

Mastering Micro-volumetrics and Pipetting One Drop at a Time

Grade 9-12 Lesson Plan

Lesson Plan Developed by Teresa Kagotho

Overview

Every breakthrough medicine begins with a single precise drop. Whether scientists are engineering insulin-producing yeast, developing vaccines, or discovering new antibiotics, one of the first laboratory skills they must master is accurate micropipetting.

This introductory biotechnology lesson is designed for high school students who have **never used a micropipette**. Students discover how scientists measure microscopic volumes that are far too small to see with the naked eye while learning proper laboratory techniques used in biotechnology, microbiology, genetics, and pharmaceutical manufacturing.

Students begin with an engaging demonstration comparing everyday measurements to microliters before participating in a **Rainbow Pipetting Challenge**, where they use colored water to practice setting volumes, aspirating liquids, and dispensing accurate amounts. Students then complete a **Pipette Card Challenge**, matching mystery volume cards to the correct micropipette settings before demonstrating their skills in a biotechnology simulation.

The lesson emphasizes precision, laboratory safety, contamination prevention, and good laboratory practices (GLP), while introducing students to biotechnology careers where micropipetting is an essential skill.

The lesson follows the **5E Instructional Model (Engage, Explore, Explain, Elaborate, Evaluate)** and provides students with the foundational laboratory skills needed for future biotechnology investigations.

Key Search Words

Subject: Biology, Physical and Earth and Environmental Science

Grade: Grades 9-12

Topic: Micropipette Fundamentals, Laboratory Measurement, Biotechnology Tools, Precision and Accuracy, Good Laboratory Practice (GLP)

Critical Vocabulary: Micropipette, Microliter (μL), Accuracy, Precision, Pipette Tip, Aspirate, Dispense, Plunger, First Stop, Second Stop, Contamination, Sterile Technique, Calibration, Biotechnology, Biomanufacturing

Pedagogical Strategy: 5E Instructional Model, Inquiry-Based Learning, **Hands-On Skills-Based Learning**, Cooperative Learning, Think-Pair-Share, **Experiential Learning**, **Guided Inquiry** (students discover how technique affects accuracy through practice), **Cooperative Learning**, **Demonstration and Guided Practice**

Learning Objectives

By the end of this lesson students will be able to:

1. Identify the major parts of a micropipette.
2. Select the appropriate micropipette for different liquid volumes.
3. Correctly set a micropipette to a desired volume.
4. Demonstrate proper aspiration and dispensing techniques using the first and second plunger stops.
5. Apply laboratory safety procedures when using micropipettes.
6. Explain why accurate pipetting is essential in biotechnology, medicine, and scientific research.
7. Evaluate common pipetting errors and describe strategies to improve accuracy.

Curriculum Alignment

LS.Bio.8.2 Biotech Applications – Explain how biotechnology is used to manipulate organisms and their products to improve human health and solve real-world problems.

- Students learn that micropipettes are essential tools used in biotechnology laboratories for DNA analysis, genetic engineering, microbiology, cell culture, and the production of medicines such as insulin.

Analyze and interpret data collected during scientific investigations using appropriate tools and methods.

- Students compare pipetted volumes, evaluate the accuracy and precision of their technique, and identify sources of experimental error during Micropipetting Practice Card and Rainbow Pipetting Challenge.

Carry out investigations to answer questions about biological systems using appropriate scientific tools, technologies, and laboratory techniques.

- Students use a micropipette to accurately measure and transfer small volumes of liquid while practicing proper laboratory techniques, precision, and contamination prevention.

Classroom time required

One 95-minute block period

- Engage – 15 minutes
- Explore – 35 minutes
- Explain – 20 minutes
- Elaborate – 15 minutes
- Evaluate – 10 minutes

Materials & Technology

Materials & Technology

Laboratory Materials

For each group of 3–4 students:

- Safety Glasses
- Lap Coats
- Voltex

- Centrifuge
- P2,P20,P200,P1000 micropipettes
- P2,P20,P200,P1000 disposable pipette tips
- Colored water (red, blue, yellow, green)
- Microcentrifuge tubes
- Waste paper and container
- Paper towels
- [Micropipette Cards/ wells](#) (20 μ L, 50 μ L, 75 μ L, 100 μ L, 150 μ L, 200 μ L, 500 μ L, 750 μ L, 1000 μ L)
- [Laminated Rainbow/ Pictures](#)
- Micro Tube Racks
- 25-30 Student lab Instructions and recording sheets
- Pencils

Technology:

- Projector
- Computer -25-30 Chromebooks
- [LabXchange Micropipetting Simulation](#)

Safety

- Wear safety goggles throughout the activity.
- Handle micropipettes gently.
- Never pipette liquids without a disposable tip attached.
- Never lay a liquid-filled micropipette on the laboratory bench.
- Never force the volume adjustment beyond the pipette's limits.
- Release the plunger slowly to prevent splashing and equipment damage.
- Dispose of used pipette tips in designated waste containers.
- Clean spills immediately and notify the teacher of damaged equipment.
- Wash hands before and after the investigation.

Teacher Preparation for Activity

- Review the functions and parts of the P200 and P1000 micropipettes.
- Practice proper micropipetting techniques, including setting the volume, attaching a tip, aspirating, dispensing using the first and second stops, and ejecting the tip.
- Prepare a short presentation introducing micropipettes and their importance in biotechnology, biomedical research, and biomanufacturing.
- Prepare one laboratory station for each pair or small group of students.
- Gather and organize the following materials:
 - Voltex
 - Centrifuge
 - P2,P20,P200,P1000 micropipettes
 - Disposable pipette tips for the above micropipettes
 - Red, blue, yellow, and green colored water
 - Microcentrifuge tubes
 - Waste paper and containers for used tips
 - Paper towels
 - Student worksheets and recording sheets

- Create and laminate **Micropipette Volume Challenge Cards** (e.g., 20 μL , 50 μL , 100 μL , 150 μL , 200 μL , 500 μL , 750 μL , and 1000 μL).
- Set up the **Rainbow Pipetting Challenge** by placing colored water in clearly labeled containers.
- Check that all micropipettes are clean, calibrated (if applicable), and functioning properly.
- Set up a teacher demonstration station where all students can clearly observe the correct pipetting technique.
- Prepare a projector to demonstrate the micropipette parts and proper technique.
- Review laboratory safety procedures, including proper handling of micropipettes, contamination prevention, and correct disposal of pipette tips.
- Arrange students into pairs or small groups to maximize hands-on practice and collaboration.
- Print copies of student worksheets, safety guidelines, assessment rubrics, exit tickets, and the "7 Essential Steps for Accurate Pipetting" reference sheet.
- Ensure sufficient laboratory supplies are available so each student has multiple opportunities to practice accurate pipetting.

Student Preparation for Activity

- Review basic laboratory safety rules and expectations.
- Understand the importance of following written and verbal laboratory instructions.
- Be familiar with common laboratory equipment such as beakers, test tubes, and graduated cylinders.
- Understand that scientists use different units of measurement for liquid volumes, including milliliters (mL) and microliters (μL).
- Review the concepts of **accuracy** and **precision** and why they are important in scientific investigations.
- Learn basic biotechnology vocabulary, including **micropipette**, **microliter (μL)**, **aspiration**, **dispense**, **contamination**, **sterile technique**, and **biotechnology**.
- Wear appropriate personal protective equipment (PPE), including safety goggles and closed-toe shoes.
- Tie back long hair and secure loose clothing or jewelry before beginning the laboratory activity.
- Read the laboratory procedures and safety guidelines before handling the micropipette.
- Be prepared to work collaboratively with a partner or small group during the laboratory activities.

Procedure (95-Minute Lesson)

Engage (10 minutes): WOW! A Tiny Drop Can Save a Life

Teacher Actions

- Display a vial of an eye drop (or an image) and ask:
 - "How do scientists measure the tiny amounts of liquid needed to make life-saving medicines?"
 - "Could being off by one tiny drop matter?"
- Show a standard kitchen measuring spoon and a micropipette.
- Explain that biotechnology scientists measure liquids in **microliters (μL)**, which are much smaller than milliliters.
- Introduce the micropipette as one of the most commonly used tools in biotechnology laboratories.

Key Teaching Points

- Micropipettes measure extremely small volumes accurately.
- Accurate measurements are essential for producing safe medicines.
- Micropipettes are used in genetics, microbiology, forensic science, pharmaceutical manufacturing, and medical research.

Student Discussion

Students complete a Think-Pair-Share:

- Why is accuracy important in science?
- What could happen if scientists measured the wrong amount of medicine?
- Where have you seen scientists use laboratory equipment?

Students share responses with the class.

Explore Part 1 (20 minutes): Meet the Micropipette

Teacher Demonstration

Using a document camera or large model, identify:

- Plunger
- First stop
- Second stop
- Volume adjustment dial
- Volume display
- Tip ejector
- Shaft
- Disposable pipette tip

Demonstrate:

- Adjusting the volume
- Attaching a tip correctly
- Holding the pipette vertically
- Aspirating liquid
- Dispensing liquid
- Ejecting the tip

Discuss common mistakes:

- Pressing to the second stop before aspirating
- Letting the plunger snap back
- Tilting the pipette while drawing liquid
- Using the wrong pipette
- Laying a liquid-filled pipette on the table

Student Activity

Students receive an unlabeled micropipette diagram and label each part.

Students then complete a partner discussion:

"What is the purpose of each part?"

Explore Part 2 (35 minutes): Micropipette Card and Rainbow Pipetting Challenge

Students work in pairs.

Each group receives:

- P2,P20,P200,P1000 micropipettes
- Colored water
- Microcentrifuge tubes
- Pipette tips
- Colored water (red, blue, yellow, green)
- Microcentrifuge tubes
- Waste paper and container
- Paper towels
- [Micropipette Cards/ wells](#) (20 μ L, 50 μ L, 75 μ L, 100 μ L, 150 μ L, 200 μ L, 500 μ L, 750 μ L, 1000 μ L)
- [Laminated Rainbow/ Pictures](#)
- Micro Tube Racks
- 25-30 Student lab Instructions and recording sheets
- Pencils
- Centrifuge (shared in a corner)

Micropipette Card Activity

Students practice transferring:

- 2 μ L blue
- 5 μ L green
- 10 μ L yellow
- 15 μ L red
- 20 μ L purple

Discussion Questions

- Which volume was easiest?
- Which volume was hardest?

Elaborate (15 minutes): Pipette Challenge Game

Students receive **Laminated rainbow or pictures** and practice transferring:

- 25 μ L Red
- 75 μ L Orange
- 150 μ L Yellow
- 200 μ L Green
- 500 μ L Blue
- 750 μ L Indigo
- 1000 μ L Violet

Students must:

1. Choose the correct micropipette.
2. Set the correct volume.
3. Explain why they selected that pipette.
4. Demonstrate proper pipetting technique.

Extension Challenge

Students calculate:

- How many microliters are in 2 mL?

$$1\text{L} = 1,000,000 \mu\text{L}$$

$$2\text{L} = \underline{\hspace{2cm}}$$

- Which pipette would measure 850 μL ?
- Why can't a P200 measure 500 μL ?

[Labxchange Simulation](#)

Explain (15 minutes): Why Precision Matters

The teacher leads a discussion.

Topics:

- Difference between **accuracy** and **precision**
- Why do biotechnology companies rely on micropipettes?
- What is Cross-contamination?
- Why do scientists always use the correct pipette?
- What is the importance of using the first and second stops correctly?

Show examples of laboratories that use micropipettes:

- DNA testing
 - Insulin production
 - Vaccine manufacturing
 - Cell culture
 - Medical diagnostics
-

Evaluate (10 minutes)

Students complete an Exit Ticket.

Practical Assessment

Each student demonstrates:

- ✓ Selecting the correct micropipette
- ✓ Setting the volume correctly
- ✓ Attaching a tip
- ✓ Aspirating correctly
- ✓ Dispensing correctly
- ✓ Ejecting the tip safely

Teacher scores using a skills rubric.

Exit Ticket Questions

1. A scientist needs to measure **150 µL**. Which micropipette should be used and why?
 2. Why should the pipette plunger be released slowly during pipetting?
 3. Why are micropipettes important tools in biotechnology? Provide one example of their use.
 4. Describe one safety rule for using a micropipette.
 5. Name one STEM career that uses micropipettes.
-

Closure (Optional – 5 minutes if time allows)

Ask students:

"Today you learned one of the first laboratory skills taught to biotechnology technicians, microbiologists, biomedical scientists, and pharmaceutical researchers. How could mastering this skill help prepare you for a future STEM career?"

Briefly introduce careers such as:

- Manufacturing Associate
- Biomedical Scientist
- Cell Culture Technician
- Quality Control Analyst
- Molecular Biologist
- Bioprocess Engineer

Differentiation

This lesson is designed to support diverse learners through multiple instructional strategies, hands-on activities, visual supports, and collaborative learning.

Students with Learning Disabilities (LD)

Instructional Modifications

- Provide step-by-step illustrated instructions for using the micropipette.
- Demonstrate each pipetting step before students practice independently.
- Break the activity into smaller tasks with frequent check-ins.
- Pair students with supportive peers during the Rainbow Pipetting Challenge.
- Allow additional time to practice pipetting skills.

Alternative Assessment

- Assess students individually using a teacher observation checklist during the pipetting demonstration instead of a written assessment.
-

English Language Learners (ELL)

Instructional Modifications

- Pre-teach key vocabulary using pictures and real laboratory equipment (e.g., micropipette, pipette tip, aspiration, dispense, microliter, contamination, accuracy, precision).
- Provide a bilingual vocabulary sheet when appropriate.
- Use visual demonstrations and modeling before independent practice.
- Encourage partner discussions using sentence starters such as:
 - "The correct pipette is..."
 - "I selected this volume because..."
 - "I observed..."

Alternative Assessment

- Allow students to demonstrate correct pipetting techniques orally or through a hands-on demonstration instead of relying solely on written responses.
-

Gifted and Academically Advanced Students (AIG)

Instructional Modifications

- Challenge students to calculate and convert volumes between microliters (μL) and milliliters (mL).
- Have students explain the importance of precision and accuracy in biotechnology, pharmaceutical manufacturing, and scientific research.
- Assign students to mentor peers during the Pipette Challenge.
- Extend learning by researching how micropipettes are used in fields such as genetic engineering, forensic science, microbiology, or biomanufacturing.

Extension Activity

- Design a pipetting protocol that requires multiple volume transfers to create a target color using the Rainbow Pipetting Challenge.

Assessment/Check for Understanding

Student learning will be assessed throughout the lesson using **formative and summative assessments** to determine whether students can correctly use a micropipette, apply laboratory safety practices, and explain the importance of precision and accuracy in biotechnology.

Formative Assessment (During Lesson)

Teacher Observation and Questioning

- The teacher will circulate during demonstrations and hands-on practice to monitor student technique and provide immediate feedback.
- Students will be assessed on their ability to:
 - Identify the major parts of a micropipette.
 - Select the correct micropipette based on the required volume.
 - Set the correct volume using the adjustment dial.
 - Attach a pipette tip properly.
 - Use the first and second plunger stops correctly.
 - Aspirate and dispense liquid accurately.
 - Follow laboratory safety procedures.

Teacher Check-for-Understanding Questions

During the lesson, the teacher will ask:

- "Why do scientists use micropipettes instead of regular measuring tools?"
- "What is the difference between accuracy and precision?"
- "Why must the plunger be released slowly?"
- "Why should a micropipette never be used without a tip?"
- "Why is choosing the correct pipette range important?"
- "How could an incorrect measurement affect a biotechnology product such as medicine?"

Students should demonstrate an understanding that small measurement errors can affect scientific results and that accurate technique is essential in biotechnology laboratories.

Hands-On Skills Assessment: Micropipette Demonstration

At the end of the lesson, each student will complete a practical demonstration where they will:

1. Select the correct micropipette for a given volume.
2. Adjust the micropipette to the required volume.
3. Attach a pipette tip correctly.
4. Aspirate the correct volume of liquid.
5. Dispense the liquid accurately.
6. Remove and dispose of the pipette tip safely.

The teacher will use a skills checklist/rubric to evaluate student performance.

Micropipette Skills Rubric (20 points)

Skill	Excellent (4 pts)	Developing (2–3 pts)	Needs Improvement (1 pt)
Identifies micropipette parts	Correctly identifies all major parts and functions	Identifies most parts with minor errors	Needs assistance identifying parts
Selects correct pipette	Chooses correct pipette based on volume range	Occasionally needs guidance	Selects incorrect pipette
Sets volume correctly	Accurately adjusts required volume	Minor errors corrected with feedback	Unable to set volume correctly
Proper pipetting technique	Uses first/second stops correctly and controls plunger	Performs steps with reminders	Requires significant assistance
Laboratory safety	Handles equipment safely and prevents contamination	Minor reminders needed	Does not consistently follow safety procedures

Student Worksheet Assessment

Students complete the **Rainbow Pipetting Challenge Worksheet**, where they:

- Record assigned volumes from challenge cards.
- Identify the correct micropipette used.
- Predict and record color combinations.
- Reflect on accuracy and precision.

Students answer:

1. Why are micropipettes important tools in biotechnology?
 2. Explain the difference between accuracy and precision.
 3. Describe one mistake that could affect pipetting results.
 4. Explain why scientists must carefully measure small volumes.
-

Summative Assessment: Exit Ticket

Students complete a short exit ticket at the end of class.

Example Questions:

1. A scientist needs to measure **150 µL**. Which micropipette should be used and why?
 2. Why should the pipette plunger be released slowly during pipetting?
 3. Why are micropipettes important tools in biotechnology? Provide one example of their use.
 4. Describe one safety rule for using a micropipette.
 5. Name one STEM career that uses micropipettes.
-

Alternative Assessments

Students with Learning Disabilities

- Students may complete a teacher-guided demonstration instead of the written exit ticket.
- Students may use a visual step-by-step pipetting checklist.
- Assessment will focus on demonstrating understanding of the process rather than speed.

English Language Learners (ELL)

- Students may explain answers verbally using vocabulary supports.
- Students may label a micropipette diagram instead of completing written explanations.
- Students may demonstrate proper pipetting technique as evidence of understanding.

Advanced Learners (AIG)

- Students may complete an extension task requiring them to design a biotechnology protocol using multiple pipetting volumes.
- Students may calculate measurement error and compare accuracy between trials.

Required resources

This section lists any resources and/or websites that are necessary for lesson implementation. Include resources teachers can use with students, such as images or animations which students will be directed to use independently.

Printed and Instructional Resources

- Volume Challenge Cards
- Micropipette Parts Diagram and Student Notes
- Student Worksheet: "Mastering the Micropipette..."
- Micropipette Skills Checklist/Rubric

Online Resources

- **[Labxchange Simulation](#) and [Video](#):**
- **Amgen Biotech Experience (ABE) – Biotechnology Education Resources**
<https://www.amgenbiotechexperience.com/>
Provides biotechnology laboratory activities, teacher resources, and micropipette training materials.
- **North Carolina Department of Public Instruction (NCDPI) – Science Standards**
<https://www.dpi.nc.gov/>
Provides the North Carolina Biology Standard Course of Study and curriculum alignment resources.

- **PreMiEr Engineering Research Center for Precision Microbiome Engineering – Duke University**
<https://premier-erc.org/>
Provides biotechnology research connections and STEM career resources related to modern biological engineering.
- **Pipetting Techniques and Good Laboratory Practice (GLP) Resources**
Manufacturer training resources from biotechnology companies such as Thermo Fisher Scientific, Eppendorf, and Sartorius provide examples of proper pipetting technique, laboratory accuracy, and equipment care

Supplemental resources- Optional

Author comments

*This field is **optional**.*

Sources

Include citations (APA format) for direct quotes from other resources, as well as links to websites from which this lesson might have been adapted. Direct wording taken from previous resources must be contained within quotation marks and cited both in text and in the sources list here.

Appendix A: Student Laboratory Handout

Mastering Micro-volumetrics and Pipetting

Student Name: _____

Date: _____

Partner(s): _____

Learning Objectives

By the end of today's lesson, I can:

- ☐ Identify the major parts of a micropipette.
 - ☐ Select the correct micropipette for different liquid volumes.
 - ☐ Demonstrate proper aspiration and dispensing techniques.
 - ☐ Explain why accurate pipetting is important in biotechnology.
-

Safety Checklist

Before beginning, check each box.

- ☐ Wear safety goggles.
 - ☐ Tie back long hair.
 - ☐ Never use a pipette without a tip.
 - ☐ Dispose of used tips properly.
 - ☐ Never force the volume adjustment.
 - ☐ Release the plunger slowly.
-

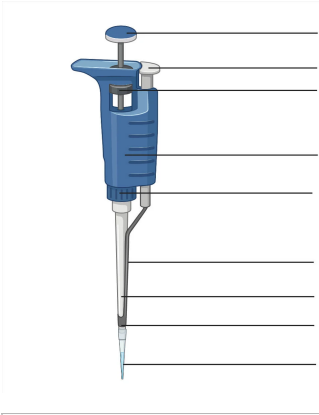
Vocabulary

Word	Definition
Micropipette	_____
Microliter (μL)	_____
Accuracy	_____
Precision	_____
Aspirate	_____
Dispense	_____
Contamination	_____

Appendix B: Micropipette Parts Worksheet

Directions: Label the parts of a pipette.

1. Plunger
2. First Stop
3. Second Stop
4. Volume Display
5. Volume Adjustment Dial
6. Tip Ejector
7. Shaft
8. Disposable Tip



Answer Key

1. Plunger
 2. First Stop
 3. Second Stop
 4. Volume Display
 5. Volume Adjustment Dial
 6. Tip Ejector
 7. Shaft
 8. Disposable Tip
-

Appendix C: Rainbow Pipetting Challenge Recording Sheet

Color	Volume	Pipette Used	Completed
-------	--------	--------------	-----------



Blue	2 μ L	_____	
------	-----------	-------	--

Green	5 μ L	_____	
-------	-----------	-------	--

Yellow	10 μ L	_____	
--------	------------	-------	--

Red	15 μ L	_____	
-----	------------	-------	--

Purple	20 μ L	_____	
--------	------------	-------	--

Reflection

Which volume was easiest?

Which volume was hardest?

What technique helped improve your accuracy?

Answer Key

There are no single correct answers.

Expected pipettes:

- 2 μL $\rightarrow$ P2
 - 5 μL $\rightarrow$ P20
 - 10 μL $\rightarrow$ P20
 - 15 μL $\rightarrow$ P20
 - 20 μL $\rightarrow$ P20
-

Appendix D: Pipette Challenge Card Worksheet

Volume	Pipette Selected	Correct?
--------	------------------	----------

25 μL	_____	
------------------	-------	--

75 μL	_____	
------------------	-------	--

150 μL	_____	
-------------------	-------	--

200 μL	_____	
-------------------	-------	--

500 μL	_____	
-------------------	-------	--

750 μL	_____	
-------------------	-------	--

1000 μL	_____	
--------------------	-------	--

Answer Key

25 μL $\rightarrow$ P200

75 μL $\rightarrow$ P200

150 μL $\rightarrow$ P200

200 μL $\rightarrow$ P200

500 μL $\rightarrow$ P1000

750 μL $\rightarrow$ P1000

1000 μL $\rightarrow$ P1000

Appendix E: Accuracy and Precision Reflection

Short Answer

1. Why is accuracy important in biotechnology?

2. What is the difference between accuracy and precision?

3. Describe one mistake that could affect pipetting results.

4. Why should the plunger be released slowly?

Answer Key

1. Accurate measurements ensure reliable experiments and safe biotechnology products.
 2. Accuracy is how close a measurement is to the true value; precision is how consistent repeated measurements are.
 3. Possible answers:
 - Using the wrong pipette
 - Pipetting without a tip
 - Pressing to the second stop before aspirating
 - Holding the pipette sideways
 - Letting the plunger snap back
 4. Releasing the plunger slowly prevents bubbles, splashing, inaccurate volumes, and damage to the pipette.
-

Appendix F: Exit Ticket

Name: _____

1. A scientist needs to measure **150 μL** .

Which micropipette should be used?

-
2. Why should the plunger be released slowly?

-
3. Name one biotechnology application that uses micropipettes.

-
4. Describe one laboratory safety rule.

-
5. Name one STEM career that uses micropipettes.
-
-

Answer Key

1. **P200**
 2. To prevent bubbles, inaccurate measurements, and equipment damage.
 3. Examples:
 - DNA analysis
 - Insulin production
 - Vaccine manufacturing
 - Cell culture
 - Medical diagnostics
 4. Accept any appropriate laboratory safety rule from the lesson.
 5. Examples:
 - Biomedical Scientist
 - Molecular Biologist
 - Manufacturing Associate
 - Quality Control Analyst
 - Cell Culture Technician
-

Appendix G: Micropipette Skills Checklist (Teacher)

Skill	Yes	Needs Practice
Selected correct pipette		
Set correct volume		
Attached tip correctly		
Aspirated correctly		
Dispensed correctly		
Used first and second stop correctly		
Ejected tip safely		
Followed safety procedures		