WELCOME TO

STEM Integration: Math, meet Biology!

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Karen Togliatti and Lindsey Herlehy

Why Integrate STEM?

"Scientists use technological tools to conduct experiments and mathematics and statistics to interpret the data produced by those experiments; engineers draw on scientific knowledge and mathematical reasoning to develop and model potential design inventions and solutions; technologists who build and maintain the products and systems designed by engineers must understand the scientific and mathematical principles governing their operation. And these professionals interact with one another in increasingly diverse and multidisciplinary teams."

- *STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research*

National Academy for Engineering and
National Research Council

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STEM Integration

- STEM integration does not encourage teaching the four disciplines as independent silos.
- All four STEM content areas will not be integrated into all lessons, all the time.
- Look for meaningful connections and mathematical topics which can be explored using natural phenomena or design challenges.

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Why focus on the "M" in STEM?

STEM learning reinforces that mathematics isn't about "one answer".

16% of American high school seniors are proficient in mathematics and interested in a STEM career.

U.S Dept. of Edu.

29% of Americans rate this country's K-12 education in STEM subjects as above average.

U.S Dept. of Edu.

STEM jobs in the U.S will increase 14% from 2010-2020. 3 million of these jobs will go unfulfilled.

Bill Nye

STEM learning broadens students' perspective of mathematics to be more than computational approaches.

College students interested in STEM-related careers often abandon this path within their first two years of study.

National Science Foundation

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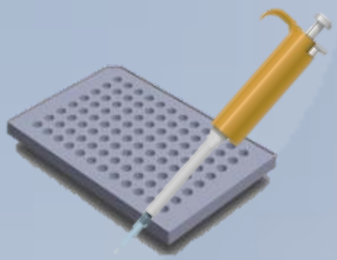

Biology and Geometry: A Telling Image

- Identify a location on the coordinate plane by using an ordered pair of numbers, or representative values, in reference to perpendicular number lines, called *axes*.
- Perform biotechnology skills in a simulated application using fixed volume micropipettes and a coordinate grid system.

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Biology and Geometry: A Telling Image

Students will begin by investigating the 10 µl micropipette and micropipette tips.

- Practice handling the micropipette and micropipette tips.
- Predict: How much water will a 10 µl micropipette dispense?
- How did your prediction compare to the actual amount of water dispensed?
- How much smaller is a microliter compared to a liter? How much smaller are 10 µl compared to a liter?
- Why do you think scientists would work with a sample of liquid that is this small?

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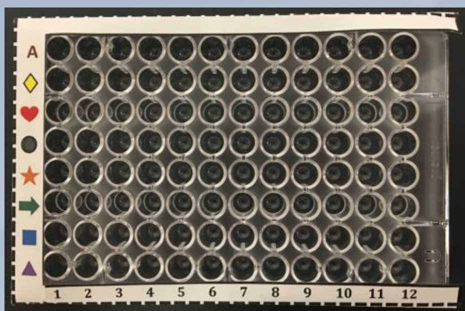
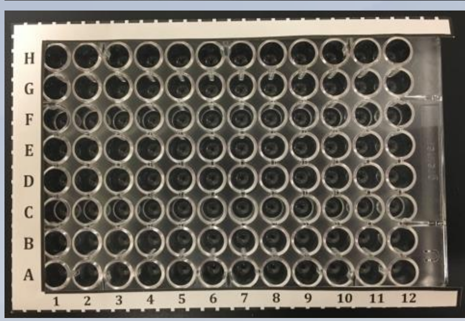
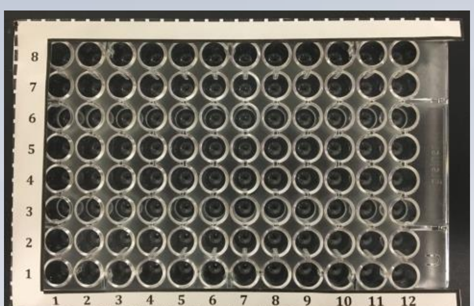
Biology and Geometry: A Telling Image

Students will then observe and explore the 96 well-plate or Well Plate Grid.







- What do you notice about the symbols, or values, that stretch across the **top** of your well plate (or grid)?
- What do you notice about he symbols, or values, that stretch across the **side** of your well plate (or grid)?
- These lines are called "**axes**". How might you use axes to locate a well?
- How might you write the location of a well?
- What might we call the point at which both axes meet?
- Well plates use a coordinate system to locate each well. Have you seen a grid, or coordinate system, before? Did it look the same, or different, from this system? Explain.

Biology and Geometry: A Telling Image

Using the materials provided on your table, choose a Pattern Sheet and complete the image by pipetting the appropriate colors into the corresponding wells.

- ✓ Select a new tip for each color.
- ✓ Dispose of used tips in the paper cup.

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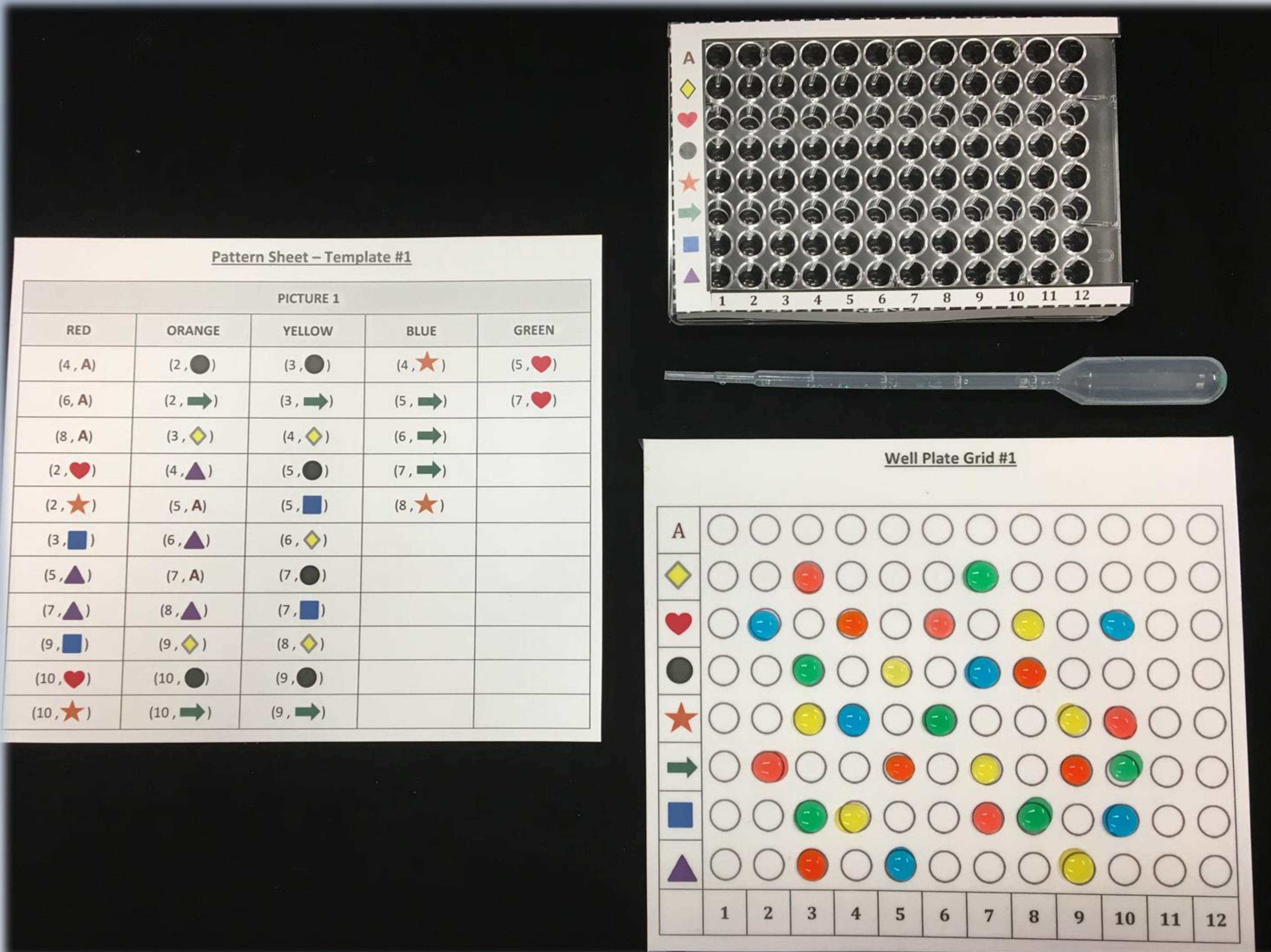
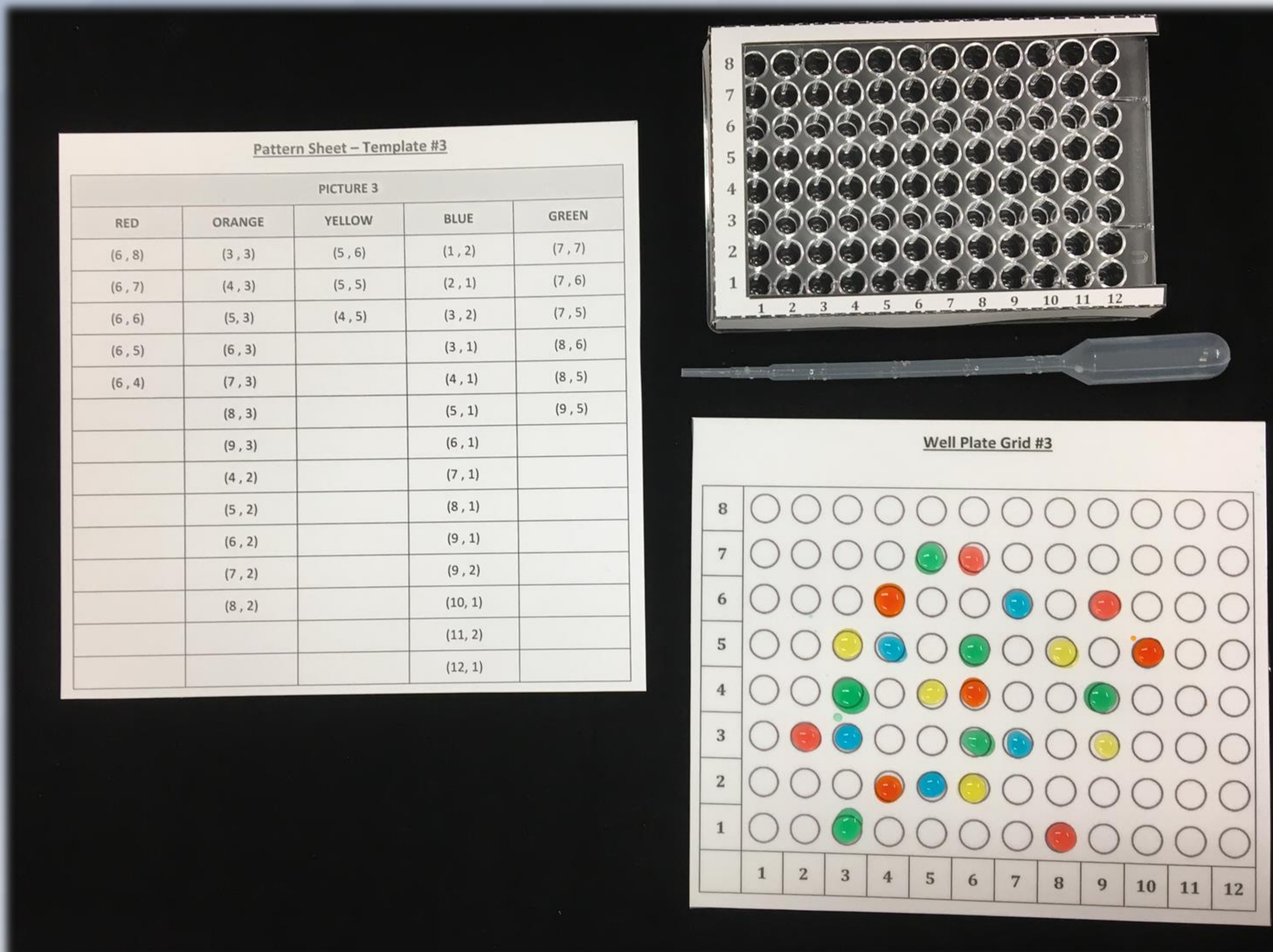
Biology and Geometry: A Telling Image



Biology and Geometry: A Telling Image



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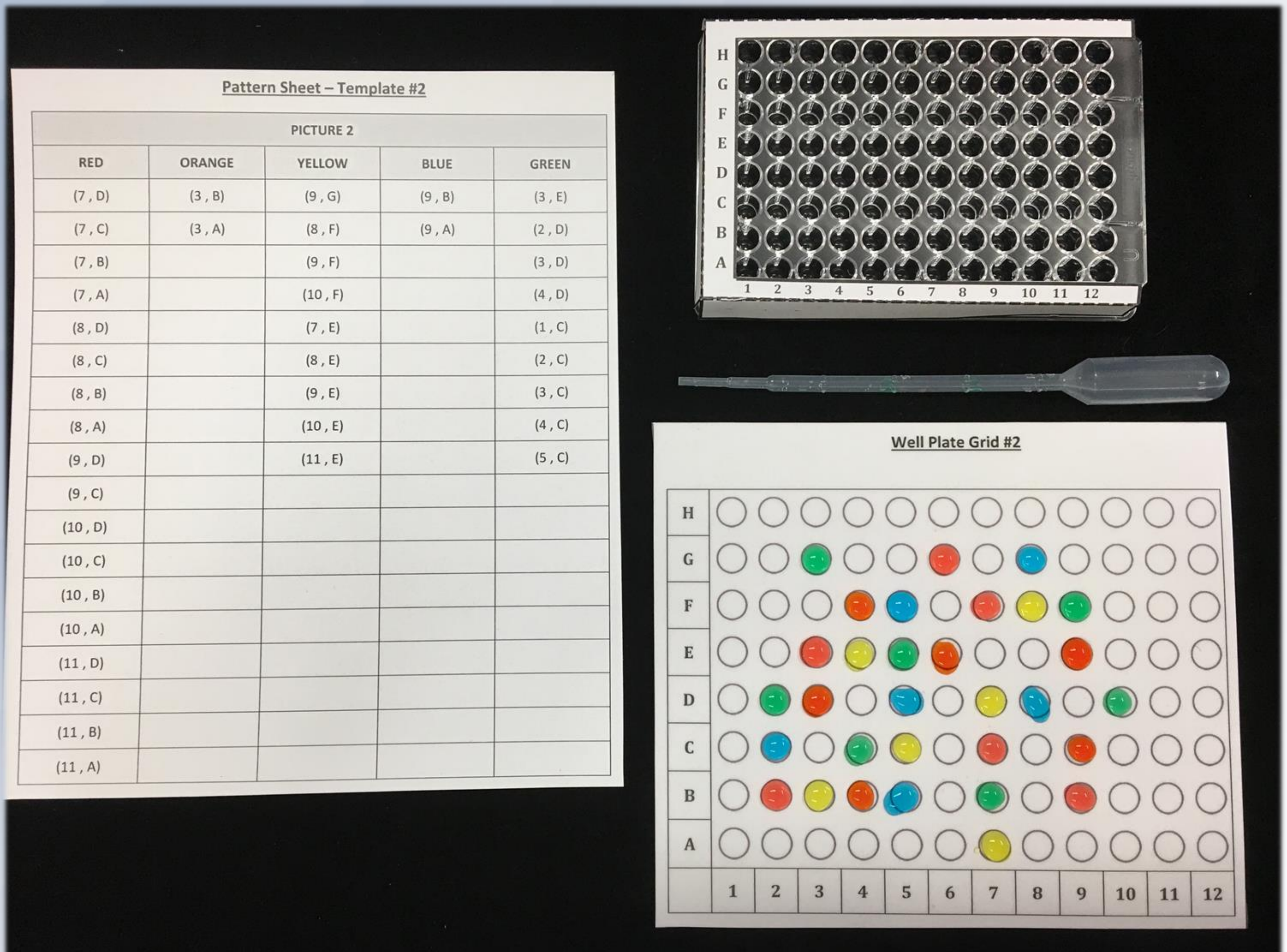
Biology and Geometry: A Telling Image



RED	ORANGE	YELLOW	BLUE	GREEN
(7 , D)	(3 , B)	(9 , G)	(9 , B)	(3 , E)
(7 , C)	(3 , A)	(8 , F)	(9 , A)	(2 , D)
(7 , B)		(9 , F)		(3 , D)
(7 , A)		(10 , F)		(4 , D)
(8 , D)		(7 , E)		(1 , C)
(8 , C)		(8 , E)		(2 , C)
(8 , B)		(9 , E)		(3 , C)
(8 , A)		(10 , E)		(4 , C)
(9 , D)		(11 , E)		(5 , C)
(9 , C)				
(10 , D)				
(10 , C)				
(10 , B)				
(10 , A)				
(11 , D)				
(11 , C)				
(11 , B)				
(11 , A)				

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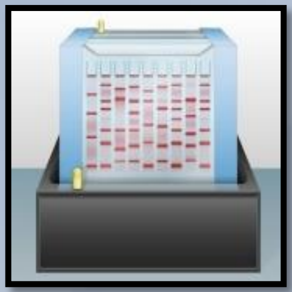
Biology and Geometry: A Telling Image – DEBRIEF

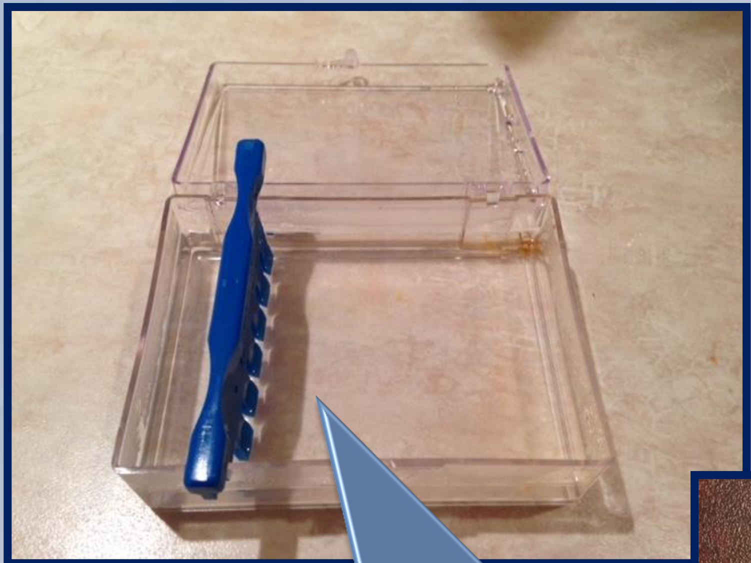
- Was pipetting easy? Challenging? Explain.
- How did you determine the location in which to pipette each color solution?
- What surprised you about the volume, or amount of liquid, that was dispensed from the micropipette?
- What other activities might a well plate be used for?
- What materials might a scientist use a well plate to explore?



Extension: Gel Electrophoresis

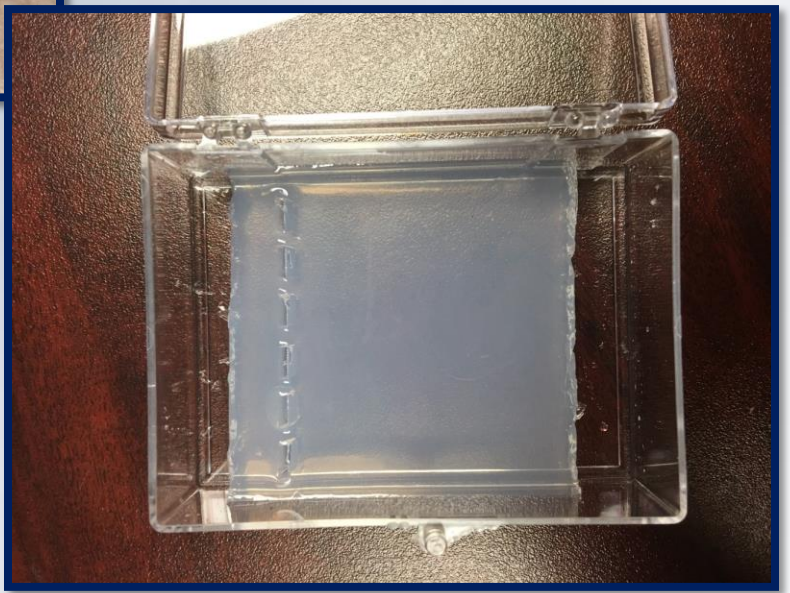
- Apply knowledge of biotechnology skills and practices by performing electrophoresis to resolve the colored dye molecules within a sample.
- Conduct a scientific experiment by precisely following a multistep procedure and performing technical tasks.

Extension: Gel Electrophoresis



Directions & Checklist for Preparing Gels for Run		
CHECK	STEP	INSTRUCTIONS
	1	Put 1 agarose tablet in 50 mL of water.
	2	Let it sit for 2 minutes or until completely dissolved.
	3	Heat in microwave until it boils. Roughly 45-65 seconds. Allow to boil for about 10 seconds.
	4	Stop. Swirl contents. Heat again for 20-30 seconds.
	5	Stop. Swirl contents. Heat again for 20-30 seconds.
	6	Let the agarose cool for 3-5 minutes. Do NOT let it solidify.
	7	Pour it into a plastic box.
	8	Insert a comb so it rests at a hinge.
	9	Allow the gel to set up. It will turn cloudy when it is setup.
	10	Remove comb once gel is set up. Clean comb in soap and water.
	11	Close box lid and store in refrigerator until ready to use.
	12	Repeat for the other boxes.

Optional Mathematics Challenge: Construct a Comb
pg. 28



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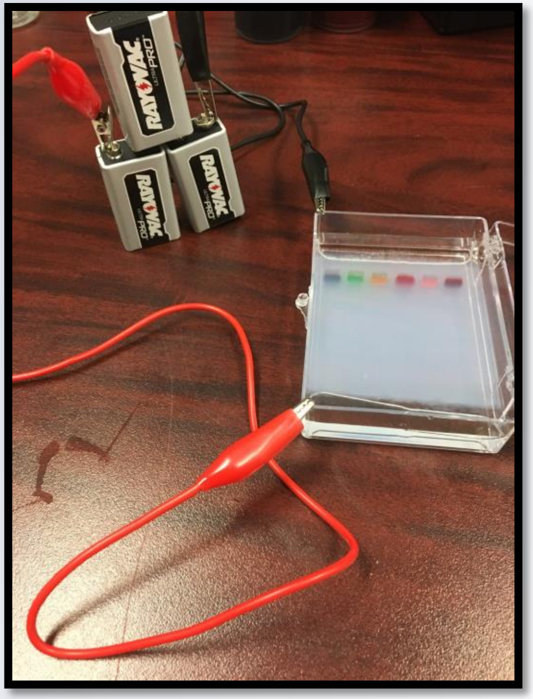
Extension: Gel Electrophoresis

Procedure:



- Remove all materials from the bag.
- Prepare the power source by connecting three 9V batteries together by inserting the positive terminal of one into the negative terminal of another.
- Attach the **red** alligator clip to the positive terminal and the **black** clip to the negative terminal.
- Open the gel box and carefully place one unfolded paperclip at each end of the gel. Adjust the paperclips to fit in the box, if necessary.
- Pour enough TAE buffer into the gel box to slightly submerge the gel.
- Using the micropipette, load approximately 20 µl of Kool-Aid into each well.
- Attach the other end of the **black** alligator clip to the paperclip above the wells, and **red** clip to the paperclip below the wells.

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Extension: Gel Electrophoresis – DEBRIEF

- What happened to your Kool-Aid samples?
- Gel electrophoresis needs a power source. That power source may be batteries or a direct current from an electrical outlet. Why do you think power is needed?
- Did all of the Kool-Aid samples separate into individual color dyes? Provide evidence to support your thoughts.
- How did electrophoresis separate the Kool-Aid samples?
- What other items could we separate with electrophoresis?

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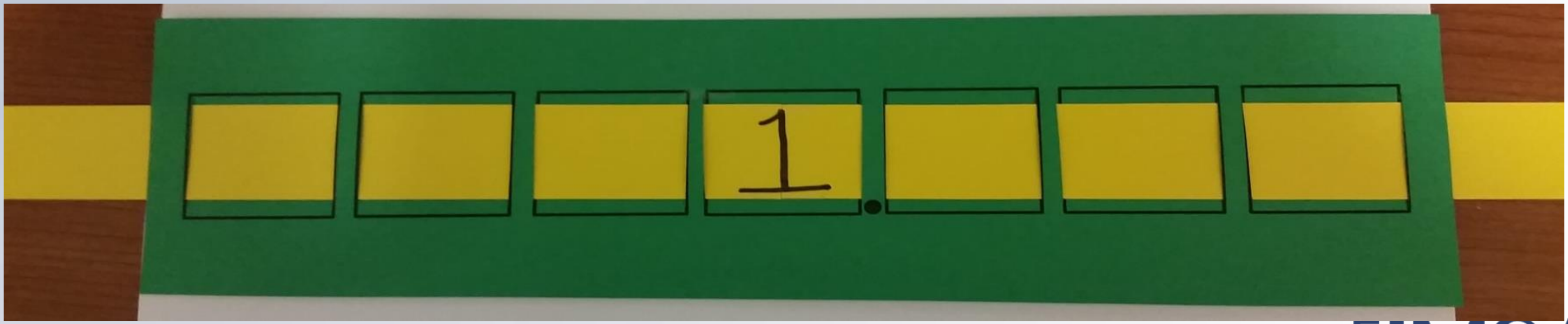
Come Scale Away – ACTIVITY 1

- Introduce Powers of Ten through a hands-on exploration using a paper “tool”.
- Begin by sliding the number 1 until it is in the ones column.
- Multiply by 100. Represent this number using the slider to move the 1 and adding zeroes.
- Go back to 1. Now, divide by 100. Represent this number using the slider to move the 1 and adding zeroes.



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Part 2: Powers of 10 Observation Table

With your partner, observe the patterns in the table below:

Multiply ↑ / Divide ↓

Standard Form	Base 10 Form	Exponential Form	Decimal
1,000,000	10 x 10 x 10 x 10 x 10 x10	10^6	
100,000	10 x 10 x 10 x 10 x 10	10^5	
10,000	10 x 10 x 10 x 10	10^4	
1,000	10 x 10 x 10	10^3	
100	10 x 10	10^2	
10	10	10^1	
1	1	10^0	
$\frac{1}{10}$	$\frac{1}{10}$	10^{-1}	0.1
$\frac{1}{100}$	$\frac{1}{10 \times 10}$	10^{-2}	0.01
$\frac{1}{1,000}$	$\frac{1}{10 \times 10 \times 10}$	10^{-3}	0.001
$\frac{1}{10,000}$	$\frac{1}{10 \times 10 \times 10 \times 10}$	10^{-4}	0.0001
$\frac{1}{100,000}$	$\frac{1}{10 \times 10 \times 10 \times 10 \times 10}$	10^{-5}	0.00001
$\frac{1}{1,000,000}$	$\frac{1}{10 \times 10 \times 10 \times 10 \times 10 \times 10}$	10^{-6}	0.000001

What patterns do you observe in the table?

How does the Exponential Form compare to Base 10 Form?

What do you think the "–" means in the Exponential Forms?

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Come Scale Away – ACTIVITY 2

- Relate Metric Table to Powers of Ten Table

Multiply

Standard Form	Base 10 Form	Exponential Form	Decimal
1,000,000	10 x 10 x 10 x 10 x 10 x10	10^6	
100,000	10 x 10 x 10 x 10 x 10	10^5	
10,000	10 x 10 x 10 x 10	10^4	
1,000	10 x 10 x 10	10^3	
100	10 x 10	10^2	
10	10	10^1	
1	1	10^0	
$\frac{1}{10}$	$\frac{1}{10}$	10^{-1}	
$\frac{1}{100}$	$\frac{1}{10 \times 10}$	10^{-2}	
$\frac{1}{1,000}$	$\frac{1}{10 \times 10 \times 10}$	10^{-3}	0.001
$\frac{1}{10,000}$	$\frac{1}{10 \times 10 \times 10 \times 10}$	10^{-4}	0.0001
1	1	10^{-5}	0.00001

Metric Table

Prefix	Abbreviation	Power of 10	× "bigger" than base
giga	G	10^9	1,000,000,000
mega	M	10^6	1,000,000
kilo	k	10^3	1,000
hecto	h	10^2	100
deka	da	10^1	10
meter	m	Base 10^0	1
deci	d	10^{-1}	0.1
centi	c	10^{-2}	0.01
milli	m	10^{-3}	0.001
micro	µ	10^{-6}	0.000001
nano	n	10^{-9}	0.000000001

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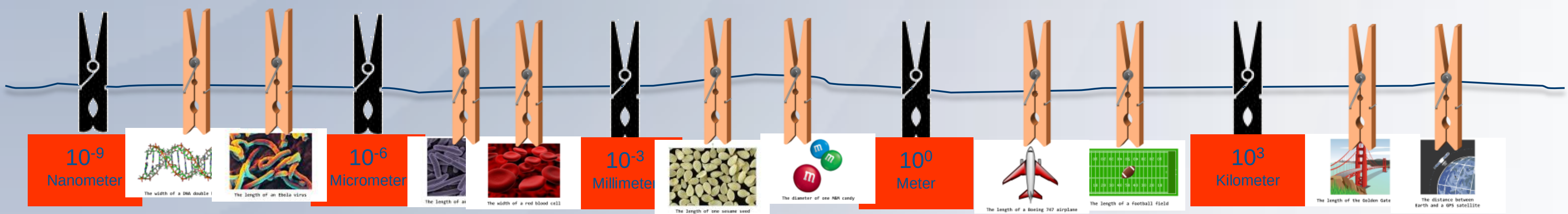
Come Scale Away – ACTIVITY 2

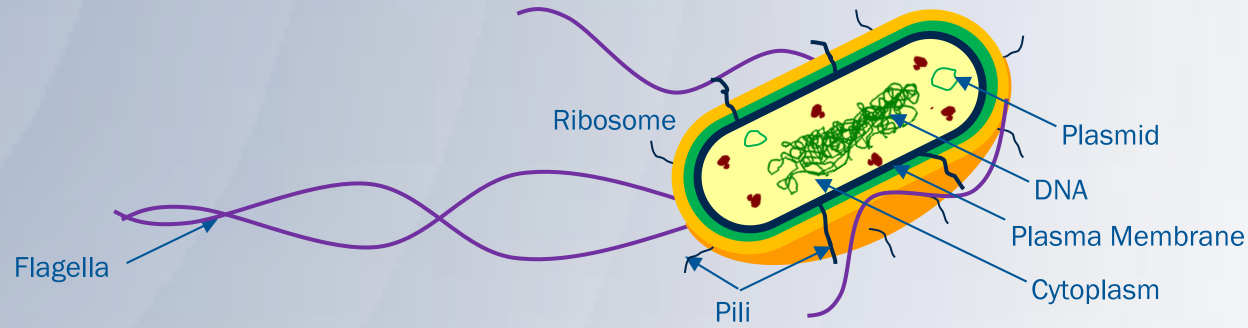
- At your tables, order the orange *Metric Measure* cards along the string from smallest to largest and secure with clothespins.



- Now sort the *Sorting Cards* from smallest to largest along the “number line.”

- The *Clue Cards* can help with the sorting.

Come Scale Away – ACTIVITY 3



- Student teams will be provided with sticky note sheets to share their ideas on the function of each labeled part of the *E. coli* bacterium.
- Use student words as much as possible to reach a consensus about each function.
- Then, create a model of the chromosomal DNA contained within the cell using snack bags, meter sticks, and thread.

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Come Scale Away – DEBRIEF

- How difficult do you think it must be for biologists to work with organisms that are so very small?
- Why might biologists be interested in the relative size of DNA contained within a single-celled organism?
- What other “things” can we use powers of 10 to measure?

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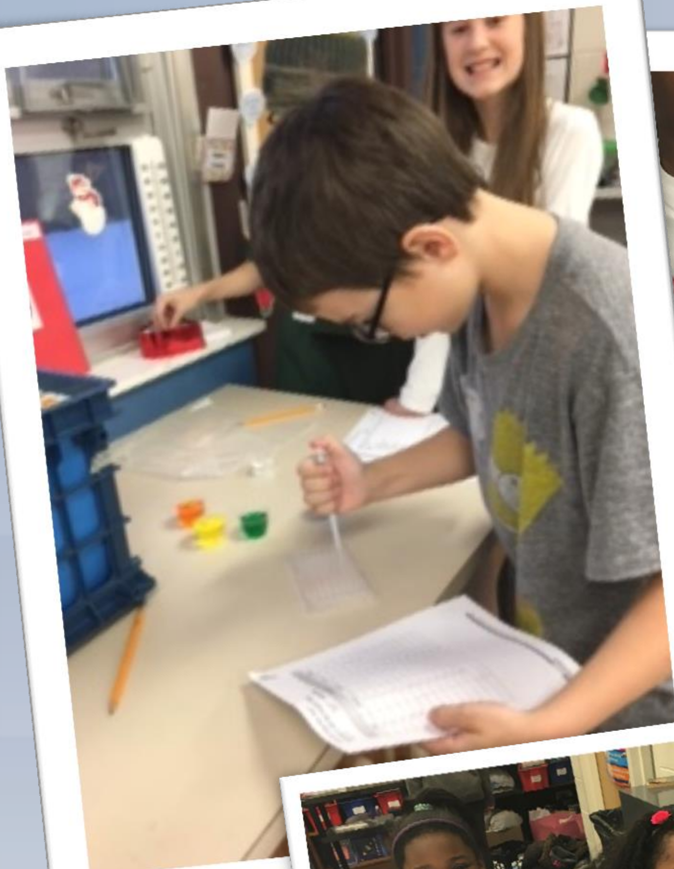

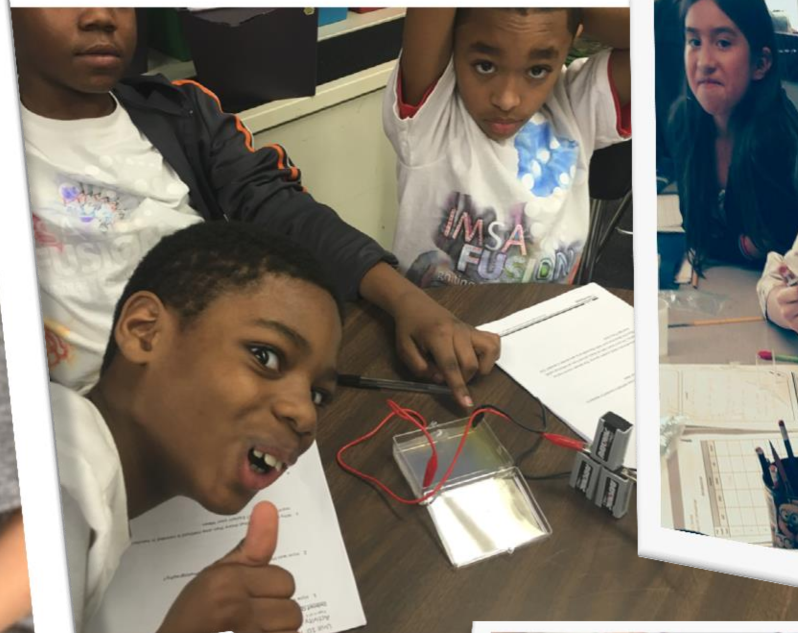
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THANK YOU!

- Lindsey Herlehy
  lherlehy@imsa.edu
- Karen Togliatti
  ktogliatti@imsa.edu
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