MAINE MOBILE BIOLAB
TEACHER GUIDE

Micropipette Challenge

Topic(s): Laboratory tools, laboratory skills, metric system, following a protocol, light and color perception

Grade level(s): 5th – 8th grades

Time: 60 minutes

Maine Standards: MS-PS4-2

ACTIVITY OVERVIEW

The Micropipette Challenge is a perfect introductory activity, allowing students to gain experience with the tools and techniques, like the micropipette, that are used in many scientific labs. In this lab, students work with small amounts of liquid to create a visible spectrum. Students will also learn how to carefully read and follow a scientific protocol and gain experience working with units in the metric system.

ALIGNMENT TO STANDARDS

MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

LEARNING OUTCOMES

Upon completion of the Micropipette Challenge, students will be able to:

- Understand how subtractive color mixing works
- Understand how to properly use a micropipette
- Read and follow a laboratory protocol
- Understand unit conversion
- Convert between microliters, milliliters, and liters

CAREER CONNECTIONS

Environmental Engineering Technician

Apply theory and principles of environmental engineering to modify, test, and operate equipment and devices used in the prevention, control, and remediation of environmental problems, including waste treatment and site remediation, under the direction of engineering staff or scientist. May assist in the development of environmental remediation devices.

Geneticists

Research and study the inheritance of traits at the molecular, organism, or population level. May evaluate or treat patients with genetic disorders.

Microbiologist

Investigate the growth, structure, development, and other characteristics of microscopic organisms, such as bacteria, algae, or fungi. Includes medical microbiologists who study the relationship between organisms and disease or the effects of antibiotics on microorganisms.

Chemist

Conduct qualitative and quantitative chemical analyses or experiments in laboratories for quality or process control or to develop new products or knowledge.

Sources:
http://www.worky.com/workypedia/careers-that-use-micropipettes/21/1974

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BACKGROUND INFORMATION

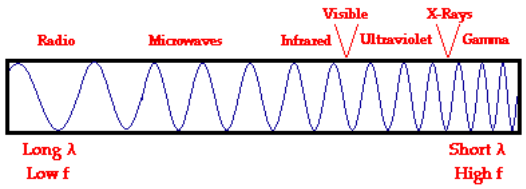
The goal of this activity is to introduce students to important laboratory tools, be able to read and follow a basic lab protocol and understand the metric system. Understanding how to use laboratory tools such as the micropipette is important for students. It allows them to practice a skill that can come in handy should they choose a career that utilizes this tool. They will already have a basic understanding of what the tool is, what the tool is used for, and how to properly set and measure out very small amounts of liquid using the tool.

This lab is also a great introductory lab to help students gain the knowledge and skills needed to learn how to read and follow a basic lab protocol. Learning to read scientific protocols and being able to follow them is important not only throughout their journey in high school lab classes, but can also spark an interest that puts them on the pathway for a STEM career. This knowledge can be invaluable as a student in college or beginning an introductory career in a lab. Even if the student is not interested in a STEM career, this skill can be beneficial in helping them understand how to read and follow other technical writings in whatever path they choose.

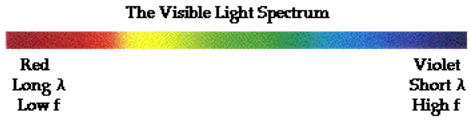
Lastly, through this activity, we hope to help students understand the importance of the metric system in the scientific community. The United States is one of a few countries that still does not use the metric system for our known system of measurements. However, in the lab quite often students will be utilizing the metric system, so having an understanding of it and the units involved with this system is important. The students will also learn how to convert from microliters to milliliters, another skill that can be invaluable to students in their future schooling or career pathways.

Key Terms

- **Electromagnetic Spectrum:** Electromagnetic waves exist with an enormous range of frequencies. This continuous range of frequencies is known as the electromagnetic spectrum.
    - The longer wavelength, lower frequency regions are located on the far left of the spectrum and the shorter wavelength, higher frequency regions are on the far right.



- **Visible Spectrum:** Although electromagnetic waves exist in a vast range of wavelengths, our eyes are sensitive to only a very narrow band. This narrow band of wavelengths is the means by which humans see, called the "visible light spectrum."
    - Dispersion of visible light produces the colors red, orange, yellow, green, blue, indigo, and violet. It is because of this that visible light is sometimes referred to as ROY G BIV.
    - The red wavelengths of light are the longer wavelengths and the violet wavelengths of light are the shorter wavelengths.



- **Metric System:** A type of decimal measuring system.

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Table A.1: The units of the metric system and their symbols

Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Table A.2: Derived units in the metric system and their symbols

Derived Unit	Base Units	Symbol
Velocity	Length/Time	m/s
Acceleration	Length / (Time * Time)	m/s^2
Force	(Mass * Length) / (Time * Time)	$kg*m/s^2$

- **Conversion Factor:** A multiplier for converting one set of units into another equivalent type of unit.
    - Example: $\frac{2.54\ cm}{1\ inch}$
    - How to use a conversion factor:
        - Write the conversion as a fraction that equals 1 (include units; see example above).
        - Multiply the desired unit by the conversion factor; ensure that the unit being converted is in the denominator of the conversion factor, and that the desired unit is in the numerator of the conversion factor.
        - Calculate the answer by multiplying the number being converted by the conversion factor.

For more information, follow these links:

- Micropipettes: https://bit.ly/2NAaPti
- Electromagnetic Spectrum: https://www.physicsclassroom.com/class/light/Lesson-2/The-Electromagnetic-and-Visible-Spectra
- Metric System: https://www.mathsisfun.com/measure/metric-system.html
- Unit Conversions: https://www.mathsisfun.com/measure/unit-conversion-method.html

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PRE-LABORATORY ENGAGEMENT

Color Reflection and Absorption

Before the mobile lab visit, it is recommended that students conduct the "Color Reflection and Absorption" activity. In this activity, students will determine the colors that make up white light and how the colors we see are the colors reflected from that surface.

POST-LABORATORY ENGAGEMENT

Colored Shadows

After the mobile lab visit, students can continue to learn about light and light waves. Using the "Science Buddies: Colored Shadows" activity, students will learn how additive color mixing differs from the subtractive color mixing seen in the pre-lab and lab activity.

The Exploratorium video can also be used to help set up or demonstrate this experience.

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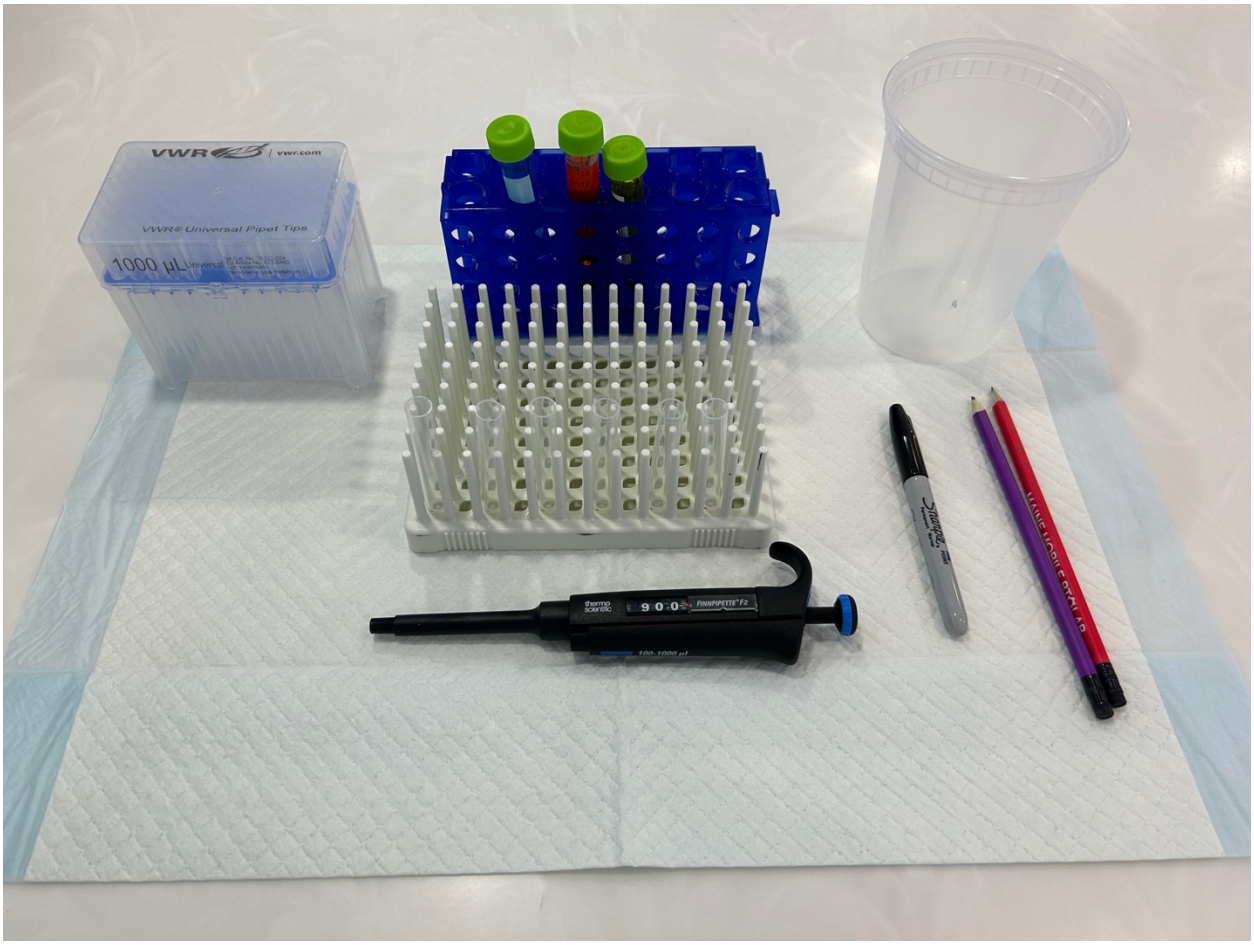
LABORATORY SETUP



MATERIALS

- Absorbency pad
- Trash container
- Permanent marker
- Six 5 mL test tubes
- Three 15 mL conicals (red, yellow, blue)
- Peg rack
- P1000 Micropipette
- Micropipette tips
- Gloves

REAGENT PREP

Prepare Colored Water

1. Mix 25 drops of red food coloring with dH_2O in a 1-liter bottle
2. Mix 15 drops of yellow food coloring with dH_2O in a 1-liter bottle

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3. Mix 25 drops of blue food coloring with dH_2O in a 1-liter bottle
4. Divide colors into 15 mL conicals

LESSON PLAN

Introduction (5 min)

- Welcome students to the lab and direct them where to sit.
- Explain to students:
    - Roy, Gee, and Biv are having problems with their science lab. Their teacher has asked them to create a spectrum, but none of them have a clue as to how to make one.
    - A spectrum is a display of light or other forms of radiation separated by properties—most often people think of the electromagnetic spectrum which is the entire range of light. The visible spectrum, the part of the spectrum that we can see with our eyes, is only a small part of the entire electromagnetic spectrum.
    - Today you will be helping Roy, Gee, and Biv by constructing your own spectrum.

Part 1: Using a Micropipette (15 minutes)

- The first thing we need to do is learn how to use our equipment.
- Hold up a micropipette and ask "does anyone knows what this is?"
    - Students will have varying answers.
    - Explain to the students that a micropipette is an accurate and precise instrument used to measure very small amounts of liquid–frequently millionths of a liter. One-millionth of a liter is equal to one microliter, abbreviated 1µL.
- Now that you know what a micropipette is, let's talk about the parts of it and how to use it.
    - The number on the side of the micropipette is the amount of liquid this pipette can hold. This pipette can hold 100-1000 microliters. Microliters are a very small unit of measurement. Think about a 2-liter bottle of soda (show the 2-liter bottle of soda) it would take 2 million microliters to fill this bottle.
    - The clear window on the side with the rotating numbers tells us how many microliters our micropipette is picking up at the moment.
    - The micropipette has a plunger that helps us to pick up liquid. This plunger can turn to change the amount of liquid you will pick up.
        - To change the amount of liquid we pick up you will rotate the plunger clockwise or counterclockwise, depending on if you want to increase or decrease the number in the window.
        - Remember, our micropipette works in a range of 100-1000 microliters, so we want to make sure we do not go below 100 or above 1000 when changing the number in the window. If you do, you can mess up the calibration of the micropipette and it will not work correctly.
        - To pick up the liquid there are a few other things the plunger can do. For example, when pressing down on the plunger you will notice there are two stops, 1st stop and 2nd stop. When you press the plunger down, you will feel it come to a natural stop. This is 1st stop. You will notice there is still a small amount of room and you can still press the plunger down a bit

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farther. When you press the plunger completely down and there is no more room between the plunger and the micropipette, this is our 2nd stop.
    - When we go to pick up a liquid you will press the plunger down to the first stop, place the tip into the liquid, and then slowly release the plunger back up. This will pick up the exact volume shown in the window. To eject the liquid from the pipette you will place your pipette tip over your tube and press down to the second stop to give the pipette extra air to get all of your liquid or sample out of the tip.

  - Pipette tips are also a very important part of the micropipette. You always want to make sure that you have a tip on your micropipette before putting it into the liquid you are using. Without a tip, you could risk getting the liquid into the mechanical parts of the micropipette and breaking it.
    - There is an eject button located on the micropipette which allows you to change your tip. Just make sure it is over the waste bin before pushing it.
    - Pipettes are used for many different science experiments and are commonly found in forensics labs. When using a pipette, we do not want to contaminate our samples so we will need to change our pipette tip after picking up each sample.

- Now it's your turn to try! Grab a tip and set your micropipette to pick up 600 microliters of blue liquid.
  - Now, dispense the liquid back into the 15ml conical with the blue liquid.
  - Make sure both partners get a chance to practice.

Part 2 (Slide 2): Completing the Spectrum (the lab) (20 minutes)

- Walk students through the first few steps of the procedure.
- Reminders to give students:
  - Many of these volumes are larger than 1,000 microliters, but our micropipette has a maximum volume of 1,000 microliters. Ask students how we can measure 1,900 microliters with a 1,000 microliter pipette.
    - We can divide the 1,900 into smaller increments. For example, we could do 1,000 and 900 or we could do 950 two times.
  - Remind students that as they add liquid to the tubes, they should record those volumes in the table. If we add liquid to the numbered tube (not the stock tubes of red, blue, yellow) we should have a plus sign (+) in front of the number. If we remove liquid from the numbered tube we should have a minus sign (-) in front of the number.
- **Slide 3:** When groups have finished the procedure, have them add the values in each row to get the total volume in each tube and its color.
  - Guide students on how to convert from microliters to milliliters for all values. *Advance the slide to fill the numbers into the chart.*
- Have students look at their tubes and see if they all have the same amount of liquid (as we calculated with our addition and subtraction).
  - Common errors in micropipette usage will result in the transfer of volumes different than intended. For example, if there are air bubbles in tip of the pipette, a smaller volume than intended is transferred. When students press to second stop

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and release while in the liquid, they will transfer a larger volume than the one intended.
    - Explain that with more practice, students can get more accurate results.

Slide 4: Types of Electromagnetic Radiation

- The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of EM radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays, and gamma rays.
    - Honey bees can see UV light which helps them see UV color patterns on flowers helping them find food. UV vision also helps them see the sun on cloudy days so they can measure angles to navigate between food sources and find their hive.

Slide 5: Light Reflection

- The color we see is the color reflected while all other colors of white light are absorbed.
- No dyes or pigments are pure colors; they reflect light over a narrow wavelength band (reflecting some but not all colors). Yellow dye reflects yellow light, but also reflects small amounts of orange and green light while absorbing red and blue light. Red paint absorbs blue and yellow light but reflects a bit of orange. When yellow and red paints are mixed, the yellow paint absorbs the red light and the red paint absorbs the yellow light, but they both reflect orange; so the mixture appears orange. When two paints mix, the color produced is the color that both paints reflect.
- We see black when all colors are absorbed, and we see white when all colors are reflected.

Slide 6: Inside Our Eyes

- Inside our eyes are three types of cones, and these cones send signals to our brain based on the wavelengths that they perceive. They roughly correspond to three colors: red, green, and blue.
- When certain wavelengths combine, depending on the strength of each, our cones will send signals that correspond to other colors. For instance, if someone were to view red and green light together, the corresponding cones would send signals to the brain that would be interpreted as yellow.
- Additionally, the human eye also features cells called rods. These rod cells only see in gradients of grey and work in low light.

Slides 7-8: Color blindness

- Color blindness can happen when one or more of the color cone cells are absent, not working, or detect a different color than normal. Severe color blindness occurs when all three cone cells are absent. Mild color blindness happens when all three cone cells are present, but one cone cell does not work right. It detects a different color than normal.
- The symptoms of color blindness can range from mild to severe. Many people have such mild symptoms that they are unaware that they have a color deficiency.
- Someone may have trouble seeing colors and the brightness of colors.
- Someone may have the inability to tell the difference between shades of the same or similar colors. This happens most with red and green, or blue and yellow.

Closing (5 minutes)

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- Congratulate students on completing a visible spectrum. Talk about how the levels should be completely level or even. Remind students that if they liked this activity there are many jobs that require the use of micropipettes.
- Explain more about 1-2 lab jobs that require the use of micropipettes.

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