, have students write in Art Journals, and define as a group. (Remember to include vocabulary in K-5 Encounter 3 as needed.)

**Scientific Illustration**

**Learning Experiences**—

**Materials:** Books and web sites about Leonardo da Vinci (see Bibliography in Appendix); computer, color copy machine; paper; pencils.

**Preparation:** Students will read several books and/or review web sites about Leonardo da Vinci to gain background information. Teacher may create a list of Leonardo’s artistic achievements, scientific accomplishments and inventions from which students will choose one on which to conduct research and write a 3 page report with bibliography. Students should make a color copy of the work of art, journal page or drawing of the invention which they research, make their own sketch of it, and include both in their final report. Teachers and students will generate rubrics on which to assess the reports.

**Create:** Students will conduct research, and make color copies and sketches. They will organize the material, and write up their illustrated reports on the computer using main titles, and sub-headings.
Discuss: After students complete their reports, they will present what they learned in small groups. Each presentation will include the following ideas:
  a) identify the work of art, scientific achievement or invention, show a picture (color copy) of it, and their own sketch of it;
  b) describe it in great detail, including how it incorporates both art and science;
  c) explain the role that Leonardo’s skills of keen observation and imagination played in creating it;
  d) associate Leonardo’s accomplishment with an aspect of your own life; and
  e) suggest an area for future research.

Write: For their Art Journal entries, students will write imaginative dialogues between Leonardo da Vinci and themselves. The following questions may help to inspire them:
  a) What 3 questions would you ask Leonardo if he were still alive?
  b) What would Leonardo be inventing/creating for the 21st century?
  c) What does Leonardo regret about his life?

Assessment—Use the teacher-student generated rubric to assess the final reports.

Standards—
Art: Standard 2—A: 1, 2.
   Standard 3—B: 2, 3.
   Standard 4—A: 1, 2, 3.

Language Arts: Strand I: Standard I: Benchmark I-A.

Science: Strand III: Standard I: Benchmark I.
Art and Science/Observation and Imagination
(Leonardo Would Have Loved It: Discovering Art and Science Through Phenomenally Acute Observation)

Encounter 4— Bodies in Motion: An Art History of Horses
Study the science of art. Study the art of science. Develop your senses—especially learn how to see. Realize that everything connects to everything else.

Leonardo da Vinci

Overview—Students will learn about 4 artists—Leonardo da Vinci, Rosa Bonheur, Eadweard Muybridge and Deborah Butterfield—who have captured the essence of horses throughout time in diverse media. Students will then create their own images of horses in a chosen medium. Finally, students will learn how technology, history and art are interconnected, and about realism and abstraction.

Time Required—Two 1-hour classes or more.

Vocabulary—Introduce words, write on board, have students write in Art Journals, and define as a group.
Abstraction  Media  Motion  Realism  Sculpture

Learning Experience—
Materials: Reproductions of Leonardo’s horse (www.leonardoshorse.com); Rosa Bonheur’s Horse Fair, 1852; Eadweard Muybridge’s photograph (on this site); and one of Deborah Butterfield’s horses. Find images in art books or at Google Images. Art materials for students will vary, but may include pencil, paper, colored pencils, oil pastels, watercolors, acrylics, cameras and film, found objects, tooth picks, twigs, glue.

Discuss: Display images of the 4 horses. Remind students that art is an interpretation of something, not the thing itself! Lead a slow and thoughtful discussion of each image as well as a “compare and contrast” of the several images. What is similar about them? What is different? Which are abstract? Realistic? How does the artist’s choice of media inform their interpretation? Challenge students to arrange the works chronologically. Discuss when the art was made, and what that has to do with the technology available at the time each artist was working. For instance, would da Vinci have been able to take a
photograph of a horse? Why or why not? Play with that idea. IF photography had been invented, predict what Leonardo would have done with it.

**Create:** Bring to the classroom reproductions and/or photographs of horses for students to sketch in their Art Journals or take a field trip—to the state fair, the zoo, or an equestrian event—to observe and sketch animals in motion and/or to photograph them. Ask students to sketch their own or a neighbor’s pet as a homework assignment. Capturing motion is *not* an easy task and the students will gain greater appreciation of the work of the artists who have accepted this challenge.

Students will develop their own projects around horses in motion and use their Art Journals as a place to record their thoughts. They may sketch several thumbnails before deciding on the composition of a painting, or they may play with ideas for a three-dimensional horse. The completion of these projects could span several class periods or become a homework assignment.

**Write:** For their Art Journal entries, students will write personal reflections on how the several stages of this “lesson” have connected to both art and science.

**Assessment—**Teacher can assess students’ participation in discussions and evaluate the completion of the making/creative component of the encounter.

**Standards**

**Art:**
- Standard 1—A: 1, 2; B: 1, 2; C: 1.
- Standard 2—A: 1, 2.
- Standard 3—A: 2.
- Standard 4—A: 1, 2, 3; B: 1, 2, 3, 4.
- Standard 5—B: 1, 2.
- Standard 7—A: 1.

**Language Arts:** Standard II—Benchmark II-A, II-C.

**Science:** Strand III: Standard I: Benchmark I.
Art and Science/Observation and Imagination

(Leonardo Would Have Loved It: Discovering Art and Science Through Phenomenally Acute Observation)

Encounter 5—Phases of the Moon
When once you have tasted flight, you will forever walk the earth with your eyes turned skyward, for there you have been, and there you will always long to return. Leonardo da Vinci

Overview—Beginning at the second encounter, students observed the moon, made detailed drawings, and wrote reflections on their observations three times per week. Now, at the end of 4 weeks of observation, the moon will have completed an entire cycle. Students will use their drawings to create a class set of flipbooks demonstrating the full 28-day lunar cycle.

Time Required—One 1-hour class.

Vocabulary—Introduce words, write on board, have students write in Art Journals, and define as a group.

Full moon Gibbous moon New moon Phase
Quarter moon Wane Wax

Learning Experience—
Materials: Student lunar observations on 3 x 5 cards, an additional twenty-eight 3 x 5 cards for each student, heavy-duty stapler.

Discuss: The goal is for all students to have their own 28-day flipbooks made up from illustrations from the entire class. Remind students to sign their drawings and check to see that dates and times have been recorded. Teacher will collect all student drawings and, with student help, arrange drawings chronologically. Class will discuss the drawings—which best demonstrates the full cycle of the moon, includes details, was drawn carefully—and share their reflections. Then they will choose 28 for the flip book. Be sure to have a drawing for each date.

Create: After deciding which images to include, teacher will make copies of the selected drawings for each student. Students will cut and paste the reproduced drawings, one per card aligned on the right side, and then staple/bind them on the far left.
**Assessment**—Teacher can assess the lunar cycle diagrammatic drawings in class, and the homework for drawing the lunar cycle they observe.

**Standards**

Art: Standard 1—A: 1, 2.

Language Arts: Standard II—Benchmark II-A, II-C.

Science: Strand II: Standard III: Benchmark I, II.
Art and Science
Observation and Imagination
Bibliography

Museum education


Interdisciplinary Education & Literature


Nature Journals & Drawing


Botanicals


**Zoological**


**Bodies in Motion**


Earth and Sky


http://hubblesite.org

http://hubblesource.stsci.edu


Optics & Photography


http://earth.google.com (satellite imagery)
Leonardo da Vinci


Museum of Leonardo:
www.mos.org/sln/Leonardo/Hotlist.html

Leonardo’s Manuscripts:
http://www.museoscienza.org/english/leonardo/manoscritti.html

Leonardo the scientist:
www.mos.org/leonardo/
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Leonardo the artist:
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