WHAT MAKES THAT COLOR?

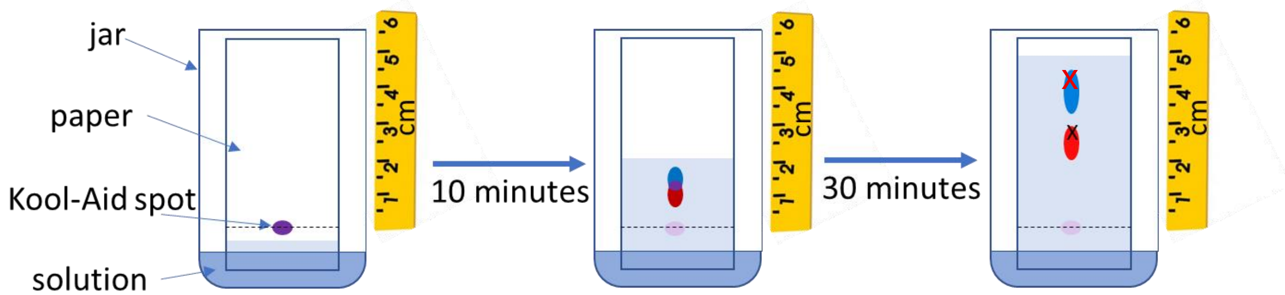
Group member: Chris Johnson **Group Member:** Clark Willford
Group member: Kobe Bowser **Group Member:** Brodric Young

15 minutes for this section

Information: A physical property is a characteristic of a substance that can be measured or observed without changing into a new substance. Examples of physical properties of a chemical substance are color, state of matter (solid, liquid, gas), density, and melting point. In this laboratory session, you will use the physical properties of various chemical substances to either make measurements of the substance or to separate one substance from another.

Mixtures are composed of multiple chemical substances. These different substances can often be separated from each other due to differences in physical properties. One such physical property to separate different chemical substances is called polarity. The separation arises from each chemical substance having a unique polarity. Significant attractions occur between molecules that have similar polarities. Chromatography is a common method to separate components in a mixture based on this property. Paper chromatography is a type of chromatography which will be utilized in this lab.

Model 1: Separating the food dyes in grape Kool-Aid using paper chromatography.



Key Questions:

1. Examine the jar on the *left*. The jar contains a small amount of solution. A strip of chromatography paper was placed in the jar which has been spotted with grape Kool-Aid. After a short amount of time, the solution starts to move up the paper through capillary action. Has the solution reached the Kool-Aid spot? No
2. The jar in the *middle* illustrates how far the solution moved up the paper after 10 minutes.
   a. Has the solution reached the original purple Kool-Aid spot? Yes
   b. Estimate how far the solution moved *past* the purple spot? 2 cm
   c. The food dyes in the grape Kool-Aid are carried up the paper by the rising solution. The dyes move up different rates due to differences in polarity.
      i. How many food dyes are in the grape Kool-Aid? 2
      ii. What are the colors of the food dyes? Red, Blue
   d. Are the food dyes completely separated after 10 minutes? No
   e. Which food dye has risen further up the paper? Blue

The paper is made of *polar* cellulose fibers. The paper, therefore, will attract molecules that are also polar. The rate the molecules of a particular food dye move up the paper relative to the movement of the solution will depend on how strongly the molecules are attracted to the polar fibers of the paper.

f. The molecules in the red food dye are more polar than those in the blue food dye. How do you know this by examining the chromatography paper in the middle jar?

Because the red has not moved up the paper as far as the blue

3. The jar on the *right* illustrates how far the solution has moved up the jar after 30 minutes.
    a. Describe how well the two different dyes are separated.

    Completely separated

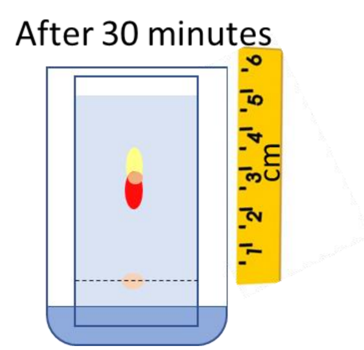
    b. How far has the solution moved up the paper? Measure from the original purple spot. _4.8 cm____
    c. The distance a dye has traveled is measured from the top of the spot. This is marked with an "X" for the red food dye. How far have the molecules in the red food dye move up the paper (measure from the original purple spot to the "X")? _2.7 cm____
    d. Mark with an "X" the distance traveled by the blue food dye. How far have the molecules in the blue food dye moved up the paper? _4.3 cm__
    e. The distance that a dye travels relative to the distance the solution travels is the R_f value. Calculate the R_f value for each food dye. Remember to use significant figures.

$$R_f = \frac{distance\ of\ food\ dye}{distance\ of\ solution}$$

R_f (red food dye) = _0.56_____
R_f (blue food dye) = _0.90_____

Exercises:

4. A separation of the food dyes present in orange Kool-Aid was performed by paper chromatography.
    a. What are the colors of the food dyes present in orange Kool-Aid? _Yellow, Red_____
    b. Which of the food dyes contain the most polar molecules? _Red______
    c. How similar are the polarities of the molecules in the two different food dyes (this contrasts with the purple Kool-Aid)?



They're much closer than the blue and red from the purple kool-aid

Entire class discussion:

Information: A physical property used to separate the different components in a mixture is solubility. The separation arises from one component being soluble in the solvent (e.g., water) and the other component (or components) being insoluble. This allows the soluble component to be separated from the mixture.

Method development:

Items needed for *each* member of the group: package of honey roasted peanuts (on first bench), 150 mL beaker, strainer, and scoopula.

5. Examine the ingredients for the honey roasted peanuts. Which ingredients are soluble in water?

   Sugar, salt

6. Examine the appearance of the honey roasted peanuts. By appearance, where is most of the sugars located?

   On the outside of the peanut

7. What is the total mass of the contents in the package (this is a serving size)? 38.9 g
   What is the mass of *Total Sugars* (examine the nutrition facts)? 7 g From these masses calculate the percentage of sugars in a serving size of peanuts. Show your work.

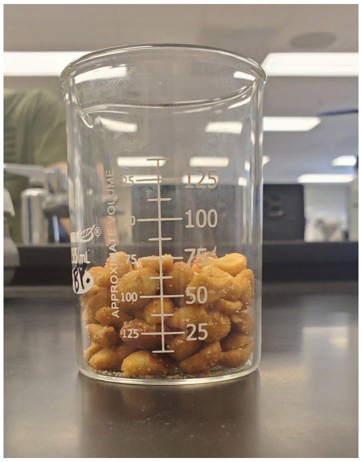
$$\frac{7g}{38.9g} \cdot 100 = 18\%$$

8. You are going to separate the soluble components of the honey roasted peanuts using water. Describe a method to perform this separation.

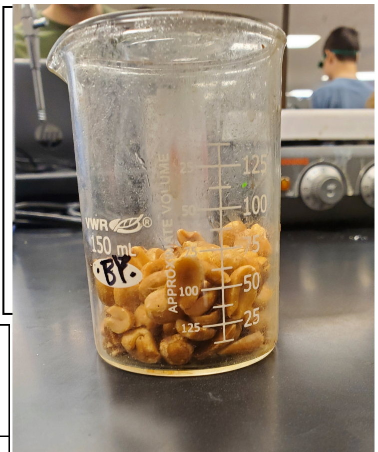
Put the peanuts in water and mix until the soluable stuff is all dissolved in the water leaving the non soluable stuff

Individual data collection (each person in the group will acquire their own data):

9. The below information will assist you in setting up the equipment to determine the percent sugars in honey roasted peanuts.
   a. Label a 150 mL beaker with your initials using a Sharpie. Acquire the mass of the 150 mL beaker and then the mass of the beaker *with* all the peanuts (place data in table below). With your cell phone take a picture of the peanuts.



b. Add about 50 mL of warm water to the peanuts. Stir gently with the scoopula for about a minute. Separate the peanuts from the liquid using a strainer. Dispose of the liquid in the sink.
c. Perform the procedure above (called an extraction) four additional times.
d. After the five extractions, put the peanuts back in the beaker. Place the beaker in the provided tray. Your teacher will place the tray in the oven for 20 minutes at 350°F (177°C). While waiting, you are encouraged to start the next section (see Information below).
e. Allow the peanuts to cool for 8-10 minutes and acquire the mass of the beaker and peanuts. With your cell phone take a picture of the peanuts. Dispose of your peanuts in the garbage.



Mass of 150 mL beaker	Mass of beaker and peanuts (before separation)	Mass of beaker and peanuts (after separation)
9.907	14.709	14.059

f. Fill in the following table from your data in the table above:

Mass of peanuts only (before separation)	Mass of peanuts only (after separation)	Mass of sugars in peanuts	Percent sugars in peanuts
4.802	4.152	0.65	13.5%

Compilation of group data and group analysis:

10. Record the percent sugars in peanuts for each group member. Calculate an average percent sugars value for your group.

	Percent sugars
Group member	13.1
Group member	15.6
Group member	14.6

Group member	13.5
AVERAGE PERCENT SUGARS	14.2

11. Are these values determined your group members for percent sugars precise?
 No

   a. Explain how you made this determination.

   2 are within 1% of the average, but the other 2 are further than 1

   b. If these measurements aren't precise, suggest a reason.

It could be that the packages themselves may differ slightly, the duration of stirring and the amount of water added to dissolve the sugars, chunks of the peanuts may have been lost in straining

12. How does the average percent sugars compare to the value calculated from the nutrition facts? Suggest a reason why the average percent sugar may differ.

The nutrition facts is about 4% higher. There could have been more sugars that weren't on the outside or that couldn't be dissolved

Ask the teacher or lab assistant to check your work for the calculations above before proceeding.

<u>Class data</u>: In the class data sheet (link in Canvas), input the average percent sugars.

<u>Information:</u> Melting point is a physical property that measures the temperature at which a solid becomes a liquid. The melting point of an unknown solid can be determined by comparing it to the melting points of known solids.

Sugar alcohols are generally derived from sugars, containing one hydroxyl group (-OH) attached to *each* carbon atom. Sugar alcohols are commonly used in the place of table sugar and are widely used in the food industry as thickeners and sweeteners.

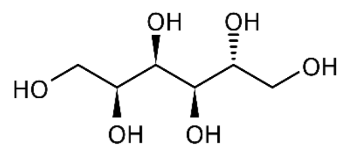
<u>Method development:</u>

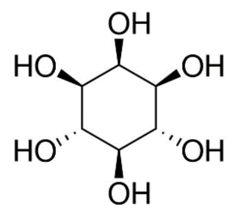
<u>Items needed for *each* member of the group</u>: aluminum block, 2 small aluminum dishes (on first bench), stem thermometer (on first bench), and one microscoop.

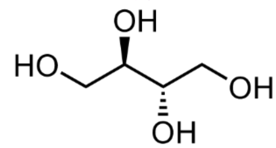
13. You are going to determine the identity of certain unknown sugar alcohols by examining melting points. Melting points of solids are available from reliable sources such as Google or the CRC Handbook. There are 8 containers on the benchtop (labeled 1-8), each containing an unknown sugar alcohol. Each member of your group will analyze *two* of these unknown sugar alcohols. Indicate which two unknowns each group member is analyzing by filling in the table.

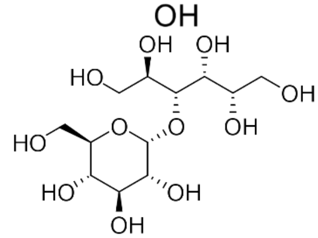
Group member name	Unknown sugar alcohols analyzed
Kobe	1 and 2
Brodric	3 and 4
Chris	5 and 6
Clark	7 and 8

14. Each of your unknown compounds will be one of the following sugar alcohols. Write down the melting point of each sugar alcohol (use Google or the CRC handbook).

    a. Sorbitol
    Melting point (in Celsius): 95
    Structure
    

    b. Myo-inositol
    Melting point (in Celsius): 222
    Structure
    

    c. Erythritol
    Melting point (in Celsius): 121
    Structure
    

    d. Maltitol
    Melting point (in Celsius): 145
    Structure
    

15. Describe a method to determine the identity of the unknown compounds using melting points. Melting points can be experimentally determined using the provided melting point equipment (hot plate, aluminum block, thermometer, and small aluminum dish).

Heat the compounds up and record the temperature at their melting point then compare with the known compounds to determine which it is.

Individual data collection (each person in the group will acquire their own data):

16. The below information will assist you in setting up the equipment to determine the melting points of the two unknown sugar alcohols.

a. Label two aluminum dishes with the numbers of your unknowns.
b. Using a clean/dry micro scoop, place a *very small* amount of each unknown sugar alcohol in the center of an aluminum dish (containers of sugar alcohols on first bench). There will be an aluminum dish for each sugar alcohol.
c. Place the aluminum block on the hot plate so that the side is facing up which is mostly flat and has a small hole in which the thermometer fits snugly. Two group members will use one hot plate.
d. Insert the thermometer in the small hole and turn it on so that the reading is in Celsius.
e. Place the two aluminum dishes with the unknown sugar alcohols on the aluminum block.
f. Describe the appearance for each sugar alcohol you are analyzing.

Unknown sugar alcohol #: 3

Appearance:

white, bigger grains or chunks

Unknown sugar alcohol #: 4

Appearance:

white, nearly a powder

g. Turn the setting on the hot plate to "7".
h. Monitor the temperature while observing the unknown sugar alcohols.
i. Record the temperature when the unknown sugar alcohol *just begins* to melt. Zoom in with your phone and take a picture of each sugar alcohol just as it begins to melt. Turn off the hot plate as soon as your last sample melts. After a few minutes, use tongs and place the aluminum blocks on the benchtop to cool.

	Number	Melting point (°C)
Unknown sugar alcohol	4	101.1
Unknown sugar alcohol	3	124.4

Compilation of group data and group analysis:

17. Determine the identify of each unknown alcohol by comparing its melting point to the melting points of the four sugar alcohols above.

	Identity
Unknown sugar alcohol #1	Sorbitol
Unknown sugar alcohol #2	Erythritol
Unknown sugar alcohol #3	Erythritol
Unknown sugar alcohol #4	Sorbitol
Unknown sugar alcohol #5	Maltitol
Unknown sugar alcohol #6	Erythritol
Unknown sugar alcohol #7	Sorbitol
Unknown sugar alcohol #8	Sorbitol

Class data: In the class data sheet (link in Canvas), input your melting point and the identify of each unknown sugar alcohol.

Information: Paper chromatography utilizes the physical property, polarity, to separation components in a mixture. Refer to the beginning of the activity if necessary.

Method development:

Items needed for *each* member of the group: ruler, Crayola markers (1 box per group), chromatography paper (on first bench), 1.50 M acetic acid solution (1 container per group, on first bench), 50 mL graduated cylinder, 16-ounce plastic cup (on first bench), and a watch glass.

18. Examine the ruler. In which place is the estimated digit for centimeters? hundredths
19. The color in a typical Crayola marker is produced by a combination of two or more dyes. Which dyes do you think are in each of the following Crayola markers? Take them out of the box and examine them. These will be analyzed below.

- Copper Red, brown

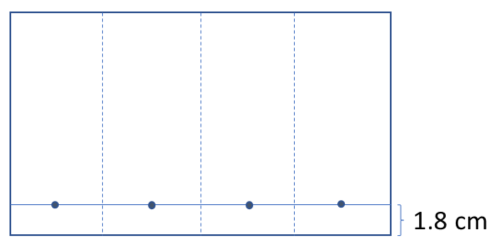
- Raspberry Red, green
- Primrose Red, blue
- Golden yellow Red, yellow

20. Describe a method to determine the dyes present in the Crayola markers (refer to the model above if needed).

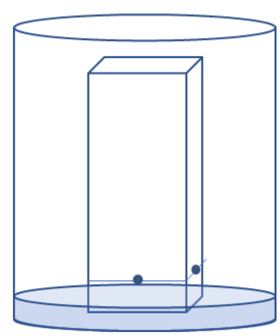
Draw a spot on the chromatographic paper and observe the separation due to polarities as a solution rises up the paper.

Individual data collection (each person in the group will acquire their own data):

21. The below information will assist you in setting up the equipment to separate the dyes in the Crayola markers using paper chromatography.
    a. On the chromatographic paper draw a line with a pencil (not a pen) about 1.8 cm from the long edge of the paper.
    b. Fold the paper in half, then in half again (you will have four sections).
    c. In the center of each section, on the line you drew previously, place a dot with a pencil. On each dot, you will place a small spot with one of the Crayola markers. The dot should be no larger than 0.5 cm. You need to remember the dot which corresponds to a particular Crayola marker.



    d. Create a "box" with the paper so it can stand freely.
    e. Pour ~10 mL of the chromatography solution (1.50 M acetic acid solution) in a *large* clear plastic cup (16 oz). **The depth of the solution should only be half the height of the spots from the bottom of the paper.**
    f. Insert the paper in the cup with the spots at the bottom. The paper cannot touch the sides of the cup. Place a watch glass on top of the cup so that the solution does not evaporate. Do not agitate the cup while solution is climbing up the paper.



    g. Remove the paper when the solution has almost reached the upper edge of the paper. Gently remove most of the solution from the chromatography paper by dabbing with a paper towel (Kleenex will also work). After a minute, draw a light pencil line to mark how far the solution moved up the paper.
    h. Allow to dry for 5 minutes and place a small "X" at the *top* of each dye spot with a pencil.

i. Dispose of remaining solution from the cup in the sink.

22. Calculate the R_f value for each dye on the chromatogram (follow the same procedure illustrated in the model). Each Crayola color may have *up to* 2 dye colors. **<u>Dye Color 1 will always have the shortest spot distance for each color</u>**. Note: The measurement needs to be made to the estimated digit. Remember to use significant figures.

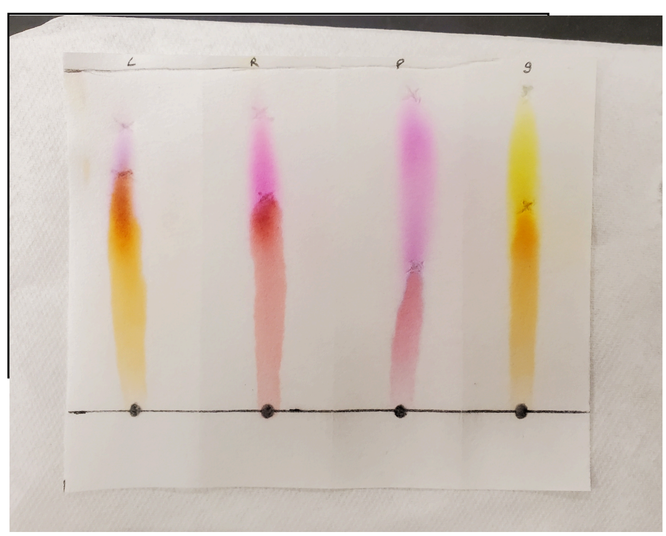
Crayola Color		Dye Color	Spot Distance	Solvent Distance	R_f Value
Copper	1	orange	5.70	8.10	0.704
	2	purple	6.80	8.10	0.840

Crayola Color		Dye Color	Spot Distance	Solvent Distance	R_f Value
Raspberry	1	red	5.15	8.20	0.628
	2	pink	7.10	8.20	0.870

Crayola Color		Dye Color	Spot Distance	Solvent Distance	R_f Value
Primrose	1	red	3.45	8.25	0.418
	2	purple	7.55	8.25	0.915

Crayola Color		Dye Color	Spot Distance	Solvent Distance	R_f Value
Golden Yellow	1	orange	4.95	8.40	0.589
	2	yellow	7.25	8.40	0.863

23. Unfold your chromatogram and lay it flat. With your cell phone, take a picture of the chromatogram.



<u>Compilation of group data and group analysis:</u>

24. Calculate an average R_f value for your group. Do this for only the Primrose and the Golden Yellow Crayola markers. **<u>Dye Color 1 will always have the shortest spot distance for each color</u>**.

Crayola Color		Dye Color	Average R_f Value
Primrose	1	red	0.517
	2	purple	0.861

Crayola Color		Dye Color	Average R_f Value
Golden Yellow	1	orange	0.596
	2	yellow	0.961

Ask the teacher or lab assistant to check your values above before proceeding.

25. Are the R_f values measured by your group members precise? No Explain how you know.

They differed by quite a bit even for the certain digits

26. If the R_f values aren't precise, suggest a reason.

Different sized dots, amounts of acetone, disturbance to it while sitting, measuring

<u>Class data</u>: In the class data sheet (link in Canvas), input the average R_f values.

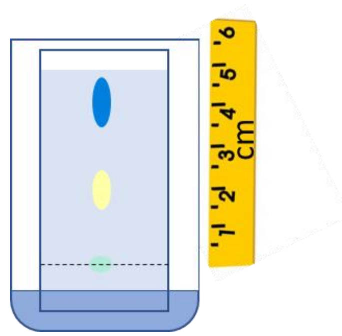
Make sure all items are clean and return them to the drawer or bench. Be sure to return the 16 oz cup. Finish cleaning any glassware used by rinsing with distilled water. Before you leave, ask the teacher or lab assistant to examine your data and laboratory space. Note: Your data must be entered into the spreadsheet before you leave.

<u>Application of principles (to be completed individually)</u>:

27. Which marker dye color (not the color of the marker) has the largest R_f value? ~~Purple~~ What does this R_f value tell you about the polarity of that dye?

It has the ~~most polarity~~ and is attracted to the paper the most.

28. Paper chromatography was performed on green food coloring with the following resulting chromatogram.



   a. Calculate the R_f value for each dye present in the green food coloring based upon the measurements that are recorded from the chromatogram.

yellow: $\frac{2.5}{4.8} = 0.52$

blue: $\frac{4.6}{4.8} = 0.96$

   b. Which of the food dyes is the most polar? Explain how you know.

The yellow because it didn't move up the paper as much, which would be because its more polar and is attracted to the paper more

29. Some sea sand was analyzed for salt content. The original sand had a mass of 6.92 grams. The salt was extracted with three washes of warm water and dried. The new mass was 6.55 grams. Calculate the percent salt in the sea sand. You must show your work by writing below or inserting a picture of your work.

$6.92 - 6.55 = 0.37$ $\frac{0.37}{6.92} \cdot 100 = 5.3\%$

30. You are now going to compare your individual values with the average values of the class in the *Class Data Sheet*. Make sure the *Class Data Sheet* is complete before doing this. You will have to wait until the end of the lab period. Fill in the following table below.

	Your individual value	**Average value of class**
Rf value for Dye Color 1 from Primrose Marker	0.418	0.422
Rf value for Dye Color 2 from Primrose Marker	0.915	0.870
Rf value for Dye Color 1 from Yellow Marker	0.589	0.550
Rf value for Dye Color 2 from Yellow Marker	0.863	0.944
Percent Sugars in peanuts	13.50%	13.68%

The agreement between a measured value and an accepted value can be analyzed by performing a percent error calculation (equation given below). For this calculation, the measured value is your individual value, and the accepted value is the class average (in Google Sheet).

$$Percent\ Error = \frac{(measured\ value - accepted\ value)}{accepted\ value} \times 100.0\%$$

a. Calculate a percent error for each of your individual values.

	Percent error
Rf value for Dye Color 1 from Primrose Marker	- 0.948%
Rf value for Dye Color 2 from Primrose Marker	5.17%
Rf value for Dye Color 1 from Yellow Marker	7.09%
Rf value for Dye Color 2 from Yellow Marker	- 8.58%
Percent Sugars in peanuts	- 1.32%

b. For each percent error greater than 10% (or less than -10%), suggest at least one reason for your individual value being significantly different than the accepted value.

All were within 10% of the accepted value

31. Write down the two unknown sugar alcohols you analyzed.

Unknown sugar alcohol #: 3 Unknown sugar alcohol #: 4

Examine the class data sheet. Do your melting points and sugar alcohol selections agree with those of the class? Yes If your data is different from most of the class provide a reason.

There is one group for sugar alcohol #3 that was way different, so that brought the average down a lot but mine is close to all the others and still within 5 degrees of the average