# LESSON 14: Wacky Waxy Watercolors

**ESTIMATED TIME** **Setup:** 5–10 minutes | **Procedure:** 5–10 minutes

## • DESCRIPTION

Use white crayons and watercolor paints to make designs on paper and demonstrate the interaction of water and wax.

## • OBJECTIVE

This lesson demonstrates the interaction of water and wax. Students attempt to paint over wax images with watercolor paints and learn about soluble and insoluble substances. The lesson can be extended to address colloids and polarity.

## • CONTENT TOPICS

Scientific inquiry; properties of matter; mixtures (solutions); attractive forces (polarity)

## • MATERIALS

- ❑ White paper
- ❑ White or clear wax crayons or candles
- ❑ Watercolor paints
- ❑ Paintbrushes
- ❑ Water
- ❑ Small cups for water

Always remember to use the appropriate safety equipment when conducting your experiment. Refer to the ***Safety First*** section in the ***Resource Guide*** on pages 421–423 for more detailed information about safety in the classroom.

**Jump ahead to page 179 to view the Experimental Procedure.**

## NATIONAL SCIENCE EDUCATION STANDARDS SUBJECT MATTER

This lesson applies both *Dimension 1: Scientific and Engineering Practices* and *Dimension 2: Crosscutting Concepts* from "A Framework for K–12 Science Education," established as a guide for the updated National Science Education Standards. In addition, this lesson covers the following Disciplinary Core Ideas from that framework:

- PS1.A: Structure and Properties of Matter

## OBSERVATION & RESEARCH

### BACKGROUND

Waxes are pliable solid substances that do not have a specific chemical formula and can be made both naturally and synthetically. Despite this variety, waxes tend to have similar physical properties. Most waxes melt at moderate temperatures and can be buffed or polished under slight pressure to produce a glossy appearance. Beeswax is an example of a natural wax. Crayons are another example of wax. They are made from paraffin wax and colored with pigments. (Rub the tip of a crayon back and forth on a piece of paper. Then, look at the tip of the crayon. Does it look glossy where you "polished" it against the paper?)

Paraffin wax is a white, pliable solid obtained from crude oil. Paraffin wax and crude oil are mixtures. A mixture is a physical combination of two or more substances.

Paraffin wax has many uses. In addition to crayons, paraffin is used in candles, waterproof paper, and preservative coatings. Paraffin wax, like other waxes, is insoluble in water. A substance that dissolves in another substance is soluble. A substance that does not dissolve is insoluble. Thus, wax will not dissolve in water. In fact, it will not mix with or react with water at all. It actually repels water. Therefore, if you place water on a wax candle, it will simply sit on top of the candle or roll off.

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Other substances tend to mix well with water. For example, sugar and salt easily dissolve in water.

Likewise, watercolor paints are soluble in water. To apply the watercolor paint, the brush is dipped in water and then in the paint. The paint mixes with the water in the brush, allowing it to be applied to paper. However, when the brush moves over wax, the water will simply roll off the area with the wax, preventing the paint from being applied to that part of the paper.

### FORMULAS & EQUATIONS

Paraffin wax is the main ingredient in crayons and is obtained from crude oil. Crude oil is a mixture of hydrocarbon compounds. A hydrocarbon is a compound made of only the elements hydrogen (**H**) and carbon (**C**).

Paraffin waxes are the solid form of paraffin, and mainly contain straight-chain hydrocarbons from approximately $\mathbf{C_{20}H_{42}}$ to $\mathbf{C_{30}H_{62}}$.

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Pure water is a liquid at standard temperature and pressure.

It has the chemical formula $\mathbf{H_2O}$.

### CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on properties of matter, mixtures, and solubility can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.

### HYPOTHESIS

▶Watercolor paint will not cover parts of a paper that have been covered with wax, because wax is not soluble in water.

### Fun Fact

Beeswax is a yellow to grayish-brown wax secreted from the underside of worker honeybees. The wax is used to make honeycombs. Beeswax is used by humans in many body care products, including lip balm.

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## DIFFERENTIATION IN THE CLASSROOM

### LOWER GRADE LEVELS/BEGINNERS

Perform the experiment as described on page 179, but focus on properties and states of matter. Discuss the three common states of matter, and have students give examples of solids, liquids, and gases. You can expand further to address crystalline and amorphous solids. **Crystalline solids** are made up of atoms or molecules that are arranged in a specific, repeating pattern. Ice and salt are crystalline solids. **Amorphous solids** are made up of atoms or molecules that are locked into place but do not have a specific, repeating structure. Wax is an example of an amorphous solid. Challenge the students to think of ways crystalline and amorphous solids look and behave differently. Ask them to name other examples of crystalline and amorphous solids.

Continue to address different properties of matter by explaining that some substances have certain properties that prevent them from mixing together. Discuss what happened between the water and wax in the experiment.

### HIGHER GRADE LEVELS/ADVANCED STUDENTS

### DESCRIPTION

Use white crayons and watercolor paints to make designs on paper and explore colloids and polarity.

### OBJECTIVE

This lesson introduces colloids and illustrates polarity as students attempt to apply watercolor paint to wax designs on paper.

### OBSERVATION & RESEARCH

Waxes are pliable solid substances that do not have a specific chemical formula and can be made both naturally and synthetically. Despite this variety, waxes tend to have similar physical properties. Most waxes melt at moderate temperatures and can be buffed or polished under slight pressure to produce a glossy appearance. Another common property of waxes is polarity: waxes are nonpolar substances. Conversely, water is a polar substance.

**Polar substances** are made up of particles that have an uneven distribution of electrons, creating a negative and a positive side. Generally, polar solutes will only dissolve in polar solvents. (Essentially, polar substances will only mix with other polar substances.) Other polar substances include acetic acid, salt, and sugar. **Nonpolar substances** are made up of particles that have an even distribution of electrons. The charges on the particles are neutralized. Nonpolar solutes generally only dissolve in nonpolar solvents. (Essentially, nonpolar substances will only mix with other nonpolar substances.) Other nonpolar substances include oil, fats, alkanes, and benzene.

To figure out whether certain substances will mix, remember that "like dissolves like." This means that the oils, fats, alkanes, and wax will mix, but they will not mix with water or substances similar to water. However, sugars and salts will easily dissolve in water.

Paints are a type of colloid. A **colloid** is a mixture in which very small particles are spread evenly through another substance. The particles in a colloid usually have a size of about one micrometer to one nanometer. Because of the tiny size of these particles, some colloids look like uniform solutions. However, the particles in a solution are even smaller than the particles in a colloid. You just can't see this difference without a powerful microscope.

Paints are classified as sols, which are colloids made of fine solid particles spread throughout a liquid. To apply the watercolor paint, the brush is dipped in water and then in the solid paint material. The solid paint material mixes with the water on the brush, creating the sol that can be applied to the paper. Because the solid paint particles are dispersed in water, the paint will roll off the area with the wax. Therefore, the paint is not applied to the parts of the paper covered with the wax.

### CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on polar and nonpolar substances can be found in the Chemicals by Volume—Solutions section of CEF's *Passport to Science Exploration: Chemistry Connections*.
- Additional information on colloids can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry.*

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## EXPERIMENTATION

As the students perform the experiment, challenge them to identify the independent, dependent, and controlled variables, as well as whether there is a control setup for the experiment. (Hint: If you use colored pencils, pens, or markers, will you get the same results?) Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss variables.

### EXPERIMENTAL PROCEDURE

1. Give each student a piece of white paper.
2. Use white crayons to draw designs on the paper. Be sure to press firmly.
3. Use different watercolor paints to lightly paint the entire sheet of paper. Observe the results. The paint will not be absorbed in the areas of the paper that are covered by crayon wax.

**Make sure the students mix plenty of water with the paint and paint lightly. If the brush is relatively dry and pressed hard against the wax, color particles may stick to the wax.**

### DATA COLLECTION

Have students record data in their science notebooks or on the following activity sheet. What are the properties of wax? What are the properties of the watercolor paint? Have students answer the questions on the activity sheet (or similar ones of your own) to guide the process.

## NOTES

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## ANALYSIS & CONCLUSION

Use the questions from the activity sheet or your own questions to discuss the experimental data. Ask students to determine whether they should accept or reject their hypotheses. Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss valid and invalid hypotheses.

### ASSESSMENT/GOALS

Upon completion of this lesson, students should be able to …

- Apply a scientific inquiry process and perform an experiment.
- Define soluble and insoluble substances and give examples.
- Identify wax substances and their properties.
- Differentiate between polar and nonpolar substances (see ***Differentiation in the Classroom***).
- Define and identify colloids (see ***Differentiation in the Classroom***).

**Fun Fact**

Waxes generally consist of hydrocarbons and will burn with a yellow flame because of the presence of carbon.

### MODIFICATIONS/EXTENSIONS

Modifications and extensions provide alternative methods for performing the lesson or similar lessons. They also introduce ways to expand on the content topics presented and think beyond those topics. Use the following examples, or have a discussion to generate other ideas as a class.

- Because you are using white or clear crayons/wax, it will be very difficult to see what the students are creating. You can have the students write secret messages and exchange them between classmates. The message can only be revealed by painting the paper.
- You can also have the students bring in pictures or cut pictures out of magazines to trace. Have each student place a piece of white paper over the picture and trace the outline of the picture with the crayon. Then, the students can paint their papers with various watercolors to reveal the picture.
- Discuss the different types of wax—natural versus synthetic—and provide examples of both natural and synthetic waxes.

### REAL-WORLD APPLICATIONS

- Surfers use wax to make their surfboards less slippery. Since they stand or lie on the surfboard, they need the wax to repel some of the water so that they do not lose their footing and fall off the board.
- Paraffin wax is edible and is added to foods as a preservative and to make the food more attractive. Many chocolates and sweets contain paraffin wax to give candy a shiny coating. The wax also stops moisture from leaving the coated candy, keeping the candy moist and less likely to spoil in unrefrigerated conditions.

### COMMUNICATION

Discuss the results as a class and review the activity sheet. Review the information in the ***Scientific Inquiry*** section on pages 14–16 to discuss the importance of communication to scientific progress.

# LESSON 14 ACTIVITY SHEET: Wacky Waxy Watercolors

## OBSERVE & RESEARCH

**1.** Write down the materials you observe. _____

_____

_____

**2.** Predict how these materials may be used. _____

_____

_____

**3.** Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

| Term | Definition | Example (write or add image) |
|---|---|---|
| **Paraffin wax** | | |
| **Soluble** | | |
| **Insoluble** | | |
| **Crude oil** | | |
| **Hydrocarbon** | | |

**4.** Consider what will happen if you apply watercolor paint to wax and why.

▶**Write your hypothesis.** _____

_____

_____

# LESSON 14 ACTIVITY SHEET: Wacky Waxy Watercolors

## PERFORM YOUR EXPERIMENT

1. Use a white or clear crayon to draw or write on a piece of white paper. Be sure to press firmly.

2. Use different watercolor paints to paint lightly over the entire sheet of paper. Observe.

## ANALYZE & CONCLUDE

1. Describe the crayon. How does it look and feel? What makes up the crayon? _____

_____

_____

2. Can you see the designs you drew with the crayon before applying the paint? If so, how well can you see the designs?

_____

_____

_____

3. What happens when you paint the paper? _____

_____

_____

4. Why does the paint not have the same effect on the wax as it does on the paper? _____

_____

_____

5. Is your hypothesis valid? Why or why not? If not, what would be your next steps? _____

_____

_____

# LESSON 14 ACTIVITY SHEET: Wacky Waxy Watercolors

## EXPAND YOUR KNOWLEDGE—ADVANCED

**1.** Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

| Term | Definition | Example (write or add image) |
|---|---|---|
| **Polar substance** | | |
| **Nonpolar substance** | | |
| **Colloid** | | |

**2.** Can wax be dissolved in water? Why or why not? _____

_____

_____

**3.** What other ways can wax be used? _____

_____

_____

**4.** List some other nonpolar substances. _____

_____

_____

**5.** List some other polar substances. _____

_____

_____

# LESSON 14 ACTIVITY SHEET: Wacky Waxy Watercolors

**ANSWER KEY** *Below are suggested answers. Other answers may also be acceptable.*

## OBSERVE & RESEARCH

**1.** Write down the materials you observe. Paper, white or clear crayons, watercolor paints ...

**2.** Predict how these materials may be used. The paper and crayons may be used to write information or draw designs. Watercolor paints may be used to make designs on the paper. These materials may be combined to illustrate physical properties of the substances.

**3.** Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

| Term | Definition | Example (write or add image) |
|---|---|---|
| **Paraffin wax** | A white, pliable solid that can be obtained from crude oil. | |
| **Soluble** | The ability of a substance to dissolve in another substance. | |
| **Insoluble** | The inability of a substance to be dissolved into another substance. | |
| **Crude oil** | A mixture made of hydrocarbon compounds, used to produce various fuels, such as gasoline. | |
| **Hydrocarbon** | A compound made of only the elements hydrogen (H) and carbon (C). | |

**4.** Consider what will happen if you apply watercolor paint to wax and why.

▶**Write your hypothesis.** Watercolor paint will not stain a paper that has been covered with the wax from crayons because wax is not soluble in water. The wax will repel the water.

# LESSON 14 ACTIVITY SHEET: Wacky Waxy Watercolors

**ANSWER KEY:** *Below are suggested answers. Other answers may also be acceptable.*

## PERFORM YOUR EXPERIMENT

1. Use a white crayon to draw or write on a piece of white paper. Be sure to press firmly.

2. Use different watercolor paints to paint lightly over the entire sheet of paper. Observe.

## ANALYZE & CONCLUDE

**1.** Describe the crayon. How does it look and feel? What makes up the crayon? The crayon is hard, shiny, and white or clear. The crayon is made of wax.

**2.** Can you see the designs you drew with the crayon before applying the paint? If so, how well can you see the designs?

If you draw on white paper, only a faint reflection of the wax will be visible on the paper.

**3.** What happens when you paint the paper? When you paint over the wax designs on the paper, the water (and dissolved pigment) will repel from the areas covered with wax. The color will stain the rest of the paper, leaving behind fun designs around the wax.

**4.** Why does the paint not have the same effect on the wax as it does on the paper? The paint will not stain the wax because wax is not soluble in water. The wax repels the water containing the paint. The water will bead up and roll off the wax if it is applied. On the other hand, the color (pigment) is soluble in water, so the water collects the paint, which is then absorbed by the paper.

**5.** Is your hypothesis valid? Why or why not? If not, what would be your next steps?

Answer 1: Valid because the data support my hypothesis.

Answer 2: Invalid because the data do not support my hypothesis. I would reject my hypothesis and could form a new one, such as …

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**ANSWER KEY:** *Below are suggested answers. Other answers may also be acceptable.*

## EXPAND YOUR KNOWLEDGE—ADVANCED

Have students complete this section if you used the advanced differentiation information, or challenge them to find the answers to these questions at home and discuss how these terms relate to the experiment in class the next day.

**1.** Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

| Term | Definition | Example (write or add image) |
|---|---|---|
| **Polar substance** | A substance made up of particles that have an uneven distribution of electrons, creating a negative and a positive side. | |
| **Nonpolar substance** | A substance made up of particles that have an even distribution of electrons; the charges on these particles are neutralized. | |
| **Colloid** | A mixture, between homogeneous and heterogeneous, in which very small particles are spread evenly throughout another substance. | |

**2.** Can wax be dissolved in water? Why or why not? No, paraffin wax is made from crude oil, which is insoluble in water. Other waxes are made from other fats or oils, which are also insoluble in water.

**3.** What other ways can wax be used? Waxes can be used to repel water from a surfboard and as a water-repellent film on the bottoms of skis and snowboards. Wax can also be used to line paper cups so they can hold water without leaking.

**4.** List some other nonpolar substances. Other nonpolar substances include fats, alkanes, and benzene.

**5.** List some other polar substances. Other polar substances include sugar, salt, and ammonia.