

Measuring the Unmeasurable

The Secret Tool Scientists Use to Study Cells and Microbes

Overview

In this lesson, students discover why precision and accuracy matter when scientists investigate matter and living systems. Students will use micropipettes to measure exact volumes of colored water, complete color-mixing challenges, transfer simulated biological samples, and explain their reasoning using the Claim-Evidence-Reasoning (CER) framework. Through hands-on practice with P20 and P200 micropipettes, students will develop foundational biotechnology skills while reinforcing physical science concepts (PS.5.1.1, PS.5.1.2, PS.5.1.3) and preparing for life science investigations (LS.5.1.1). Students will demonstrate their learning by successfully completing accuracy challenges, recording precise measurements, and writing CER explanations for why scientists use micropipettes instead of pouring liquids. This lesson is designed for 20-22 students per three 70 minute blocks.

Key Search Words

- Micropipette
- Precision
- Accuracy
- Measurement
- Scientific Tools
- Mixing
- Microliters
- Volume
- Quantitative Data
- Calibration
- Cells
- Biomedical Research

Learning Objectives

Students will

- Define and explain the difference between precision and accuracy in scientific measurement
- Use P20 and P200 micropipettes correctly to measure and transfer precise volumes (20, 50, 100 microliters) of liquid
- Calibrate and verify micropipette accuracy using water and visual comparison methods
- Explain why precision matters when scientists study matter, cells, and living systems instead of pouring or approximating volumes

- Complete color-mixing challenges using micropipettes to demonstrate that precise volumes produce predictable, consistent results
- Transfer simulated biological samples accurately using micropipettes while maintaining measurement consistency
- Collect and analyze data on micropipette accuracy and identify sources of error in measurement
- Use the Claim-Evidence-Reasoning (CER) framework to explain why scientists use micropipettes in research investigations
- Connect micropipette skills to real-world applications in DNA research, cell study, microbiome science, and biomedical careers
- Demonstrate scientific thinking by prioritizing accuracy over speed and explaining how precision affects the reliability of scientific investigations

Curriculum Alignment

This lesson is appropriate for 5th Grade Science students and addresses the following Next Generation Science Standards:

Physical Science Standards:

- PS.5.1.1: Conduct investigations and communicate findings about the physical properties of materials (e.g., hardness, flexibility, color, texture, ability to dissolve in water)
- PS.5.1.2: Conduct investigations to determine how mixing materials can cause physical or chemical changes and communicate findings about these changes
- PS.5.1.3: Carry out investigations to compare how heating and cooling affect some materials and how this relates to their purpose and practical applications

Life Science Standards (Bridge):

- LS.5.1.1: Understand that all living things are composed of cells and that cells are the basic unit of life

Disciplinary Core Ideas/Practices/Cross-cutting concepts covered

Grades 5

- Disciplinary Core Ideas: Matter and its interactions; Life and living processes
- Science and Engineering Practices: Conducting investigations; Using tools appropriately; Analyzing and interpreting data; Engaging in argument from evidence
- Crosscutting Concepts: Cause and effect (precise measurement causes reliable results); Scale, proportion, and quantity (understanding microliters); Systems and system models (micropipettes as precision tools)

Classroom time required

Class Time:

- Block 1 (Day 1): 70 minutes (Engage, Explore, Calibration)
- Block 2 (Days 2-3): 70 minutes (Explore - Color-Mixing Challenge)
- Block 3 (Days 4-5): 70 minutes (Explain, Elaborate, Evaluate)
- Total class time: 210 minutes (3 hours 30 minutes)
- (More than likely, each block will complete the same activity each day)

After-Class Time:

- Cleaning and storing micropipettes: 10-15 minutes after final block
- Organizing data and preparing assessment results: 15-20 minutes
- Total after-class time: 25-35 minutes

Materials & Technology

Reusable materials:

- P20 micropipettes (2–20 μL) - 9-12 total (3-4 sets per block)
- P200 micropipettes (20–200 μL) - 6-9 total (2-3 sets per block)
- Micropipette storage racks or designated safe locations
- Tip racks or organized storage boxes for tips
- Desk lamps or task lighting - 6-12 total (2-4 per block)
- Document camera with display screen (optional)
- Projector and screen
- White paper or laminated calibration mats - 15-30 sheets
- Small clear cups or microtubes (reusable) - 30-50 total
- Measuring ruler or scale (optional)
- Color prediction charts or templates (laminated; reusable)
- Laminated challenge mats showing target colors
- CER (Claim-Evidence-Reasoning) template (laminated copies for reference)
- Chart paper and colored markers
- White backgrounds or trays for color observation - 6-8 total
- Micropipette storage containers

Perishable or disposable materials:

- Disposable micropipette tips - P20 tips (1,000+ total; 300-400 per block)
- Disposable micropipette tips - P200 tips (1,000+ total; 300-400 per block)
- Distilled water - 3 bottles (1 per block)
- Food coloring (red, yellow, blue) - 1 bottle of each (3 of each total)
- Paper towels - 6-9 rolls (2-3 per block)
- Absorbent mats or paper for spills - 3 rolls
- Sealed disposal bags - 6-9 boxes (2-3 per block)
- Hand sanitizer - 6-9 bottles (2-3 per block)
- Disinfecting wet wipes - 9 containers (3 per block)
- Nitrile gloves (optional) - 3 boxes (1 per block)

Safety

Ensure that students understand and adhere to safe laboratory practices when performing any activity in the classroom or lab. Demonstrate the protocol for correctly using the instruments and materials necessary to complete the activities, and emphasize the importance of proper usage. Use personal protective equipment such as safety glasses or goggles, gloves, and aprons when appropriate. Model proper laboratory safety practices for your students and require them to adhere to all laboratory safety rules.

Teacher Preparation for Activity

- PATIENCE IS KEY!
- Allow scholars to truly EXPLORE and gain knowledge using their hands
- For each day/activity, invest the time to prepare as if you were completing the activities versus the student

Before the Lesson (1-2 weeks prior):

1. Gather and organize all materials
 - Collect P20 and P200 micropipettes and verify they are functional
 - Organize tip boxes by type and ensure tips are clean and dry
 - Check that all micropipettes have storage racks available
 - Verify that document camera and projector are working
 - Test all desk lamps for brightness
2. Prepare solutions
 - Mix food coloring solutions: prepare small bottles of red, yellow, and blue food coloring
 - Fill distilled water bottles and label clearly
 - Prepare salt water solution (if using for alternative activities)
3. Print and organize student materials
 - Print 90-120 copies each of: Micropipette Accuracy Recording Sheet, Color Prediction Chart, Sample Transfer Recording Sheet, CER Template, Exit Ticket, and Student Guide
 - Organize printed materials into block-specific folders
4. Set up station materials
 - Organize each station's materials into labeled bins or trays
 - Prepare white paper and laminated mats for each station
 - Arrange all materials so they can be quickly reset between blocks
5. Test micropipettes and calibration
 - Practice using P20 and P200 micropipettes yourself
 - Test calibration by measuring water droplets on white paper
 - Verify that volume settings are accurate
 - Check that plungers move smoothly and tips fit securely
6. Create reference materials
 - Prepare color prediction reference chart showing expected colors for each mix
 - Create laminated challenge mats if not already available
 - Prepare CER example sentences for teacher reference

Before Each Block (15-20 minutes before class):

1. Reset micropipette materials
 - Replace all used tips with fresh ones
 - Verify micropipettes are clean and functional
 - Place micropipettes in storage racks
2. Prepare fresh solutions
 - Fill small cups with distilled water for calibration practice
 - Prepare fresh food coloring solutions for color-mixing challenge
 - Label all containers clearly
3. Set up work stations
 - Place white paper or laminated mats at each station
 - Arrange colored water, cups, and micropipettes
 - Verify all recording sheets and pencils are in place
 - Check desk lamps are positioned for clear visibility
4. Prepare cleanup supplies
 - Place hand sanitizer, wet wipes, and paper towels at each station

- Verify disposal bags are ready for used tips
- Arrange absorbent mats for spill cleanup
- 5. Test technology
 - Verify document camera is focused and projecting clearly
 - Check that projector and screen are working
 - Ensure lighting is adequate for observing droplets and colors
- 6. Review safety protocols
 - Set up visual reminder signs for hand hygiene and micropipette safety
 - Arrange station rotation signals and visual timers
 - Prepare station rotation schedule

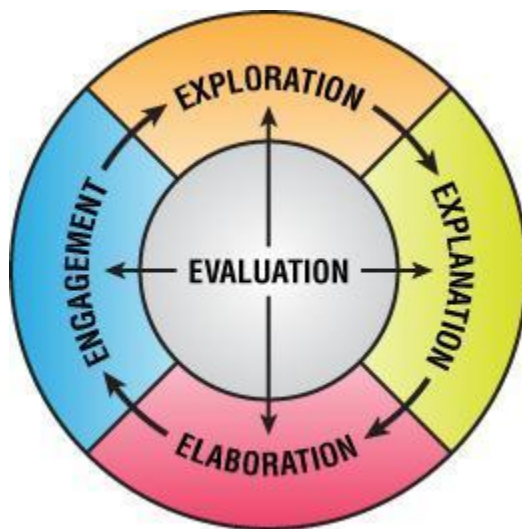
Between Blocks (10-15 minutes):

1. Empty used tip containers into sealed disposal bags
2. Replace all micropipette tips with fresh ones
3. Wipe down work surfaces with disinfecting wipes
4. Prepare fresh distilled water cups
5. Refill food coloring solutions if needed
6. Replenish hand sanitizer and wet wipes
7. Clear any spilled water or colored solution
8. Verify lighting and document camera are ready for next block
9. Check that all recording sheets are organized for next block

Student Preparation for Activity

This lesson is intended for 5th Graders after completing their Physical Science Unit and NC Check-In and a BRIDGE into the Life Science Unit.

Procedure



(Day 1): Engage, Explore & Calibration (70 minutes)

- **Engage - Why Precision Matters** (10 minutes)
 - Compare two scientists scenario (pouring vs. micropipette)
 - Discussion: When does precision matter? When is approximation okay?
- **Explore - Micropipette Practice & Calibration** (30 minutes)
- Station rotation setup and safety review (5 minutes)

- Micropipette handling and calibration demonstration (10 minutes)
- Student practice: measuring 20, 50, 100 μL of water onto white paper (15 minutes) - rotated in 2 groups of 10-11 students
- **Recording and Reflection** (15 minutes)
- Students record observations about droplet size consistency
- Discuss: How do we know if a micropipette is accurate?
- **Cleanup and Preparation** (5 minutes)
- Reset tips, refresh water, organize for next block
- **Setup for Color-Mixing Challenge** (10 minutes)
- Introduce challenge: "Can you predict the color if you mix precise amounts?"

(Days 2-3): Explore - Color-Mixing Challenge (70 minutes)

- **Review and Safety** (5 minutes)
- Remind students of micropipette safety and proper technique
- Review what precision means
- **Color-Mixing Challenge - Station Rotations** (35 minutes)
- Station 1: Mix red and yellow in precise amounts (10 μL + 10 μL) → predict and observe orange (7 minutes per group)
- Station 2: Mix blue and yellow in precise amounts (10 μL + 10 μL) → predict and observe green (7 minutes per group)
- Station 3: Mix red and blue in precise amounts (10 μL + 10 μL) → predict and observe purple (7 minutes per group)
- Transition time between stations (2 minutes)
- All students complete all three rotations
- **Data Recording** (15 minutes)
- Students record predicted colors, actual colors, and accuracy observations
- Discuss: Were results consistent? Why or why not?
- **Explanation Connection** (10 minutes)
- "Why did we use micropipettes instead of pouring? What would have happened if we guessed the amounts?"
- Introduce: "Scientists use this same precision when studying cells and microbes"
- **Cleanup** (5 minutes)

• Days 4-5): Explain, Elaborate & Evaluate (70 minutes)

- **Explain - Real-World Applications** (10 minutes)
- PreMiEr connection: "Scientists studying microbes in buildings use micropipettes to measure exact amounts of samples"
- ABE connection: "Biotechnology researchers use micropipettes to work with DNA and cells"
- Career connection: Biomedical researcher, microbiologist, lab technician
- **Elaborate - 'Save the Sample' Challenge** (35 minutes)

- Scenario: "You have a tiny sample of important biological material. You must transfer it accurately to multiple test tubes without losing any or wasting it."
- Students work in pairs to transfer 50 µL of colored water (simulating biological sample) from source tube to 3 target tubes using micropipettes
- Challenge: Maintain accuracy across all transfers; record volume in each target tube
- Stations rotate so all students participate (10-12 minutes per pair)
- Data recording: Did you successfully transfer the target volume? How do you know?
- **CER Framework Activity** (15 minutes)
- **Claim:** "Scientists should use micropipettes instead of pouring when measuring small volumes"
- **Evidence:** Students provide observations from color-mixing and sample transfer challenges
- **Reasoning:** Students explain WHY precision matters in scientific investigation
- Teacher circulates to support CER development
- **Evaluate - Exit Ticket** (8 minutes)
- Question: "Why would a scientist use a micropipette instead of pouring liquid when studying cells? Explain your thinking."
- Students respond in writing or verbally
- **Cleanup and Disposal** (2 minutes)
- Final tip disposal, water cleanup, materials storage

Differentiation

Learner	Differentiation Practices
Advanced/Gifted Learners	• Having to complete a picture using a micropipette such as "Pipette the Rainbow". • Having to complete the "Save the Sample" Challenge utilizing multiple micropipettes. • Independent LabXchange Module
Grade-Level Proficient Learners	• Clear demonstrations provided and accessible • Guided Discussions • Opportunities to practice and refine skills with feedback (Small Group with Smith or Peers)
Emerging/Below Grade-Level Learners	• Pre-Teaching of Vocabulary • Graphic Directives (pictures, notebook) • Sentence Starters • Teacher Support (Small Group with Smith)

Assessment/Check for Understanding

- Exit Tickets
- Lab Sheets
- Teacher Observation

Sources

MagicSchool AI. (n.d.). *MagicSchool AI*. <https://www.magicschool.ai/>