

COLORS OF NATURE / KIT 1

SCIENCE AND ART: CORE PRACTICES

HOW DO ART AND SCIENCE HELP US UNDERSTAND THE WORLD AROUND US?

This kit is designed to help students explore the core question: *how do art and science help us understand the world around us?* Through a series of investigations, students will become familiar with the core practices of art and science, and develop scientific and artistic habits of mind that empower them to engage in self-directed inquiry through the generation and evaluation of ideas.

A **STEAM** APPROACH TO EDUCATION (Science, Technology, Engineering, Art, Math)

STEAM is an educational philosophy that seeks to balance the development of divergent and convergent thinking by integrating the arts with traditional STEM fields (Science, Technology, Engineering, Math). In the STEAM approach to learning, students engage in projects and experiments that reflect the transdisciplinary nature of real-world problem solving. Rather than focusing on the delivery and memorization of content as isolated facts or repetition of rote procedures, STEAM seeks to develop scientific and artistic habits of mind and the confidence to engage in self-directed inquiry by familiarizing students with the core practices of art and science in an open and exploratory environment. The STEAM investigations in this kit are designed to foster creative inquiry by promoting individual agency and establishing meaningful connections to students' own lives.

For additional teaching resources visit www.colorsofnature.org

ART / SCIENCE OVERLAP

Both science and art seek to broaden our understanding of the world around us. Although art and science are often thought of as separate ways of knowing, they are similar in many important ways in principles and practice. Driven by curiosity, creativity and technique, both disciplines contribute new experiences, ideas, and technologies to society and create the foundation of knowledge from which future innovations emerge. The core practices of art and science reveal significant overlap as well: observing, questioning, experimenting, analyzing, and communicating are the means by which both disciplines generate and distribute new ideas and technologies.

CORE PRACTICES of ART and SCIENCE:

Observing
Experimenting
Questioning
Analyzing
Describing
Communicating

ENGAGEMENT IN SCIENCE PRACTICE

Young children engage naturally in core science practices. They make observations and test and revise their predictions as they seek to understand how the world around them works (how high can I stack these blocks before they tumble?). But when science is presented in the classroom as isolated facts to be memorized, or procedural steps to copy, students can lose sight of their own capacity to question the world around them, test their ideas, and share their discoveries. Many students, especially girls and people from non-dominant groups, start to view science as rote, passionless, and uncreative. Students who have difficulty memorizing and repeating facts, or making connections to complex systems that don't feel relevant to their daily lives begin to disengage from science. Again, these STEAM investigations should emphasize developing familiarity with the practice and tools of scientific inquiry, rather than on memorizing content or achieving specific results.

ENGAGEMENT IN ART PRACTICE

Similarly, young children almost universally engage in art making. They progress from simple scribbles as they learn to handle and control their mark-making tools to the development of symbols that represent their understanding of the world. As the complexity of these graphical symbols increases, children begin to aim for realism (of proportion, form, lighting) in their representation. Around age 9, as social awareness increases, children begin to shift their focus from the expressive pleasure of making art to the results of their work, especially in comparison to the work of their peers. Between age 10 and 13, children decide whether or not they are good at art (as opposed to whether or not they enjoy making art), and it is in this stage of development that many children cease to engage in art-making, believing they do not have the talent to produce good (realistic) results. These beliefs are often reinforced by peers and adults who similarly value conventions of realism in western art. When an adult claims “they can't draw,” we automatically understand them to mean that they can't draw realistically, not that they can't move a pen across a piece of paper. With continued practice and instruction, nearly everyone can develop skills of realistic representation. Nevertheless, the following STEAM investigations should remain focused on the act of art making itself: an awareness of the opportunities that present themselves and the creative choices that are made in the course of artistic practice. The results of each activity are useful as a record of the process, but the emphasis should be placed on the importance of observing, experimenting, and reflecting on the activity itself.

INSTRUCTIONAL METHOD

We advocate for a STEAM approach that quiets the inner negative voice, focuses on open outcomes, and values student ideas and expression. Foundational to our approach are practices that promote identification with science and art, including the use of real science and art tools; connect science and art to everyday life; and offer students the chance to participate in authentic science and art practice.

Give students choices when possible. A sense of agency can increase identification with science.

Accept student responses as value-neutral.

Ask questions and encourage discussion and reflection.

Connect activities to everyday practices and student-relevant ideas.

GUIDING DISCUSSION AND REFLECTION

It is important to establish an environment that encourages imaginative speculation, or thinking outside the box. If students are conditioned to “take things seriously” during classtime, they might not be comfortable offering the creative or humorous answers that are often generated by divergent thinking.

The instructor should continue asking questions to lead the discussion beyond the point where students offer answers that they believe are “correct” or what they think the instructor expects to hear. This can be facilitated by the instructor’s willingness to contribute their own playful ideas and follow up with questions that solicit deeper analysis:

What do this fly’s eyes remind you of?

They remind me of a discoball!

What about them is like a discoball?

What does a discoball do to light?

What do you think the fly’s eyes do to light?

How might this be useful for the fly?

ASKING QUESTIONS TO DEEPEN ENGAGEMENT

Each investigation in this kit provides:

A central question to focus the investigation, repeated in the header of each page.

Specific questions integrated with the procedural steps of the activity to prompt the discussion, *shown in italics for quick reference*.

Throughout the activity, the instructor should use open questions to guide observation, encourage experimentation, and prompt reflection.

Questions should aim to:

Expand upon an idea:

what else could you do with this? could this be for? could this mean?

Draw attention to specific details:

what do you see? what texture? color? pattern? what is different/similar between this and that?

Encourage synthesis with existing knowledge:

*what does this remind you of? where have you seen something like this before?
what about this is different than where you saw something similar before?*

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INTRODUCTION / NOTEBOOK EXTENSION

NOTEBOOK EXTENSION 30 minutes

Keeping a notebook is a common practice in both art and science. The notebook is a place to keep track of ideas, observations, measurements, sketches and other information relevant to the ideas the practitioner is exploring. It is a space that allows for informal musings and reflections alongside notes and data recorded for later reference. Each investigation in the Colors of Nature Kits includes suggestions on how to incorporate the notebook into the lesson.

Notebooks can be incorporated into numerous other classroom activities beyond these investigations, providing a private space for students to reflect on what they are learning and develop their ideas outside of the normal constraints of classroom assignments.



Part of a page from one of Leonardo Da Vinci's notebooks, showing a study of the bone structure of a wing, and ideas for the design of a flying machine.

MATERIALS

- Blank student notebooks
- Writing/ drawing tools (pens, pencils, etc.)
- Glue stick

INTRODUCTION

Discuss with students the various reasons why artists and scientists might keep notebooks and how it helps them study the world around them.

Why do artists and scientists keep notebooks?

Some examples include, but are not limited to:

- observe a subject more closely
- record observations when other methods of recording not possible or available at the time
- capture additional information such as measurements, notes, other observations
- keep a record of what was done, how data was collected
- think through and work out ideas and designs on paper before trying in real life

PREPARE NOTEBOOKS FOR USE

Discuss with students what information might be useful to include in their notebook, to assist with identification and use as a reference of their observations. At the very least, have students write their name on the inside cover, so misplaced notebooks can be returned to their owner when found.

What information might be important to include in the notebook?

Some examples include, but are not limited to:

- name
- contact information
- page numbers
- page titles
- table of contents
- dates of entries or observations
- measurements
- photos or other materials that can be glued in

TIME REQUIREMENT:

60 minutes

SCIENCE STANDARDS (NGSS):

Science/ Engineering practices

Asking Questions and Defining Problems:

Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

Planning and Carrying Out Investigations:

Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

Constructing Explanations and Designing

Solutions: Apply scientific ideas or principles to design an object, tool, process or system.

Crosscutting concepts

Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

ART STANDARDS (NCCAS):

VA:Cr1.1.4 Brainstorm multiple approaches to a creative art or design problem.

VA:Cr1.1.5 Combine ideas to generate an innovative idea for art-making.

VA:Cr2.1.5 Experiment and develop skills in multiple art-making techniques and approaches through practice.

VA:Cr1.2.5a Identify and demonstrate diverse methods of artistic investigation to choose an approach for beginning a work of art.

VA:Cr2.1.4 Explore and invent art-making techniques and approaches.

VA:Cr2.1.6 Demonstrate openness in trying new ideas, materials, methods, and approaches in making works of art and design.

COLORS OF NATURE / KIT 1

HOW DO ART AND SCIENCE HELP US UNDERSTAND THE WORLD AROUND US?

SUMINAGASHI / INVESTIGATION 1

How does open experimentation and careful observation lead to new questions and discoveries?

OVERVIEW

Students use Suminagashi, a traditional Japanese marbling technique, to build awareness of central, overlapping practices in science and art, such as observation and experimentation. The technique also reinforces that “mistakes” can have positive outcomes.

LEARNING OBJECTIVES

Students will be able to discuss and demonstrate examples of how:

- *Experimentation and observation are core practices of art and science.*
- *Open experimentation and close observation create opportunities for innovation.*
- *There are no mistakes, only alternative outcomes.*

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 1/ SUMINAGASHI

How does open experimentation and careful observation lead to new questions and discoveries?

INSTRUCTIONAL APPROACH

This investigation is designed to introduce students to methods used by both artists and scientists to generate new ideas and questions. The suminagashi paper-marbling method allows for open experimentation, and the bright, pleasing results minimize disappointment or a sense that there is a “right” way to approach it. The instructor should guide the students through questions and prompts that encourage:

- *observation of the materials and their interactions*
- *experimentation and modification of techniques based on observations*
- *analysis and discussion of results*
- *discussion of how artists and scientists approach their work*

The instructor should accept all student answers as value neutral.

ART BACKGROUND

Suminagashi is a traditional marbling technique, practiced for centuries in Japan to create decorative paper. The word *suminagashi* means “ink-floating,” and the technique involves doing exactly that: colored inks are applied to the surface of a container filled with water, manipulated to form designs, and lifted off with a piece of absorbent paper.

At each step of this process there is room for experimentation with technique, and the resulting images are rarely disappointing. This reinforces the idea that there are no “mistakes,” only alternative outcomes.

SCIENCE BACKGROUND

Surface tension is the result of the molecules in a liquid being strongly attracted to each other. At the interface between water and air, the water molecules are much more attracted to each other than they are to the air molecules, causing them to pull together and act as though an elastic skin is stretched across the surface. Water has a very high surface tension, which is what causes dew to form drops, like tiny balloons, instead of spreading out like pancakes. It is also what allows things that are denser than water to float on its surface. This can be demonstrated by floating a paper clip on the surface of a glass of water, if it is applied gently.

When we do suminagashi, the surface tension of the water causes the ink to float if it is applied gently to the surface. If it is applied with enough force to break through the surface, such as when a drop of ink falls from above, the ink sinks, because it actually has greater density than the water. Density of a material is its mass per unit volume. For example, a one-inch cube of lead has much greater density than a one-inch cube of cork.

When adding different colors of ink, students may notice one color appears to “push” the other away. This can be demonstrated with a drop of dish soap (a surfactant) as well, which lowers the surface tension of water. Changing the surface tension of the water at one point by adding a drop of a surfactant causes the elastic “skin,” formed by normal surface tension, to pull away from that point as the surfactant spreads out. Anything floating on the surface, like suminagashi ink, will move with it. This can be explored further in the extension activity.

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How do art and science help us understand the world around us?

INVESTIGATION 1/ SUMINAGASHI

How does open experimentation and careful observation lead to new questions and discoveries?

PREP

KIT MATERIALS

- Suminagashi colored ink set (1 set per table group)
- White construction paper (2-3 sheets per student, cut in half)
- 3 x 5 unlined index cards (~ 4 per student)
- Palettes (1 per working group of 2-3 students)
- Brushes (3-4 per working group)
- Water bins (1 bin for every 2-3 students, large enough to float an index card. A shoebox-sized container works well)
- Paper/ plastic cups with water for rinsing brushes while working (1 per student)

ADDITIONAL SUPPLIES

- Paper towels and wet wipes for cleanup
- Pencils (1 per student)
- Table covers and drop cloths to protect working area
- Additional paper material for experiments (allow students to identify and collect this around classroom. Examples include: manila envelopes, lined notebook paper, kraft lunch bag, paper towel, and so forth)
- Additional tools for experiments (allow students to identify and collect this around classroom)

SETUP 10 minutes

1. Protect working area

Use paper or plastic coverings on tables and dropcloths on the floor to minimize cleanup from ink spills.

2. Create drying area

Adjacent to the working area, protect a large counter, table, or part of the floor with butcher paper or drop cloth. This area will need to be available for a several hours, depending on temperature and humidity, while the prints dry.

3. Prepare work stations

Fill several bins with cold water. Set out sumi inks, palettes, and brushes. Two to three students can share each water bin, palette, and a few brushes, while the ink sets can be shared by the whole table and used to replenish the palettes.

4. Test surface tension

Not all tap water is the same. Depending on the source, there can be minerals or additives present that reduce the surface tension of your water and prevent the suminagashi ink from floating. Test this by dipping a paintbrush into the suminagashi ink, allowing the ink to absorb into the bristles, and then touching the loaded brush gently to the surface of the water.

If the ink spreads out across the surface, you are ready to proceed with the investigation. If the ink sinks, you may need to adjust the surface tension of your water or use distilled water. One effective method is soaking a sheet of drawing paper in the water for a minute. The sizing and binding agents in the paper dissolve into the water and help the ink float. Test again by gently touching your ink-loaded brush to the surface of the water. You can also try dissolving a teaspoon of table salt (sodium chloride) in the water to increase the surface tension.



Protect working area and assemble materials: water bins, paper towels and cleaner, scissors, suminagashi inks, palettes, paintbrushes, pencils, construction paper and other scrap paper if available.



If the surface tension of your water is good for suminagashi, you will see the ink spread across the surface when you touch a loaded brush to it, rather than sinking towards the bottom.

INTRO DISCUSSION 10 minutes

Introduce the idea that many important innovations are arrived at “by mistake.” By remaining observant, open-minded, and willing to engage the opportunity created by an unexpected incident, these “mistakes” become opportunities for innovation. The outcome depends on how one reacts to the unexpected incident.

Have you ever discovered something useful by mistake?

What did you do in that situation that made the difference between a mistake and a discovery?



Penicillin is one of the important scientific discoveries made “by mistake,” thanks to close observation and a willingness to pursue an unexpected outcome. In 1928, biologist Alexander Fleming returned to his lab after a summer holiday and found an unexpected mold had contaminated some of the bacterial cultures he had been working with. He noticed that the bacteria did not survive in the vicinity of the fungus and investigated the effect on other organisms, finding a similar result. This observation led to the discovery and development of the first antibiotic medicine, Penicillin. X-rays, popsicles, and pacemakers are other examples of accidental discoveries by creative observers.

DEMONSTRATION 5 minutes

1. Tell students that today, they will be experimenting with a paper and ink art form called suminagashi, which involves lifting floating inks off the surface of water with paper.

2. Let students know there is no right or wrong way to do this technique. By carefully observing the behavior of their materials and actions, they can experiment with new ways of creating patterns and effects.

3. Show students the materials they will be working with (2-3 students per water bin, palette, brush set, ink sets shared by table).

4. Drop a few different colors onto the surface of a water bin and ask students to observe and discuss what they see happening as the teacher drops in the inks.

What do you see happening when the ink hits the water?

What happens when a drop of another color is added?

Does this remind you of anything you have seen before?

5. Now, invite students to do their own art. They should start by writing their name in pencil on the back of an index card (pencil is important, as it won't wash off during the dipping of the card in the water).

6. Now, let the students know that they should set the card gently on the surface of the water and quickly lift it off.

7. Ask students what they observe. *What is transferred to the paper?*

8. Show the students the drying area where they can set prints as they complete them. This will keep the workstation clean and protect the finished prints from ink spills, water and inky fingers.



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How do art and science help us understand the world around us?

INVESTIGATION 1/ SUMINAGASHI

How does open experimentation and careful observation lead to new questions and discoveries?

SUMINAGASHI EXPERIMENTATION *20 minutes*

1. Instruct students to write their name, in pencil, on each of their pieces of construction paper before they begin. This is important as it is very hard to know whose is whose later after they are dry.

2. Students can begin experimenting with the ink, and lifting off patterns onto the construction paper.

3. After a few minutes, while the students work in small groups, ask them to experiment with other ways of applying the ink to the water, manipulating the surface, or capturing the image. Remind them to make note of what techniques work well.

Examples of student discoveries: stirring ink with the brush handle, spattering ink onto the water by tapping the handle of the brush, dropping in concentric circles of ink, painting ink onto paper first, dipping paper in sideways, and using tape as a resist in certain areas of the paper to block the ink.

4. After students have had some time to play with ideas, ask them to turn to a partner and share any exciting techniques they have discovered. This allows students to combine, modify and expand on these discoveries with the remaining time.

REFLECTION *10 minutes*

Ask students to finish their last print and gather around the drying area to observe the results and share their discoveries.

What did you discover as you experimented with these materials and this method?

Did you notice anything specific about:

-certain colors of ink?

-interactions between certain colors?

-differences in the paper types?

-differences between the way the paper is dipped?

How did these variables change the resulting print?

What part of this process do you think is similar to what scientists do?

What part of this process do you think is similar to what artists do?

How do you think artists and scientists might approach this differently?

CLEANUP *5 minutes*

Have students empty and rinse water bins, brushes and palettes, replace ink caps, and cleanup work area.

NOTEBOOKS

Have students write about their experiences in their notebooks or journals. Students should document the procedures they used, their observations, the results of their experiments, and further questions they would like to explore. Corresponding prints can be added to the notebooks when dry.



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How do art and science help us understand the world around us?

INVESTIGATION 1/ SUMINAGASHI

How does open experimentation and careful observation lead to new questions and discoveries?

EXTENSION

Suminagashi inks can be used to explore scientific concepts such as surface tension and density. This 30 minutes extension activity can be used in addition to the core activity if time allows.

Allow students to experiment with changing the surface tension of the water, by using other materials on hand in the classroom (salt, dish soap, etc). After they have had a chance to explore, ask them to develop application techniques for their suminagashi prints that take advantage of what they know about surface tension and fluid density. Have students record the techniques they will try on the back of each piece of paper, before applying it to the surface and lifting the ink off. At the end of the period, have students share the results of the techniques they developed.

NOTE

If your water has proper surface tension for floating the ink, you can explore what happens when you decrease the surface tension by adding a surfactant like dish-soap. If your water has low surface tension and requires adjustments in order to float the ink, students can use the opportunity to test different additives, water temperatures, and other ideas to discover what increases the surface tension sufficiently for suminagashi.



REFLECTION

Discuss observations and discoveries made during the exploration.

Why does some of the ink float on the surface, while the rest sinks to the bottom?

What else have you seen that floats on water even though it seems like it should sink?

Why do different ink colors seem to “push” each other away?

Are you reminded of anything you have seen before elsewhere?

TIME REQUIREMENT:

60 minutes

SCIENCE STANDARDS (NGSS):

Science/ Engineering practices

Asking Questions and Defining Problems:

Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

Planning and Carrying Out Investigations:

Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.

Obtaining, Evaluating, and Communicating Information: Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.

Crosscutting concepts

Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Influence of Science, Engineering, and Technology on Society and the Natural World: The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.

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COLORS OF NATURE / KIT 1

HOW DO ART AND SCIENCE HELP US UNDERSTAND THE WORLD AROUND US?

OBSERVATIONAL DRAWING / INVESTIGATION 2

How does close observation help us generate new questions and ideas?

OVERVIEW

In both art and science, observation is the initial step in generating new ideas. By practicing our observational skills through focused exercises such as life drawing, we increase our ability to generate questions and make new discoveries. This exercise helps refine observational skills through drawing, and demonstrates that close observation leads to new questions.

LEARNING OBJECTIVES

Students will be able to discuss and demonstrate examples of how:

- *Observation is a core practice for both artists and scientists.*
- *Close observation leads to new and more focused questions.*
- *Drawing from observation increases awareness of details.*

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How do art and science help us understand the world around us?

INVESTIGATION 2/ OBSERVATIONAL DRAWING

How does close observation help us generate new questions and ideas?

INSTRUCTIONAL APPROACH

Close observation is a core practice of both art and science. It allows us to break through our assumptions and preconceptions and notice new features and patterns in the world around us. As we learned in the previous experiment with suminagashi, close observation helps us ask new questions, discover new techniques, and generate new ideas. The instructor should guide the students through questions and prompts that encourage:

- **attention to details of color, texture, and form**
- **development of new questions based on observations**
- **discussion of how artists and scientists approach their work**

The instructor should accept all student answers as value neutral, as well as refrain from offering “corrections” to drawings. Rather, the instructor can help students observe their subject more closely by calling students’ attention to details with open questions such as:

how many colors do you see?

how does the texture change in different areas of the object you are drawing?

ART BACKGROUND

Drawing from life is, essentially, a practice in observation. We have preconceived ideas about the form of familiar subjects, such as a face or a hand. These preconceptions tend towards generic icons and symbols. Ask someone to draw a mountain in ten seconds and they will likely draw an inverted chevron, an upside-down V. Ask them to add snow, and they might add a wavy horizontal line. Young children’s drawings exhibit these kinds of symbolic representations almost exclusively, where a hand might be rendered as a circle with short lines radiating outward, often indifferent to the actual number of fingers on the average human hand.

Training ourselves to become better observers leads to more accurate and specific renderings in our drawings. These qualities of accuracy and specificity are what cause us to deem a drawing “realistic,” although even the most realistic drawing is a kind of abstraction, where the three dimensional world is flattened and translated onto the picture plane.

There is also a psychological component to our translation of the three-dimensional world to the two-dimensional picture plane, where certain features are made prominent based on the importance we assign them. When first drawing portraits, even skilled adult students will almost always drastically enlarge the eyes of their subject, even when asked to pay careful attention to observed proportions. This is because we tend to focus our attention on the eyes (rather than, say, the temple or chin) when we interact with another human.

SCIENCE BACKGROUND

When we draw from life, we must overcome our preconceived visual memory and train ourselves to draw what we actually see, rather than what we think we should see. Close observation is a skill that gets better with practice.

Learning to draw from life also helps us see things we normally overlook in the world around us. Because drawing requires sustained and focused observation of form, proportion, texture, and light, we must overcome assumptions about what we *think* we are looking at, and instead begin to truly *see* what we are looking at. This close observation reveals new details and features, which in turn helps us generate new questions and ideas about the subject of our study. Such questions, in turn, can guide scientific investigations or aid in distinguishing different species.

KIT MATERIALS

- Drawing media for each student (pen, pencil, colored pencils)
- Drawing paper or blank-paged notebook
- Natural objects to draw (insects, flowers, minerals, shells, seedpods, etcetera)
- Blue painter's masking tape

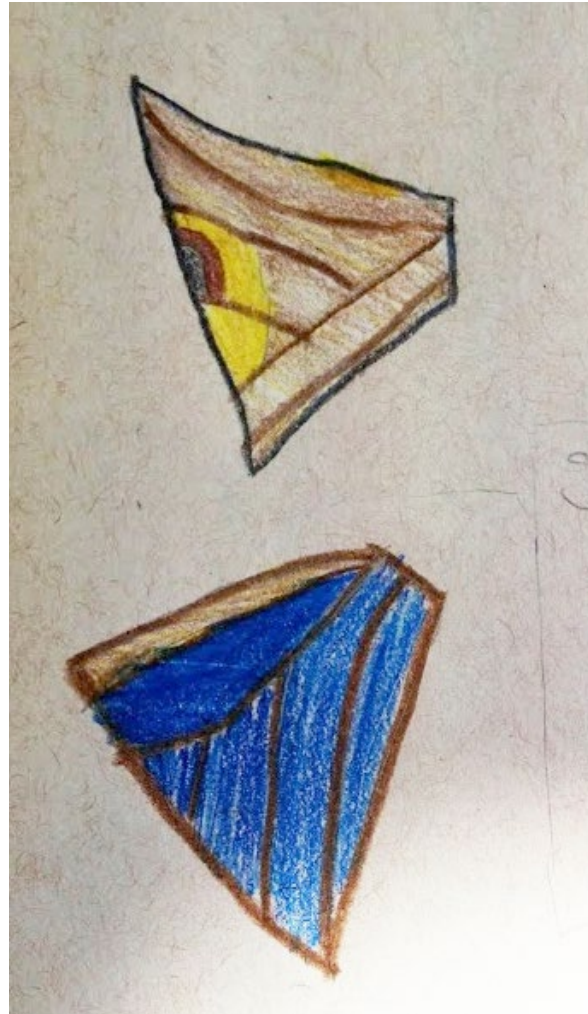
INVESTIGATION

How does close observation help us generate new questions and ideas?

This series of exercises reveals to students how drawing from life necessitates close observation, and how close observation naturally leads to new questions and ideas.

In these exercises the students will begin by using their non-dominant hand as the subject of their observational drawing. The hand is ideal for this exploration, as it is both a familiar and extremely complex form.

After completing the exercises designed to bring attention to the act of observation itself, students will use this awareness to draw natural objects, provided in the kit, or found in the classroom.



Same wing, different sides. Student drawing of a butterfly wing.

DRAWING FROM MEMORY 5 minutes

1. Students should prepare their pen and paper to draw. The paper, if not in a notebook, will need to be supported on a flat, hard surface.

2. Have the students take a quick look at their non-dominant hand (the one they are not drawing with) then hide it behind their back.

3. Tell them they will now draw their hand from memory for two minutes, without looking at it. Let them know the goal is not to get it “right,” but to bring their attention to how we store familiar images in our memory.

4. Set a timer for two minutes and tell them to begin. They should draw everything they can remember about their hidden hand, until the time ends.

5. When the time ends ask the students to keep their hands hidden, and ask them to share any questions that arose about their hand while drawing it from memory.

Were some features easier to remember than others? Why might that be?

6. Ask students to compare their hand to their drawing, and take notice of what features they captured in their sketch and what features they left out.

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How do art and science help us understand the world around us?

INVESTIGATION 2/ OBSERVATIONAL DRAWING

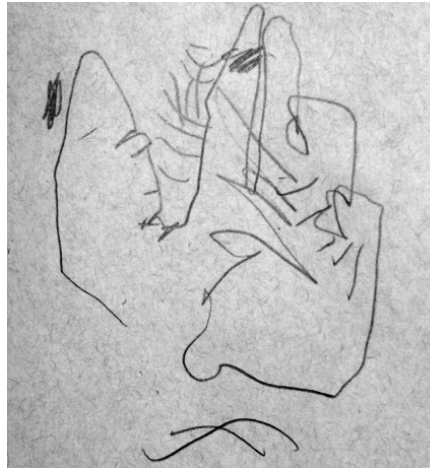
How does close observation help us generate new questions and ideas?

BLIND CONTOUR DRAWING 5 minutes

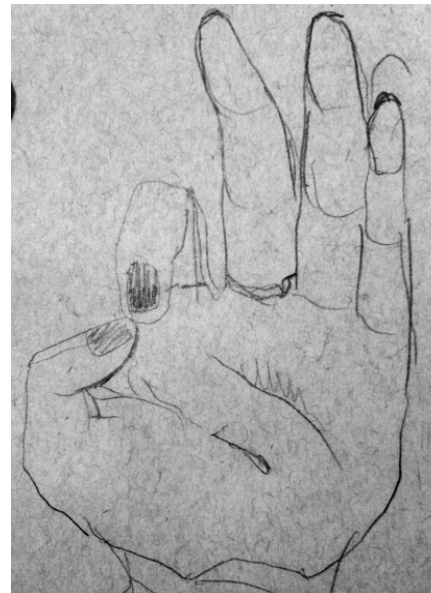
Blind contour drawing, where the drawing is obscured and kept out of view until completion, focuses the students' attention solely on the act of observation. Because the drawing-in-progress cannot be compared to a preconceived idea of what it "should" look like, the student is free to focus exclusively on observing their subject, while the drawing hand practices moving along with what they see.

1. Have students place a blank sheet of paper, or a new notebook page, where they cannot see it but can still draw on it. For example, they can place it on their lap under a desk, or to the side and slightly behind them if they are sitting on a hard floor. A textbook can also be opened and stood upright to create a blind between the student and their paper on the desk. Another way to do this is to poke a pen through a sheet of paper, so it acts as a wide blind to the sheet below. Use the blue tape to secure paper to table if needed.

NOTE: It is very tempting for some students to look at their paper while they draw, to see if they are getting it "right." *Remind students that this is an exercise in observation, and that the resulting marks on the paper will not be a realistic rendering.*



Blind contour drawing of hand (above) and, later, drawing from observation (below).



2. Let students know they will again be drawing their hand for two minutes, but this time they will only be looking at their hand and the drawing will be hidden. Students should draw continuously until they are asked to stop, adding more and more detail until the time is up.

3. Set the timer for 2 minutes and tell students to begin drawing. When the time is up, ask the students to stop and put down their pens.

4. Before they look at their drawings, ask the students to share something they noticed, or any questions that arose, as they drew their hand.

Were there features you noticed while doing this drawing that you had not included in the previous drawing?

Did any questions arise when you noticed that feature?

For example, "I noticed creases on the insides of my fingers that run perpendicular to the creases at the joints. I am wondering how did they form, given that my finger bends the other way?"

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 2/ OBSERVATIONAL DRAWING

How does close observation help us generate new questions and ideas?

HAND DRAWING FROM MEMORY REVISITED

10 minutes

1. Have students prepare another sheet of paper, or turn to a new page in their notebook. This time, the students will be looking at their drawing so the paper can be positioned however is most comfortable.

2. Let students know they are going to combine the first two approaches, by drawing from memory after a period of close observation. They will observe their hand for 2 minutes without drawing, and then draw without looking at their hand for another 2 minutes.

3. Have the students place their non-dominant hand in a comfortable position, set the timer for 2 minutes and tell them to begin observing their hand. Have them imagine that they are drawing their hand as they observe it, as they did in the blind contour exercise. They can even mime the drawing motions with an invisible pen as they observe their hand, to help commit the shapes to memory.

4. When time is up, tell the students to put the hand they were just observing out of sight.

5. Set the timer for 2 minutes and have students begin drawing everything they recollect about their hand. Students should draw continuously and add as much detail as they can recall.

6. When the timer ends, ask students to discuss their experience:

How was this drawing different from your first drawing from memory?

What features changed, and why do you think these changes occurred?

What would you pay more attention to if you did this process again?

7. Have the students position their non-dominant hand as it was in the previous drawing. Ask students to keep in mind the features of their hand they wished they had recorded, and to make mental note of them this time.

8. Set timer and repeat the process, with 2 minutes of observation, followed by 2 minutes of drawing.

9. Discuss the results.

Did you record different information in the second round of observation?

What did you look for?

How did your drawing change?

What questions do you have now and what would you look for if you did this again?

NOTE: The first drawing, done before observing their hand, will tend towards a generic symbol of a hand, with some iconic features included, such as fingernails and knuckle creases. The third drawing, after a period of close observation, will generally exhibit more details, such as creases and lines in the palm, and more specific positioning of fingers, as students incorporate their observations into their preconceived visual memory of a hand.

NOTEBOOKS

If students are using notebooks, have students reflect on the pages adjacent to each drawing what they noticed, what changed, and what questions arose as they did each drawing.

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 2/ OBSERVATIONAL DRAWING

How does close observation help us generate new questions and ideas?

DRAWING FROM OBSERVATION 30 minutes

1. Distribute the various natural objects (e.g. flowers, shells, pinecones, rocks, animal mounts, insects, seed pods, etc.) among the groups of students. For students to get the maximum benefit out of this exercise, they should be able to choose from a range of objects, rather than being assigned an object. These can also be collected in advance during a quick trip outside, where students can select objects that interest them.

2. The remaining class time can be devoted to drawing these objects from observation, with five minutes at the end for a debriefing.

3. Remind students that it is okay if their drawing doesn't look exactly like the object they are drawing (representational accuracy can be developed through practice, but it is not the goal here) and that it is more important to record everything they see and notice about their object.

4. As the students draw, direct their attention to various features with prompts:

What colors do you see? Do the colors change in different areas?

What textures? Do the textures change in different areas?

Are there repeating shapes or other patterns?

NOTE: If a student finishes quickly, ask them to continue drawing until the time ends, adding more and more detail to their drawing. If there is not room on their drawing for more marks, they can start another “detail” drawing elsewhere on the page and focus on a small area of their object (for example, the wing of an insect, or the pistil of a flower).

5. Do not suggest corrections to drawings. Instead, ask questions that help students observe their object more closely. Asking about relationships (for example: *is the beak longer or shorter than the neck? is the back lighter or darker than the belly? What is the difference in texture between the petal and the leaf?*) can direct students' attention to the information they are missing and help them hone their own observations.



6. Allow at least five minutes at the end of the period to debrief. It is okay if students continue drawing during this time.

7. Ask students to share something they noticed about their object while drawing

What questions arose about your object as you drew it?

If they have trouble formulating questions based on their observations, prompt them by asking *why they think their object has a specific feature*. For example, a student might share that they noticed a texture of tiny craters all over the birds' egg they were drawing. Ask if they think the texture has a function, and what it might be? Does it remind them of anything they have seen before?

Why do you think an artist or scientist might use drawing in their work?

What else do artists and scientists use to help them observe the world more closely?

NOTEBOOKS

Have students record the questions that arose about their object as they drew it on an adjacent page of their notebook.

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 2/ OBSERVATIONAL DRAWING

How does close observation help us generate new questions and ideas?

EXTENSION

Now that students have generated questions about objects that interest them, you may extend this activity by asking students to research their questions.

Ask each student to choose one of the new questions that arose as they closely observed the natural objects they were drawing. Have the students investigate this question and compile their findings in a written report, a notebook entry, or an oral presentation to the class.

EXAMPLE

When drawing a spruce grouse from the museum collection in Fairbanks, students noticed interesting scales projecting laterally from each digit on the feet. Features like this easily go unnoticed in a cursory examination of the bird, but drawing the object brought their attention to details such as this. Students wondered why the bird had these strange scales. As we speculated about their purpose, new questions arose about the grouse's habitat and behavior, and how the scales might benefit the grouse. Further investigation produced information on these seasonal adaptations, called pectinations, which during winter provide extra grip on icy branches and act as snowshoes by distributing the grouse's weight across the surface of the snow. They are shed in the spring and regrown annually.



Students drawing mounted animal specimens in art/science notebooks.

TIME REQUIREMENT: 60 minutes

SCIENCE STANDARDS (NGSS):

Science/ Engineering practices

Asking Questions and Defining Problems: Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. (MS-PS2-3)

Planning and Carrying Out Investigations:

Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)

Crosscutting concepts

Scale, Proportion, and Quantity: Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

Scientific Knowledge Assumes an Order and Consistency in Natural Systems: Science assumes consistent patterns in natural systems. (5-PS1-2)

Scale, Proportion, and Quantity: Natural objects exist from the very small to the immensely large. (5-PS1-1)

Patterns: Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)

ART STANDARDS (NCCAS):

VA:Cr2.1.5 Experiment and develop skills in multiple art-making techniques and approaches through practice.

VA:Cr1.2.5a Identify and demonstrate diverse methods of artistic investigation to choose an approach for beginning a work of art.

VA:Cr2.1.6 Demonstrate openness in trying new ideas, materials, methods, and approaches in making works of art and design.

COLORS OF NATURE / KIT 1

HOW DO ART AND SCIENCE HELP US UNDERSTAND THE WORLD AROUND US?

DRAWING WITH TOOLS / INVESTIGATION 3

How do tools help us observe and record the world around us?

OVERVIEW

Both artists and scientists use a variety of tools to observe, experiment and document their work. In this investigation, students explore how tools enhance and affect their observations and recordings of the world around them. Using hand lenses (loupes) and a variety of drawing media, students investigate natural objects at different scales and explore how choice of media (pen, pencil, colored pencil, etc.) changes the way they record their observations.

LEARNING OBJECTIVES

Students will be able to discuss and demonstrate examples of how:

- *Artists and scientists use tools to observe, measure and record the world around us.*
- *Different tools offer different benefits and limitations.*
- *The choice of tool affects the kind of information that is collected and recorded.*
- *Tools must be applied strategically based on their specific benefits and limitations.*

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 3/ DRAWING WITH TOOLS

How do tools help us observe and record the world around us?

INSTRUCTIONAL APPROACH

This investigation is designed to encourage critical engagement with tools that aid our exploration of the world around us. By comparing different tools and identifying their benefits and limitations, students learn to make strategic tool choices to meet their needs.

The instructor should guide the students through questions and prompts that encourage:

- *identification of benefits and limitations of different tools*
- *comparison and analysis of results*
- *discussion of how artists and scientists use tools in their work*

The instructor should accept all student answers as value neutral.

In this investigation, students will spend the class period in a sustained investigation of an object. It is important that students are able to choose an object that specifically interests them, rather than having an object assigned to them or distributed randomly. This promotes a sense of agency in each student as the director of his or her own investigation.



The loupe, a small magnifying lens (like the one above) is an example of a tool used by both artists and scientists to observe things that are too small to easily see with the naked eye. Photographers use loupes to examine film negatives, or look for dust marks or other blemishes on printed photographs, and jewelers use them to examine gemstones for cracks and other characteristics. Scientists carry them into the field to look closely at things like the gills on the underside of a mushroom, helping them identify the species.

KIT MATERIALS

- Variety of natural objects (feathers, shells, butterfly wings)
- Ballpoint pens (1 per student)
- Colored pencils (1 set per 2 students)
- Drawing paper or notebooks (1 set per 2 students)
- Loupes
- Blue painter's tape

ADDITIONAL/ OPTIONAL SUPPLIES

- Variety of natural objects collected by students if time allows
- Pencils (1 per student)
- Microscopes, binoculars or other classroom equipment that allows observation at different scales
- Additional drawing media (felt pens, crayons, etc.)



Seedpods, flowers, and insects for further examination can often be collected with a quick trip outside.

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 3/ DRAWING WITH TOOLS

How do tools help us observe and record the world around us?

SCIENCE BACKGROUND

The tools used by scientists are likewise as varied and infinite as those used by artists. They range from simple to complex and are used to observe (telescopes, microscopes, cameras) to measure (thermometers, scales, rulers), and to record and analyze observations (computers, calculators). Like artists, many scientists must invent and create new tools that do not yet exist so that they can investigate new questions. Over 10,000 scientists and engineers from all over the world worked to create the Large Hadron Collider, a giant device located underneath the border of France and Switzerland, in order to observe and record particles and interactions that no one had been able to detect before.

Some tools, like the magnifying hand lens called a loupe that we will use today, have been refined and modified by humans for many centuries. By bending the path of reflected light, curved transparent lenses can magnify the appearance of the object. We can see this effect when looking through a drop of water. Lenses made of polished crystal have been found that are over 2000 years old.

By the thirteenth century, vision-correcting eyeglasses were being manufactured in the Netherlands, which became a center of optic technology. The master artist Jan Vermeer lived and worked in the midst of this, and his life-like paintings are considered a result of using lenses as a painting aid. The Dutch hotbed of optical production led to the invention of both the microscope and telescope, tools that gave us access to understanding our world, from microorganisms to distant galaxies, in ways that had previously been impossible.



13th century Dutch artist Jan Vermeer is believed to have designed a camera obscura using newly available glass lens technology to help him paint from live scenes with near photographic accuracy.



Today, scientists use highly technical modern versions of glass lenses which allow them to study galaxies far, far away through telescopes.

ART BACKGROUND

The tools used in the arts are as varied, and infinite, as those in science. Some tools are used to aid observations (for example, cameras), some to produce work (paintbrushes), and others to document or reproduce it (printing presses). Like scientists, artists often find that the specific tool they need does not yet exist and must make it themselves.

The Dutch artist Jan Vermeer is the subject of ongoing debate regarding his use of inventive optical tools to aid his production of hyper-realistic paintings in the 1600's, despite a lack of formal training in the arts. Art historians believe he created a kind of camera obscura to project an image of the live scene he wished to paint onto his panel at a reduced scale.

In art, the materials used to produce work are referred to as "media." Basic drawing media include things like pens or pencils on paper, but can be any combination of materials the artist decides to create marks with... like a twig in dirt, or chocolate sauce on cake.

Like all tools, different media have unique benefits and limitations. One of the core skills of the artist is identifying the appropriate tools to employ for the intended results.

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 3/ DRAWING WITH TOOLS

How do tools help us observe and record the world around us?

PREP

SETUP 5 minutes

Lay out a selection of natural objects for students to select as their subject of investigation. If time allows, students can also collect their own objects outside. Alternatively, the teacher could assign students to collect natural objects from home earlier in the week. A wide variety of leaves, flowers, feathers, seed pods, rocks and other objects can often be acquired in the immediate surroundings.

Set out loupes and drawing supplies.



When examined through the loupe, as on the right, small structures such as scales become visible. Students might focus on drawing these, and question their function.

INTRO DISCUSSION 10 minutes

Introduce the idea that artists and scientists use tools to aid their observation, investigation and documentation of the world. Accept all answers as value neutral and write them on the board.

What is a tool?

What types of tools do you use in your daily life/throughout your day (e.g., toothbrush, scissors, pencils)?

What do those tools help you do?

What is an example of a tool that an artist might use? (Follow up: do you think a scientist might use this tool also? For what?)

How do tools help scientists and artists do their work?

What is an example of a tool that a scientist might use? (Follow up: do you think an artist might use this tool also? For what?)

What is an example of a tool that both artists and scientists might use?

How do artists and scientists decide what tools to use?

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 3/ DRAWING WITH TOOLS

How do tools help us observe and record the world around us?

PART I: DRAWING TOOLS

The first part of this investigation allows students to explore different drawing media (pencil, ballpoint pen, colored pencil) and compare their benefits and limitations.

DRAWING with PENCIL *5 minutes*

1. Invite students to select one of the natural objects to focus on for the class period.
2. Let students know that they will be exploring how different tools change the way they observe and record their observations. Remind students that the goal is not to create a masterpiece, but to examine the characteristics of different tools.
3. At their desk with drawing paper and object in front of them, ask students to begin a 5-minute drawing of their object with pencil.
4. As they draw, encourage students to experiment with different ways of holding the pencil, applying light or firm pressure, and making different kinds of marks (fast, scribbly, pokey, slow, steady, and so forth).

DRAWING with BALLPOINT PEN *5 minutes*

1. Ask students to begin a 5-minute drawing of their object, this time using a ballpoint pen.
2. Again, as they draw, encourage students to experiment with different ways of holding the pen, applying varied pressure, and making different kinds of marks to capture the texture and form of the object they are observing.
3. Remind them that the goal is to explore the limits of their drawing tool, not to create a masterpiece.

DRAWING with COLORED PENCILS *5 minutes*

1. As before, ask students to begin a 5-minute drawing of their object, this time using colored pencils.

NOTE: The qualities that make a tool appropriate for a given task can be subjective and personal, too. Personal preference plays a significant role in the way we work as individuals. For some students, working with colored pencil allows them to focus on the patterns and colors they observe and relieves the pressure they may self-impose to create a “realistic” drawing. Other students prefer being able to make revisions to a graphite pencil drawing using the eraser, and others might enjoy the immediacy or tonal range (light to dark) of working with the ballpoint pen.

REFLECTION *5 minutes*

Ask students to share their discoveries about different effects they were able to achieve and what they consider the benefits and limitations of the different drawing media.

What are the benefits of using the graphite pencil? Ballpoint pen? Colored pencil?

What drawing media was most effective for recording your observations of your object?

Which drawing media did you prefer? Why?

COLORS OF NATURE / KIT 1

How do art and science help us understand the world around us?

INVESTIGATION 3/ DRAWING WITH TOOLS

How do tools help us observe and record the world around us?

PART II: OBSERVATION TOOLS

The second part of this investigation allows students to explore a tool that changes the scale at which they observe their object, and consider the benefits and limitations of this approach.

DRAWING with LOUPES *15 minutes*

1. Hold up a loupe for the class to see and ask students if they have ever seen or used a loupe? When? What do they do (function)? Hand out the loupes and allow students to spend a few minutes observing their objects through them.

2. Ask if anyone has discovered an optimal distance for using the loupe and have them share with their peers.

NOTE: Bring the loupe close to the eye and move the object towards the loupe until it comes into focus. The focal length will depend on the magnification power of the loupe. For a 10x magnifier loupe, the focal length will be an inch or less.

3. Confirm that everyone has been able to obtain a focused image with the loupe.

4. Let students know that loupes (pronounced “loops”) are portable hand lenses used by both artists and scientists.

Why might an artist use this tool?

Why might a scientist use this tool?

5. Let students know they will be using this tool to observe their chosen object and will be drawing the magnified image they see. This can be just a small part of the object, such as the surface texture or a specific feature.

6. Ask students to begin a 10-minute drawing of their object as seen through the loupe. They can draw in pen, pencil or colored pencil or a combination, whatever they feel is most appropriate to record their observations based on their previous experiment with the different media.

REFLECTION *10 minutes*

Ask students to share their discoveries.

What are the benefits of using the loupe to observe your object?

What are the drawbacks or limitations of using the loupe to observe your object?

What did you notice about your object when observed through the loupe that you did not notice before?

Is there anything you could do to make the loupe more useful as an observation tool?

What other tools might you use to examine your object?

What drawing media was most useful for drawing the magnified image of your object?

Have students make notes on the back or in the margins of the drawing, including what tools they used and their reflections on the benefits and drawbacks of each.

NOTEBOOKS

If students are keeping notebooks, have them write what tools they used and their reflections on pages adjacent to the drawings.

EXTENSION

Ask students to identify other items in the classroom that they could use as a tool to further examine their chosen object. This could be a microscope, a flashlight, a magnet, a ruler, a scale, or anything else they think might give them new information about their object.

Now, ask students to identify other items in the classroom that they could use as a tool to record their observations. This could be other drawing media, a camera, modeling clay, or any other tool they think might be appropriate.

Ask students to experiment with the new tools they have chosen to examine and record their observations. Have students document the tools they use and the benefits and limitations of each, and share the results of their experiments with their peers.



Examining birds up close, with an illuminating loupe, and far away, with binoculars. The information obtained by each tool is significantly different, as both tools offer benefits and limitations.

