WORKSHOP

DNA Detective: Reuniting Families with DNA Fingerprinting & Electrophoresis

EDVOTEK®

Designed for the Classroom

SINCE 1987

Introduction

Step into the shoes of a DNA detective! In this hands-on experiment, you'll use DNA fingerprinting and electrophoresis to help two boys uncover their true parentage and reunite with their family.

Background Information

DNA fingerprinting has become a crucial tool in forensic science, helping to reunite families, resolve historical mysteries, and even solve crimes. This technique can be used in cases of adoption, immigration, and when families are separated due to unexpected circumstances such as natural disasters or conflicts.

SCENARIO

In a time of great upheaval, two young boys were separated from their families and taken in by a kind guardian who raised them as brothers. Though they always suspected they might not be biologically related, they had no way to prove it—until they turned 18.

Eager to uncover the truth about their past, the boys searched for records at the orphanage where they had once lived. There, they discovered documents suggesting that they were not actually brothers, but cousins. Their mothers were half-sisters, sharing the same mother but different fathers. However, the documents provided little information about what had happened to their parents.

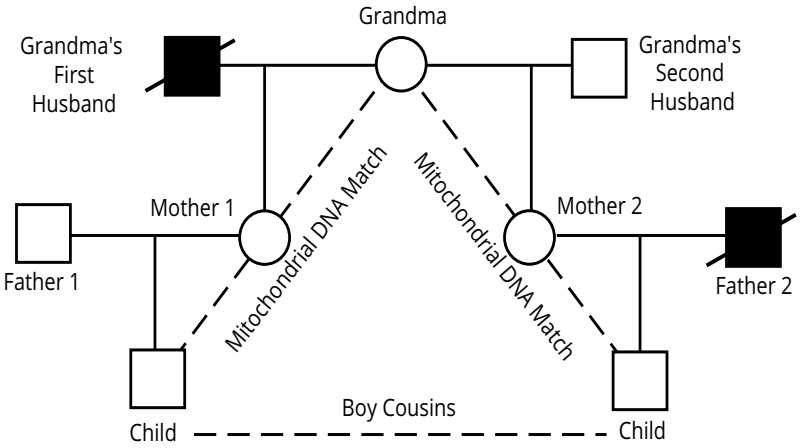


Figure 1: Pedigree of the Boys in Question

Determined to learn more, they turned to the elders of their community, hoping for answers. The elders informed them that one of their fathers had passed away, while the other was still alive but suffered from memory loss due to an accident. As for their mothers, the two women believed to be their biological parents were located in a rehabilitation facility. The facility housed nearly 200 women, many of whom had been displaced. Based on age and appearance, about ten women fit the possible profile of their mothers.

DETERMINATION OF PARENTAGE USING DNA FINGERPRINTING

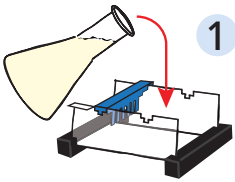
First, the boys sought to determine which of the ten women were their mothers by performing mitochondrial DNA fingerprinting. Mitochondria, the "powerhouse" of the cell, are unique organelles in that they contain a small DNA genome. This genome is useful for identifying maternity because mitochondria are inherited through the female line. Before conception, a human egg contains a large number of mitochondria. In contrast, human sperm contains very few mitochondria. Upon fertilization of the human egg by a sperm, the developing zygote contains mitochondria obtained from the mother's egg.

Mitochondrial DNA fingerprinting tests can be used as an initial screening technique because they are less expensive than chromosomal DNA testing and results are available in a shorter period of time. ***In this case, since the boys were cousins (their mothers were half-sisters who shared the same mother), the mitochondrial testing results would be identical for the two boys. The tests did identify two women with mitochondrial DNA fingerprinting patterns that matched that of the boys!***

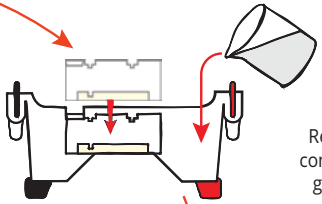
Now, in order to match the boys with the correct parents, chromosomal DNA fingerprinting tests were ordered for the boys, the two mothers, and the surviving father. Chromosomal DNA, which is present in the nucleus of every living cell, is the genetic material that acts as a blueprint for all of the proteins synthesized by that cell. Unlike mitochondrial DNA, chromosomal DNA is an equal composite of both parents. In each chromosome pair, one is inherited from the father and the second from the mother. Although most of this DNA is identical between individuals, small sequence differences, or "polymorphisms", occur at specific locations throughout the genome. These polymorphisms include single base pair changes and repetitive DNA elements. By examining several of these polymorphic regions, we can generate a unique "DNA fingerprint" for that person.

DNA fingerprints can allow us to distinguish one individual from another. Because polymorphisms are inherited, DNA fingerprints can also be used to determine paternity/maternity (and other familial relationships). ***In this experiment, to determine parentage, the DNA fingerprints of the boys are compared with the DNA fingerprints from the surviving father and the two mothers.*** Since chromosomal DNA is inherited from both parents, the DNA fingerprint of a child will contain a mixture of polymorphisms from each parent. By analyzing DNA bands on a gel, students will uncover how forensic genetics can reunite families and solve real-life mysteries.

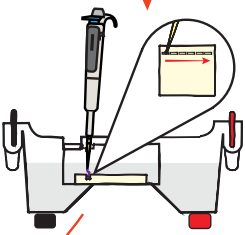
Experiment Overview



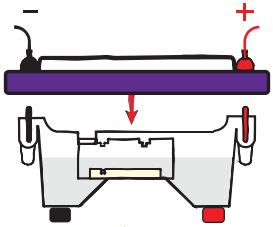
1 Prepare agarose gel in casting tray.



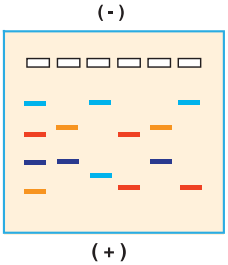
2 Remove end caps & comb, then submerge gel under buffer in electrophoresis chamber.



3 Load each sample in consecutive wells



4 Attach safety cover & connect leads to power source to conduct electrophoresis.



5 Analysis on a white light source.

Tables for Agarose Gel Electrophoresis

Table A — Individual 0.8% UltraSpec-Agarose™ Gels

Size of Gel Casting tray	Concentrated Buffer (50x) +	Distilled Water +	Amt of Agarose =	TOTAL Volume
7 x 7 cm	0.6 mL	29.4 mL	0.24 g	30 mL
10 x 7 cm*	0.9 mL	44.1 mL	0.36 g	45 mL
14 x 7 cm	1.2 mL	58.8 mL	0.48 g	60 mL

**Recommended gel volume for the EDGE™ Integrated Electrophoresis System. (Cat. #500).*

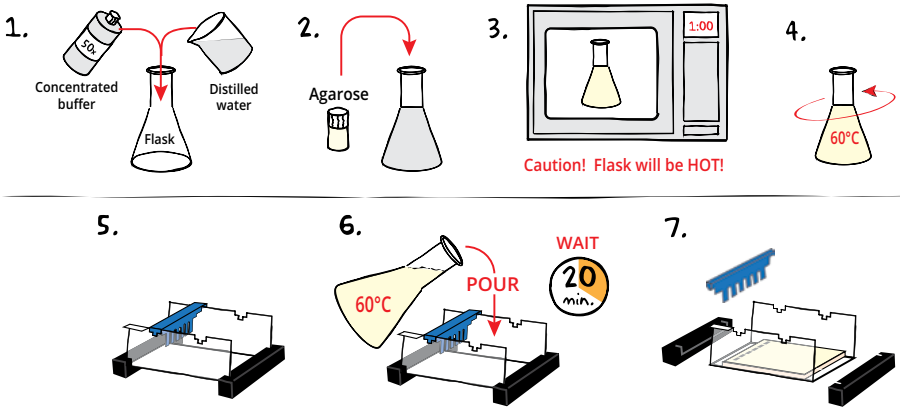
Table B — 1x Electrophoresis Buffer (Chamber Buffer)

EDVOTEK Model #	Total Volume Required	Dilution: 50x Conc. Buffer +	Dilution: Distilled Water
EDGE™	150 mL	3 mL	147 mL
M12	400 mL	8 mL	392 mL
M36	1000 mL	20 mL	980 mL

Table C — Time and Voltage Guidelines (0.8% Agarose Gel)

	Electrophoresis Model: EDGE™	Electrophoresis Model: M12 & M36
Volts	Min/Max (minutes)	Min/Max (minutes)
150	10/20	20/35
125	N/A	30/45
100	15/25	40/60

Agarose Gel Electrophoresis



1. **DILUTE** concentrated (50X) buffer with distilled water to create 1X buffer (see Table A).

2. **MIX** agarose powder with 1X buffer in a 250 mL flask (see Table A).

3. **DISSOLVE** agarose powder by boiling the solution. **MICROWAVE** the solution on high for 1 minute. Carefully **REMOVE** the flask from the microwave and **MIX** by swirling the flask. Continue to **HEAT** the solution in 15-second bursts until the agarose is completely dissolved (the solution should be clear like water).

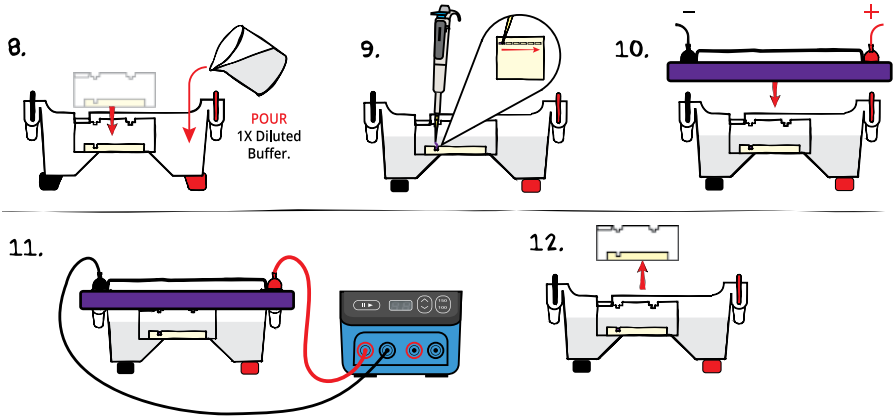
4. **COOL** agarose to 60°C with careful swirling to promote even dissipation of heat.

5. While agarose is cooling, **SEAL** the ends of the gel-casting tray with the rubber end caps. **PLACE** the well template (comb) in the appropriate notch.

6. **POUR** the cooled agarose solution into the prepared gel-casting tray. The gel should thoroughly solidify within 20 minutes. The gel will stiffen and become less transparent as it solidifies.

7. **REMOVE** end caps and comb. Take particular care when removing the comb to prevent damage to the wells.

Agarose Gel Electrophoresis, continued



8. **PLACE** the gel (on the tray) into the electrophoresis chamber. **COVER** the gel with 1X electrophoresis buffer (See Table B for recommended volumes). The gel should be completely submerged.

9. **LOAD** the entire sample (35 µL) into the well in the order indicated by the Gel Loading Table.

10. **CHECK** that the gel is properly oriented, then **PLACE** the safety cover onto the chamber. Remember, the DNA samples will migrate toward the positive (red) electrode.

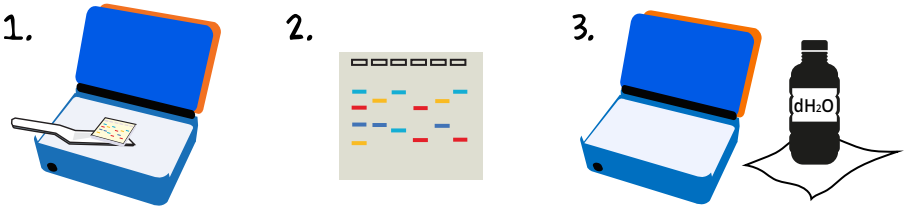
11. **CONNECT** the leads to the power source and **PERFORM** electrophoresis (See Table C for time and voltage guidelines).

GEL LOADING TABLE

LANE	TUBE	SAMPLE
1	Tube A	Standard Dye Markers
2	Tube B	Mother 1
3	Tube C	Mother 2
4	Tube D	Boy 1
5	Tube E	Boy 2
6	Tube F	Father

12. After electrophoresis is complete, **REMOVE** the gel and casting tray from the electrophoresis chamber and **PROCEED** to visualization.

Visualizing the Gel



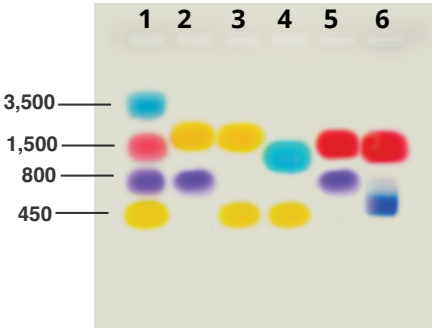
1. **SLIDE** the gel off the casting tray onto the white viewing surface of the transilluminator. Dyes should appear as colorful bands on a light background.

2. **PHOTOGRAPH** the results.

3. **REMOVE** and **DISPOSE** of the gel and **CLEAN** the transilluminator surfaces with distilled water.

Related EDVOTEK® Instructional Videos:

Results and Analysis



LANE	TUBE	SAMPLE
1	Tube A	Standard Dye Markers
2	Tube B	Mother 1
3	Tube C	Mother 2
4	Tube D	Boy 1
5	Tube E	Boy 2
6	Tube F	Father

After running gel electrophoresis on the DNA samples, the results revealed the key to unlocking the boys' true parentage! The colored bands on the gel represent different DNA fragments, helping us match each child to their biological parents.

BREAKING DOWN THE RESULTS:

Boy 1 (Lane 4) is the child of Mother 2 (Lane 3) and the deceased father.

- His lower yellow band matches Mother 2's yellow band, confirming maternity.
- None of his bands match the surviving father, meaning his biological father must be the deceased one.

Boy 2 (Lane 5) is the child of Mother 1 (Lane 2) and the surviving father (Lane 6).

- His purple band matches Mother 1's purple band, confirming maternity.
- His red band matches the father's red band, confirming paternity.

By carefully analyzing the banding patterns, we've used forensic science to reunite the boys with their biological parents—just like real DNA detectives!

Featured Experiment

Cat. #S-49

In Search of My Father

For 10 Lab Groups.

Your class will enjoy discovering the true identity of two boys who were separated from their parents a decade ago. Their mothers are identified by mitochondrial DNA and their fathers from chromosomal DNA. Will it be a happy ending?

- Learn about mitochondrial and cell DNA-based fingerprinting
- Explore inheritance and DNA polymorphisms
- Perform agarose gel electrophoresis to separate different sized dye molecules
- Analyze simulated DNA samples from two brother and three potential parents to reunite a family

INCLUDES:
Instructions, Ready-to-Load™ QuickStrip™ Dye samples, UltraSpec-Agarose™ powder, electrophoresis buffer, practice gel loading solution, disposable pipets.

ALL YOU NEED:
Electrophoresis apparatus, power supply, automatic micropipette and tips (optional), white light box (optional), microwave or hot plate, distilled water.

STORAGE:
Room Temperature Stable. Storage of Ready-to-Load QuickStrip™ samples in the Refrigerator is Recommended.

45 min.

Requires approximately 45 min. to complete.

LNGSS-aligned with MS-LS3.B & MS- LS3.A

Additional Related Products:

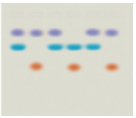
Linking STEM to Agarose Gel Electrophoresis

For 10 Lab Groups. Link important STEM concepts using Agarose Gel Electrophoresis. Help your students learn about the application of gel electrophoresis in DNA Fingerprinting, DNA Paternity Testing, Genetics (related to health and well-being), and the detection of Genetically Modified Foods. These dyes can be separated in agarose gels and students will use core STEM tools to determine band size and utilize critical thinking and reasoning skills. Four unique module options are supplied.

- Learn the biology behind gel electrophoresis and polymerase chain reactions (PCR)
- Perform agarose gel electrophoresis to separate different sized dye molecules
- Load, run, and analyze five simulated DNA samples plus a simulated DNA ladder
- Choose from four real world scenarios: crime scene, paternity test, GMO detection, or medical diagnosis

Cat. #S-46 (Dye-based experiment)

Whose DNA Was Left Behind?

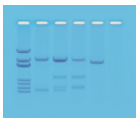


For 10 Lab Groups. DNA obtained from a single hair left behind at a crime scene can be used to identify a criminal. In this experiment, your students will compare simulated crime scene DNA with that of two suspects.

- Learn about DNA fingerprinting while solving a crime!
- Introduce the biotechnologies of restriction enzyme digestion, PCR, and electrophoresis
- Perform agarose gel electrophoresis to separate different sized dye molecules
- Load, run, and analyze simulated crime scene and suspect samples.

Cat. #S-51 (Dye-based experiment)

DNA Paternity Testing Simulation



For 8 Gels. This experiment introduces students to the use of DNA fingerprinting in a simulated paternity determination. A child's DNA fingerprint is compared with his parents. The experiment does not contain human DNA.

- Learn genetics and molecular biology techniques by solving a hypothetical paternity case
- Introduce students to restriction enzymes, PCR, and electrophoresis
- Perform agarose gel electrophoresis to separate differently-sized DNA molecules
- Load, run, analyze, and size pre-digested PCR samples to determine the biological parents of a child

Cat. #114 (with FlashBlue™ Stain)
Cat. #114-S (with SYBR® Safe DNA Stain)

Pipetting by Numbers: STEAM Pipetting Practice

Biotechnology & Pipetting: An Essential Tool

Biotechnology is used in crime-solving, food production, medicine, and environmental protection. Scientists rely on biological tools like enzymes and bacteria, as well as mechanical instruments such as microscopes and pipettes. Among these, pipettes are crucial for accurately measuring and transferring liquids in nearly all biotech labs.

Types of Pipettes

Pipettes range from simple Pasteur pipettes, resembling eye droppers, to more advanced micropipettes used in molecular biology. Graduated pipettes handle larger volumes, often requiring electronic pumps. Modern piston displacement micropipettes allow precise volume adjustments, while multichannel and robotic pipettes streamline complex procedures.

Using a Micropipette

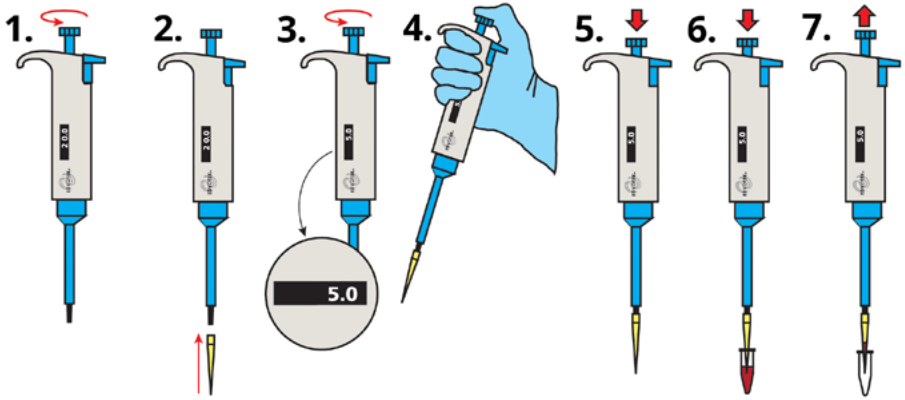
Proper pipetting follows key steps: setting the volume, aspirating liquid by creating a vacuum, dispensing liquid, repeating as needed, and purging the remaining sample. Accurate technique—such as using the correct pipette and tip, maintaining a vertical position, and avoiding cross-contamination—ensures experimental success.

Accuracy & Precision

Successful experiments require both accuracy (closeness to the true value) and precision (repeatability). Scientists achieve this through proper pipette handling, consistent technique, and regular calibration. Mastering these skills is essential for reliable biotechnology research.

Parts of an adjustable micropipette:

Introduction to Micropipetting



PRACTICE using the pipette! (For this step, you will need to obtain a test strip and red dye before starting.)

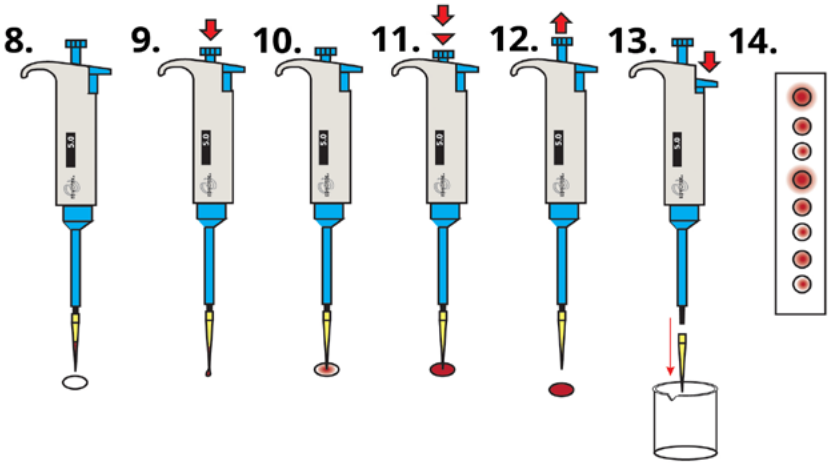
1. **PRACTICE ADJUSTING** the volume. Use your free hand to **TURN** the volume-setting wheel clockwise to increase the volume and counter clockwise to decrease the volume (see NOTE 1). **OBSERVE** the volume display (see NOTE 2). Remember to always stay within the volume range of the pipette.
2. **PLACE** a new tip on your pipette.
3. **SET** the volume to 5 µL.
4. With your free hand **PICK UP** the test tube. **HOLD** the tube between your thumb and forefinger and at or near eye level to best observe the liquid moving into the pipette during the next few steps.
5. **PRESS** the plunger down to the first soft stop and **HOLD** it in this position.
6. **DIP** the tip into the solution. Immerse the tip enough to cover the end but not so deep that it obscure your view of the liquid ~ 5 mm.
7. Keeping the tip in the solution, slowly **RELEASE** the plunger until it is in its original position. You should see the liquid flowing into the pipette tip (see NOTE 3).

NOTE 1:
If the volume-setting wheel is not moving, it may be that your pipette is locked at a certain volume. In many pipettes the volume lock is a small button that is located just below the tip ejector. This button can be disengaged by pushing upwards and re-locked by pushing downwards.

NOTE 2:
Most pipettes have volume displays that are read top down. Some volume displays will contain a white dash line representing the decimal point. Account for this decimal place when setting your volume!

NOTE 3:
Watch out for bubbles in the tip or air space at the end of the tip. These can significantly offset the measurement! If you observe either, expel the liquid back into the tube (Steps 9-12) and then repeat the process starting at Step 4. Often air is introduced when pipetting quickly so perform these steps slowly.

Introduction to Micropipetting, continued



8. **SLIDE** the pipette and tip out of the tube using the inside wall to dislodge any excess droplets that may be adhering to the outside of the tip. Then **MOVE** your pipette to just above the first practice circle.

9. Slowly **DEPRESS** the plunger to the first stop. You should see the liquid flowing out of the pipette tip.

10. Gently **TOUCH** the tip to the paper to create a capillary effect that will help draw any remaining fluid out of the tip.

11. Keeping the tip on the paper, **DEPRESS** the pipette plunger to the second hard stop to ensure all liquid has been ejected.

12. **RAISE** the pipette so that the tip is no longer on the paper and then **RELEASE** the plunger to its original position. (This is more important when pipetting from one liquid solution into another but also good practice here.)

13. **EJECT** the tip into a beaker for used tips.

14. **REPEAT** Steps 2-13 for the remaining circles. As this is practice, you may want to experiment and observe what happens when common micropipetting errors are made. For instance, you could intentionally press down to the second stop while sucking up the liquid or intentionally skip pressing down to second stop when ejecting the liquid to see how this affects circle size.

Pipetting By Numbers

1. **OBTAIN** a segment of the Pipetting By Numbers canvas. Each segment will have a slightly different pattern.

2. **NOTE** that colors and pipetting volumes are indicated inside each circle. Color abbreviations are Red (R), Blue (B), Purple (P), Yellow (Y), and Navy (N). Volumes are given in microliters. So a circle marked "R20" would get 20 µL of the red dye.

3. **USE** the techniques you just practiced from pages 13-14 to pipette the specified color and volume.

   For Best Results:
   - Use a small amount of tape to secure the top and bottom corners of the canvas to your lab bench. Fasten the tape to the back side (bench facing side) by wrapping the tape into a cylinder.
   - Hold the pipette perpendicular to the paper & pipette into the center of each circle.
   - When possible, start with the largest circles / highest volumes.
   - To save time, pipette all the same colored dots at once using the same tip. Then switch tips and move to the next color.
   - Dyes vary in color and in viscosity (thickness). High viscosity dyes like the Navy and Red will require slower pipetting.

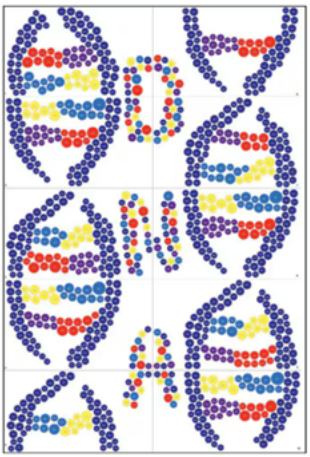
4. **COMBINE** your finished art with other groups by matching the edge patterns to create a single poster.

Featured Experiment

Cat. #S-45

Pipetting By Numbers: STEAM Pipetting Practice

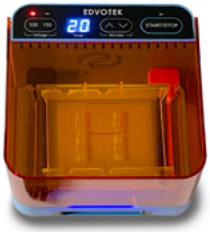
For 10 Lab Groups.



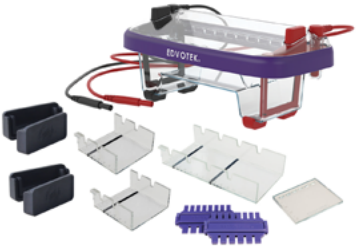
Help your students master the fundamental biotechnology technique of micropipetting while creating a colorful, science-themed classroom poster as well as their own artwork.

- Set your classroom up for a year of experimental success by mastering micropipetting
- Learn best practices, key parts, and the importance of accuracy & precision
- Engage students with a STEAM wet lab based on "paint by numbers"
- Create a colorful, science-themed classroom poster

Related Products:



EDGE™ Integrated Electrophoresis System
Runs one 10 x 7 cm gel
Cat# 500



M12 Complete™ Electrophoresis Package
For 1 or 2 Lab Groups
Cat# 502-504

DuoSource™
100/150 V, for 1 or 2 Units
Cat# 509

QuadraSource™
10-300 V, for 1 or 4 Units
Cat# 5010-Q

White Light LED Transilluminator
Cat# 552

EDVOTEK® Variable Micropipette
5-50 µL Micropipette
Cat. # 590

Fixed Volume MiniPipette™
35 µL MiniPipette™
Cat. # 587-2

Details for all these products and MORE can be found on our website!

Visit our website at **www.edvotek.com**