PPG
Science of COLOR
Patch Program

Ever wonder where the bright, brilliant colors in a rainbow or your favorite crayons come from? Or why the hot cocoa mix in your favorite winter drink seems to clump at the bottom? Do you think about what colors your pets see and how the world looks different through their eyes? Or even stain your favorite T-shirt with a permanent marker and ask yourself if there was a way to make it look cool?

These activities will assist you on your journey of color as you learn chemistry, physics, and general science pertaining to the world of color we all live in—all while working your way toward the PPG Science of Color patch that you'll get to color in yourself.

To earn this patch, you must complete all activities included in this guide.

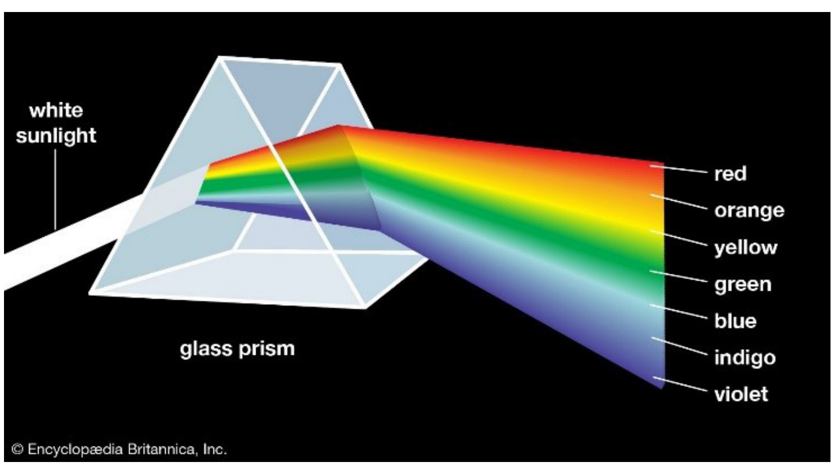
DISCOVERING the Science of Color

Isaac Newton's Prism Peeks through a Curtain and Discovers a Rainbow

Most everyone has heard the story of Sir Isaac Newton and the apple falling from the tree that led to his discovery of gravity. But did you know Newton discovered the basis for the science behind the colors we see all around us simply by playing with prisms and sunlight?

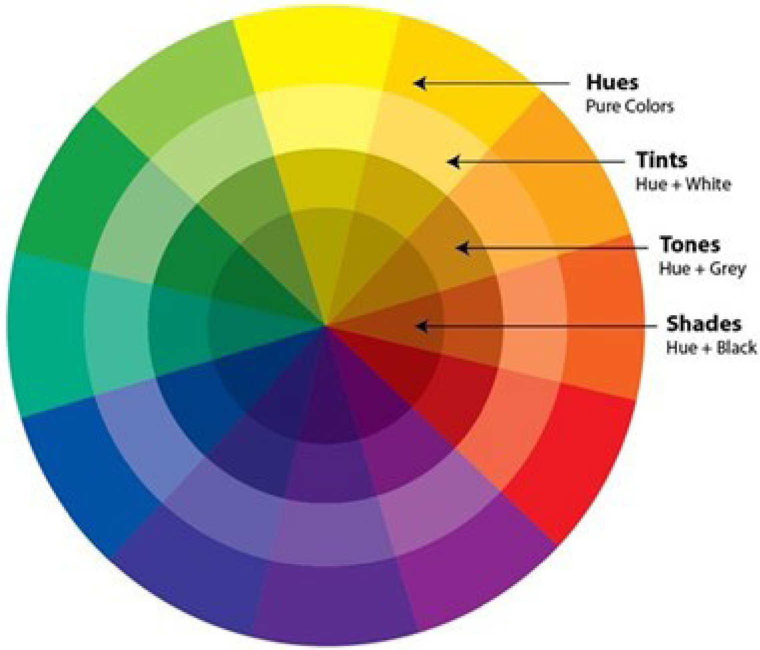
While quarantining from a plague, Newton held a prism of glass in the path of a beam of sunlight coming through a hole in the curtain of his darkened room. He observed that the "white" sunlight coming through the prism actually split (or fractured) into red, orange, yellow, green, blue, indigo, and violet (ROYGBIV) inside his room. These colors are what's known as the visible spectrum.

Newton kept on experimenting and observed something no one else had ever seen before. Using prisms and mirrors, he discovered that when the light from three separate parts of his rainbow—the red, green, and blue regions—recombined and become one again, they would regenerate the "white" sunlight streaming through his window.



Isaac Newton's prism experiment
https://www.britannica.com/print/article/126658

CONNECTING with Colorfully-Cool Definitions



Color:

This is how we describe an object based on the way that it reflects or emits light. Your eye can see different colors because a part of your eye called the retina is sensitive to different wavelengths of light.

Primary Colors:

Red, yellow, and blue. These are the building blocks from which all other colors are derived. These three colors can't be recreated by mixing other colors.

Secondary Colors:

Orange, green, and violet. These colors result from mixing equal parts of two primary colors. On the color wheel, secondary colors are located between primary colors.

Tertiary/Intermediate Colors:

Blue-green, blue-violet, red-orange, red-violet, yellow-orange, and yellow-green. These colors come from combining equal parts of primary and secondary colors.

Color Wheel:

An easy way to show the relationship of paint colors to one another by arranging them in a circle.

Hue:

The common name of a color and used to indicate its position in the spectrum or on the color wheel.

Tints:

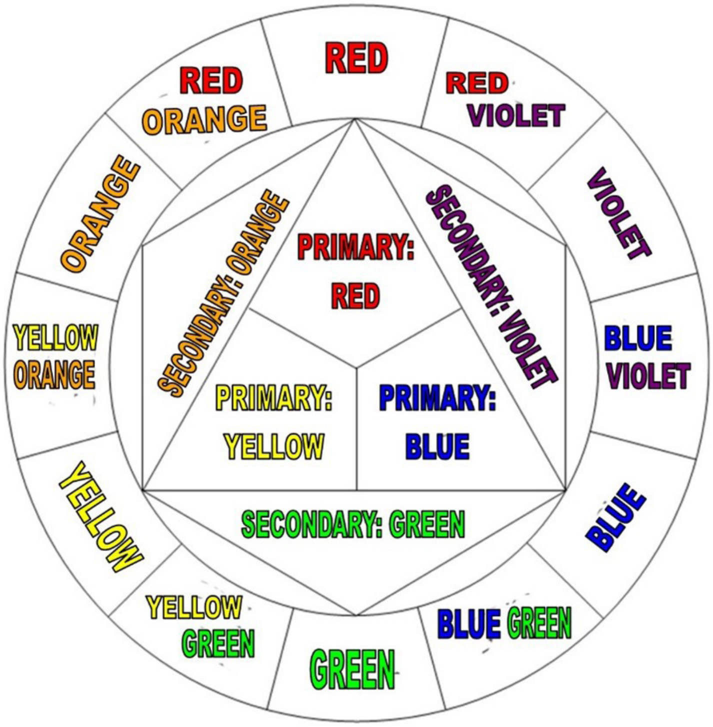
These are created when you add white to any hue on the color wheel. This will lighten and desaturate the hue, making it less intense. Tints are often referred to as pastel colors, and many feel they are calmer, quieter colors. When mixing a tint, always begin with white paint and gradually mix in small amounts of color until you've achieved the tint you want.

Shades:

These are hues or mixtures of pure colors to which only black is added. It contains no white or gray. This darkens the color, but the hue remains the same. When mixing a shade, begin with the color itself then add black one drop at a time.

1 Activity #1

Let's create our own **Color Wheels** using the three primary colors—red, blue, and yellow.



MATERIALS:
- 1 BLANK color wheel
- Acrylic paints: red, yellow, and blue
- 1 Paintbrush

DIRECTIONS:
1. Using your BLANK color wheel, paintbrush, and dabs of the yellow, red, and blue acrylic paints, paint the three parts of the center triangle RED, YELLOW and BLUE following our example here.
2. Mix equal parts RED and YELLOW (to create ORANGE); RED and BLUE (to create VIOLET); and YELLOW and BLUE (to create GREEN). Then fill in the colors on your color wheel.
3. Next, mix equal parts RED and VIOLET, then BLUE and VIOLET, continuing until you fill in the colors to match all the colors on the sample color wheel.

2 Activity #2

Let's ***TAKE ACTION*** and create some **Color Wheel Coffee Filter Flowers.**

MATERIALS:
- 4 coffee filters
- Water-based markers in red, orange, yellow, green, blue, and violet (purple)
- 1 small paper plate
- Spray bottles filled with water
- Glue
- Scissors

DIRECTIONS:
1. Cut 3 of the coffee filters in half so that you have 6 halves. Color each half with two of the water-based marker colors in the following combinations:

   RED and ORANGE
   RED and PURPLE
   BLUE and PURPLE
   GREEN and BLUE
   YELLOW and GREEN
   ORANGE and YELLOW

2. Using the last coffee filter, color the center using all six colors: RED, ORANGE, YELLOW, GREEN, BLUE, and PURPLE.

3. Cover a surface (with something like newspaper or paper towels, etc.) Set all the colored coffee filters on the covered surface, then lightly spray them with water until the colors start to spread, then set them aside to dry.

4. Scrunch the dried coffee filter halves and glue them to the paper plate so that the coffee filters cover the edges of the plate, but not the center. Group together your colors just like the color wheel.

5. Scrunch the whole coffee filter and glue it to the center of your paper plate. You have created a coffee-filter flower!

DISCOVERING the Physics Behind Color

There are many kinds of waves all around us. There are waves in the ocean and in lakes. But did you know there are also waves in the air? Did you know that light radiates from a source in waves of electromagnetic energy? Most of the electromagnetic energy that affects the Earth comes from the Sun.

Visible light is the small part within the electromagnetic spectrum (ALL the waves out there in the universe) that human eyes are sensitive to and can detect. What we see when our eyes look at an object is reflected light. When light hits an object, some wavelengths are absorbed by that object, and some are reflected.

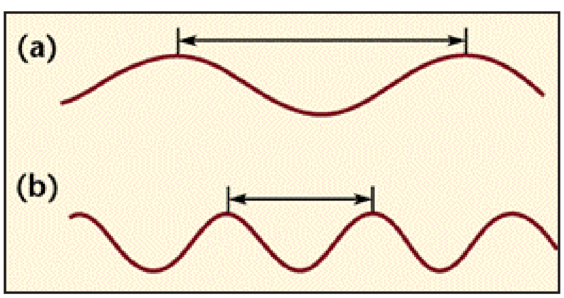
Light of different wavelengths looks like different colors. When we see an object of a certain color, that means that light of that color's wavelength is being reflected off the object. For example, when you see a red shirt, the shirt is absorbing all the colors of light except for the red color. The frequency of light that we see as red is being reflected and we see that shirt as red.

Light also moves in many ways. Light can be:

- reflected by a mirror. We can also make reflections of a reflection when we use more than one mirror.
- refracted by a lens or object. This means that the light bends when it enters a new material, like water or glass, and may emerge in an unexpected way, such as changing the size or focus of an image, or even changing its orientation.
- dispersed into a rainbow.
- absorbed by an object.

Ultra-violet light (UV light) has shorter wavelengths than violet light and can't be seen by the human eye. Some animals, including birds, reptiles, and insects, such as bees, can see into the near ultraviolet. Although invisible to humans, UV light has many of the properties of normal sunlight and can cause sunburn, hurt the eyes, and even cause discolor some materials. Some —but not all—UV light is absorbed by the ozone. That UV light that still reaches Earth can cause damage to our skin.

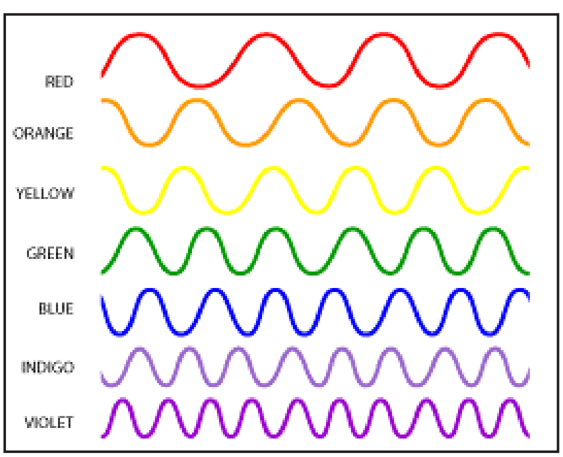
CONNECTING with Colorfully-Cool Definitions



Wavelength:

The distance between two peaks of any kind of wave.

Example:: (a) has a longer wavelength than (b).
http://ww.lbl.gov/MicroWorlds/ALSTool/EMSpec/

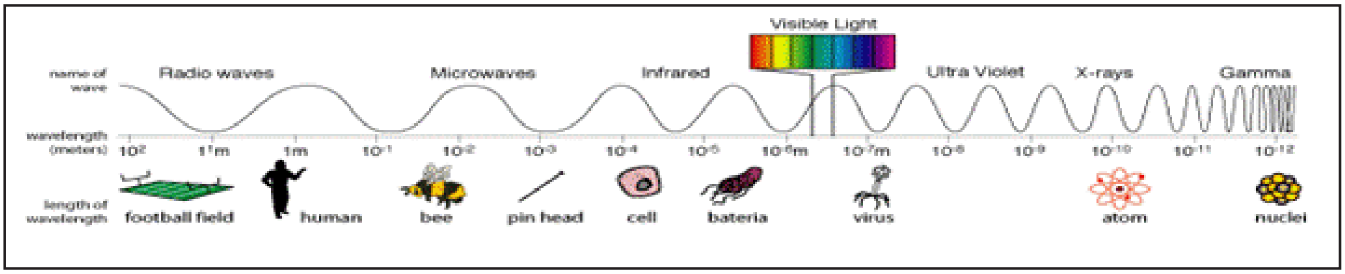


Example: Red has a longer wavelength than violet.

http://science.hq.nasa.gov/kids/imagers/ems/index.html

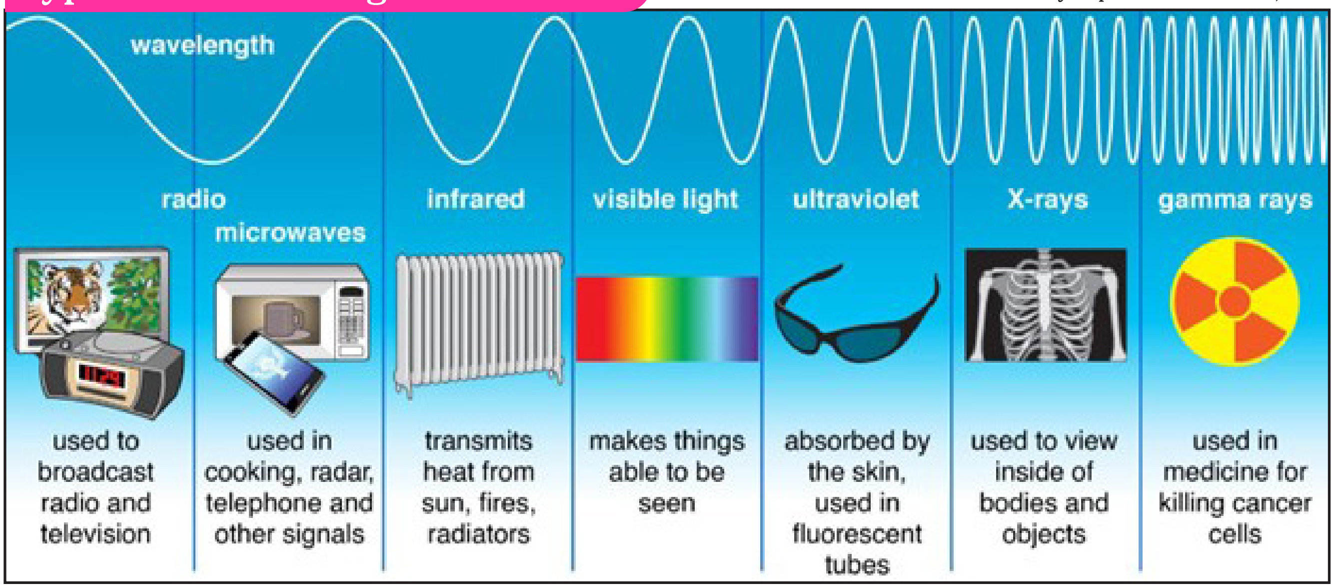
Electromagnetic Spectrum:

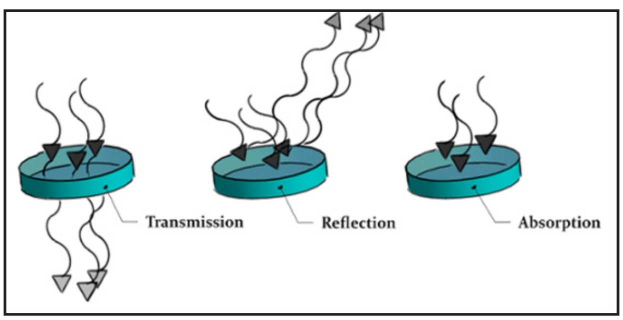
The range of all wavelengths (or frequencies) of electromagnetic radiation. These range from shorter than X-rays, through the visible region, and extend beyond radio.



http://science.hq.nasa.gov/kids/imagers/ems/index.html

Types of Electromagnet Radiation





Transmission:

When light strikes an object (or interface) and travels in a straight line through it rather than being reflected or absorbed. Example: Clear glass has a highly visible light transmission.

http://www.chroma.com/knowledge/introduction-fluorescence/transmission-reflection-and-absorption

Transparent:

Describes a material that will allow light to pass through it in a straight line. Example: Your eyeglasses are transparent, as are apple juice and Jell-O.

Opaque:

Describes a material that will not allow the transmission of light. Example: Anything that blocks light!

Reflection:

When light strikes an object (or interface) and bounces off rather than being transmitted or absorbed. Example: A mirror provides a reflection, as does the surface of water or glass.

Refraction:

When light strikes a transparent object (or interface) which causes it to change its path. Example: Because of the refraction of light through water, the spoon below looks crooked.

http://blogs.discovermagazine.com/badastronomy/tag/refraction/

Photochromic:

Describes a material that will change color upon exposure to light. A property of Transitions® lenses.

1 Activity #1

Let's create our own waves!

MATERIALS:

- Slinky
- VISIBLE Electromagnetic Spectrum Handout

DIRECTIONS:

Slinkys can demonstrate different wavelengths depending on how far apart they are or how close together they are. Play with the slinky provided and notice how pulling it farther apart creates longer wavelengths than when you put the ends closer together.

Try recreating the different wavelengths of the different colors of the rainbow using the slinky. Wiggle your slinky to get a nice wave. (Girls should use a moderate amount of shaking.) Let's consider this red.

Now try to make a green wavelength. This should have twice the wiggle as the red making the wavelength shorter. (Girls should try to create this by shaking the slinky faster.)

Finally, let's try to make violet which has twice the wiggle of green. (Girls should shake the slinky vigorously.)

FUN TWIST:

Try creating your own "wave" with a group or your troop by standing in a circle, holding hands, and doing a wave. What would your wave look like if it were the color RED? What would it look like if it were VIOLET?

2 Activity #2

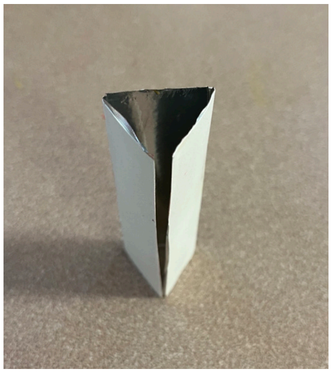
Let's ***TAKE ACTION*** and create our very own **Special Kaleidoscopes** to learn about all the cool ways that light moves and can be reflected, refracted, and dispersed. Our kaleidoscopes will also include special UV beads that will help remind us to make sure to wear sunscreen when we use them in outdoors.

MATERIALS:

- 1 toilet paper roll
- 1 clear plastic seal circle
- 1 black cardstock circle
- 1 3x3" clear contact paper (to seal the end with your beads)
- 1 white 3x3" cardstock square
- 1 metallic tape strip
- A few pony beads
- 2-3 UV beads
- Hole punch
- Tape

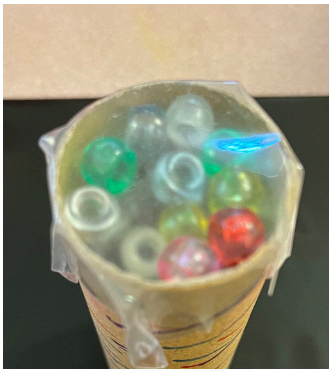
DIRECTIONS:

1. Take the metallic tape and use it to cover one whole side of the white cardstock square.
2. Fold the cardstock square with the metallic tape facing inward into 3 equal parts.
   (***Helpful Hint:*** It will look like a triangle or prism.)
3. Tape the edges of the triangle together and set aside.



4. Take the clear plastic seal, remove the backing, and arrange the clear/colored pony beads and UV beads in a single layer on the sticky side of the seal (so that they stay on the tacky side of the seal).
5. Once your beads are stuck to the seal, take the clear contact paper square, remove the backing, and carefully place it over top of your beads.

6. Take the piece of contact paper and carefully place the beads into one end of your toilet paper tube with the plastic seal going inside the tube first and then wrapping the contact paper around the outside of the tube, sealing your layer of beads inside the tube.
7. Take your prism and place it inside the open end of your tube. Use a little tape on the end to secure the prism so that it doesn't move inside your tube.



8. Trace the end of the tube on the black cardstock circle, cut out the traced circle, and then use a hole punch to punch a hole in the center of the circle.
9. Take the black cardstock circle to the open end of your kaleidoscope and take a peek through the hole while pointing the other end with the beads towards a light source.
10. Try twisting and turning your kaleidoscope in different ways. How does what you see change? Remember those UV beads? Do you notice them changing colors in the light?

OPTIONAL:
You can always decorate the outside of your kaleidoscope by drawing pictures on a piece of paper or cardstock and taping or gluing it around the outside.

DISCOVERING the Chemistry Behind Color

Have you ever spilled your favorite drink on your homework? What happens to the ink as the liquid spreads? Sometimes, the ink will smudge and get blurry. But other times, the ink on the paper splits up into weird colored streaks that creep across the page.

When that happens, you're seeing chromatography in action.

In the case of your homework, it's totally accidental. But did you know that we can also use chromatography by design to split up mixtures and other substances into their components?

Chromatography is one of the most useful investigative techniques chemists have at their disposal, helpful in everything from identifying biological materials to finding clues at crime scenes.

Chromatography is a pretty accurate description of what happens to ink on wet paper because it literally means "color writing" (from the Greek words chroma and graphe), but this process often doesn't involve color, paper, ink or even writing.

Chromatography is actually a way of separating out a mixture of chemicals, which are in gas or liquid form, by letting them creep slowly past another substance, which is typically a liquid or a solid. So, with the ink and paper trick, for example, we have a liquid (the ink) dissolved in water (or another solvent) creeping over the surface of a solid (the paper).

Essentially, we have some mixture in one state of matter (something like a gas or liquid) moving over the surface of something else in another state of matter (a liquid or solid) that stays where it is. The moving substance is called the mobile phase and the substance that stays put is the stationary phase. As the mobile phase moves, it separates out into its components on the stationary phase. We can then identify them one by one.

CONNECTING the Chemistry Behind Color

Color Value:

Refers to the lightness or darkness of a color. It indicates the quantity of light reflected. Adding black, white, or gray to a color changes this.

Chroma:

The saturation or strength of a color determined by the quantity of light reflected. The brightness or purity of a color. A pure color in its brightest form and is most intense. The addition of any color lowers the intensity.

Chromatography:

Separating out a mixture of chemicals, which are in gas or liquid form, by letting them creep slowly past another substance, which is typically a liquid or a solid.

Saturation:

The point at which a solution of a substance can dissolve no more of that substance.

Mobile Phase:

The fluid used in chromatography. It carries a mixture of chemicals, and depending on the balance of attraction between this fluid and the stationary phase, will separate the mixture.

Mixture:

A combination of two or more substances in such a way that no chemical reaction occurs between the components. Original components are still present and can sometimes be separated out.

Solute:

Material that mixes at the molecular level with another. Commonly, this is the solid minor component in a liquid component like a spoonful of sugar in water as is done in the Liquid Rainbow Experiment.

Stationary Phase:

The material in chromatography that does not move. As the mobile phases move over this material, chemicals will separate out of a mixture depending on the balance of attraction between this material and the mobile phase.

Chemical Reaction:

Most simply, this occurs when one chemical compound is changed into another. Commonly, this is illustrated by mixing two chemicals together to produce a third (and different) chemical.

Solution:

A mixture of two or more substances, where the distribution is so uniform, it looks like a single substance. A common example is sugar stirred into water.

Density:

This is a measure of how much matter is in a defined volume. For example, rocks will sink in water because they have more matter in a given space than water does.

Dissolve:

When material mixes uniformly into another. A common example is when a powder, like sugar, will appear to disappear into a solution.

Concentration:

This is a measure of the amount of stuff (solute) dissolved in a liquid. For example, you can increase this property by dissolving more and more of something into a liquid.

1 Activity #1

Let's ***TAKE ACTION*** and create our own **Liquid Rainbow**!

We are going to dissolve 4 different amounts of sugar into 4 different cups containing the same amount of water, then use food coloring to add a splash of "rainbow" colors to our different mixtures. Starting with the highest concentration (the cup with the MOST sugar) and working our way to the least, we are going to carefully layer all four mixtures in our test tube to create a "Liquid Rainbow."

MATERIALS:

- Test tube
- 5 plastic cups (4 empty cups and 1 filled with water)
- 4-pack food coloring
- 1 plastic pipette
- Sugar
- 1 tablespoon
- Plastic spoons

DIRECTIONS:

1. Take the 4 empty cups and add 1 tablespoon of sugar to the first clear cup, 2 tablespoons of sugar to the second one, 3 tablespoons to the third, and 4 tablespoons to the fourth.
2. Carefully add JUST 3 tablespoons of water to each of the 4 cups and stir each solution. If the sugar does not dissolve in all the cups, then add one more tablespoon of water to each of the four cups. (Helpful Hint: The solution in the cup with the most sugar should be really thick compared to the cup with the least amount of sugar.)
3. Choose a food coloring as Color 1, Color 2, Color 3, and Color 4.
4. Add 1 drop of Color 1 food coloring to the first cup, 1 drop of Color 2 to the second, 1 drop of Color 3 to the third, and 1 drop of Color 4 to the fourth, and stir.
5. Let's observe and make some predictions: What are some of the differences you see between the four solutions? Do any appear thicker than others? Are the ones with more sugar harder to stir? Why are the cups with more sugar thicker than the others with less? Pick up the cups and see if the ones with more sugar feel heavier than the others. What do you think would happen if we tried to put all these together in our test tube?
6. Use the pipette to fill the test tube to about 1/4 full of the Color 4 sugar solution. (Helpful Hint: This should be the thickest solution with the MOST sugar in it).
7. Rinse the pipette with leftover water, then, VERY CAREFULLY, use the pipette to draw liquid from the Color 3 solution and layer it on top of the Color 4 solution in the test tube to about 1/2 full without shaking the test tube. If you have two people, one person should hold the tube steady while the other person slowly adds the second layer of our Liquid Rainbow.
8. Repeat the last two steps for the remaining solutions with Color 2 filling the test tube 3/4 full and then Color 1 filling to the top. Do not go too fast or shake the test tube, otherwise all their colors will mix together, rather than layering.
9. After observing your layered Liquid Rainbow, shake it up in the test tube to see what happens.

In this experiment, we controlled the layering of the solutions with their density based on the concentration of sugar to water in our mixture. The densest solutions, the one with the most sugar, will sit on the bottom (Color 4). The least dense will sit on the top (Color 1). If we're careful not to stir the solutions up, they will stay in layers!

Notice how ALL the different colors blended to form a sort-of brownish mush when we shook up our Liquid Rainbow. What if we wanted to "unmix" our colors once they are stirred together like this, how can we do that?

So far, we've learned about saturation, mixtures, solutions, concentration, density, and so many other cool aspects of the chemistry behind the colors. In our next experiment, we are going to learn how scientists use chromatography to separate colors while we make our own Colorfully Cool Bandannas.

Anything that involves color is a mixture and a solution. Colors have pigment and we create chroma by separating the solutions and mixtures to get individual colors. Chroma is color in its purest form. For example, when we mix colors like red and yellow, what color do we get? (Answer: orange)

Sharpie markers are made up of permanent ink, meaning they are waterproof. Their color isn't changed by water. However, the dye used in the markers IS soluble in isopropyl alcohol (rubbing alcohol). That means that when alcohol is added to the spots where the markers are used, it dissolves the dye.

Each marker uses various dyes to obtain its color. Some may contain only one dye, while others may have two, three, or four dyes. We can separate these dyes using chromatography.

2 Activity #2

Let's ***TAKE ACTION*** and test the theory of chromatography as we make our own **Colorfully-Cool Bandannas.**

MATERIALS:

- 1 white bandanna
- permanent marker set - multi-color
- Pipette
- Plastic cup
- Isopropyl alcohol
- Cardboard (or something to lay the bandanna on flat while adding the drops of alcohol)
- Zipper-seal baggie to transport wet bandanna

DIRECTIONS:

1. Take your bandanna and use the permanent markers to draw designs on your bandanna, making sure that you have something underneath the bandanna so that the ink doesn't bleed through onto the table or surface where you are working. (Helpful Hint: Too much coloring can alter how the designs on your bandanna will come out when you add drops of rubbing alcohol to them.)
2. Lay the bandanna out flat on your cardboard. This will help stop the alcohol drops we add to one side of the bandanna from touching the other side as long as we're careful and don't add TOO MUCH alcohol at once.
3. Using the pipette, carefully add drops of rubbing alcohol to the designs on your bandanna and watch how the colors separate and the designs change right before your eyes. (Helpful Hint: Add the alcohol only one or two drops at a time, and give the alcohol a chance to work its magic and separate out the colors. Adding too much will simply blur together all the colors and designs.)

FINISHING INSTRUCTIONS:

1. Leave your bandanna to air-dry completely. (Do not put it in the dryer yet!) If you need to transport your wet bandanna, place it in a Ziploc bag and take it out to completely dry.
2. Once completely dry, iron your bandanna with a hot dry iron.
3. Wash your bandanna in cold water. The ink should be permanent, but use caution when washing it with other clothing during its first wash.

Wait. What just happened?
Remember when we talked about how the dyes in the markers are soluble in alcohol (but not water) and that alcohol dissolves the dye? Notice how the alcohol moves through the bandanna through capillary action (meaning it moves on its own without you having to do anything to make it move).

Since the dye dissolves into the rubbing alcohol (much like the sugar in our earlier experiment dissolved in water), the dye travels as well. The smaller dyes (the ones with less density) will travel faster with the alcohol, while the larger (more dense/heavier) dyes will take longer.

If you look at your bandanna, you will see that some of the colors have separated into two or more colors. Do you notice any unusual combinations? A color computer printer, for example, only uses magenta, yellow, and cyan to create all the colors it uses. Therefore, just because a marker is orange, doesn't mean it only has red and yellow dye in it. What are some of the interesting color separations you are noticing?

3 EXTRA FUN: ACTIVITY 3

Let's make **Sun Prints**!

IMPORTANT: Do not open the special paper in the envelope until instructed to do so.

Cyanotypes (also known as sun prints or blueprints) are one of the first types of photographs developed in the late 1800s. They were most famously used by female botanist Anna Atkins who used this method to catalog algae and ferns in England.

The process is simple: pick some leaves, flowers—whatever you'd like—then use the power of the sun to activate the chemicals in the paper. The items that block the light turn the paper white while everything the sun touches turns blue after washing the paper.

Not only are they fun, but there are so many designs you can make with them! Use your imagination and the nature around you to make these one-of-a-kind transfer prints!

MATERIALS:
- Cyanotype paper
- plastic sheet
- pan of water
- leaves, flowers, or any other objects to make the design of your choice

A note on the Cyanotype paper: The paper in the envelope is light sensitive! This means that when it's in the light, it is activated. Don't open the envelope until you are ready to make your sun print!

Also, each piece of paper is double-sided! If you want to use both sides, you will have to expose both sides to the sun before rinsing.

DIRECTIONS:

1. Plan your design. Pick flowers, leaves, or items from around your neighborhood. Make sure any objects from outside are super dry. Arrange them in the design of your choice.
2. Remove your sun-sensitive paper from the envelope. Arrange your items as planned on top of the paper. Cover your arrangement with the sheet of plastic to keep your items from blowing away and place it in direct sunlight.
3. Keep in the sun for 20 minutes or up to an hour if in the shade or on a cloudy day.
4. Rinse by filling a pan with water and gently shake (agitate) for thirty seconds. Dump the water and repeat three times with fresh water or until the water no longer turns yellow.
5. Set your print out to dry!

HELPFUL TIPS:

- Items that are a little transparent allow some of the light to pass through, allowing for more detail to be shown (like the seaweed to the left). Try feathers or even lace fabric for a cool effect!

- The flatter the items are to the paper, the crisper the edges will appear. Try clamping the plastic sheet to a piece of cardboard with binder clips to flatten your items. Just remember to watch how you clip it, anything on the paper will show up!

Take it to the next level!

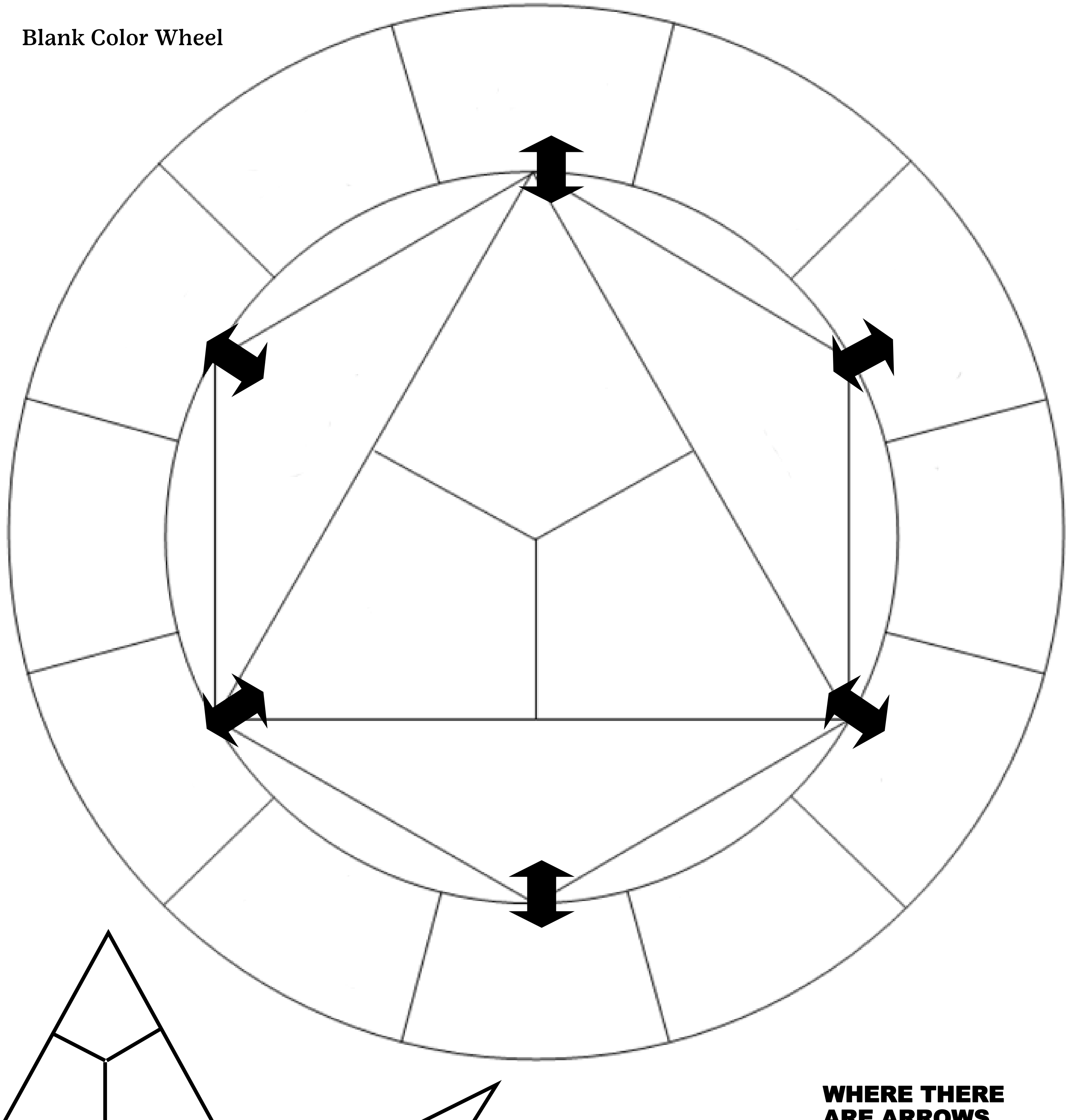
- Try drawing your own designs! You can draw on any transparent material to add designs and words to your cyanotype. This was originally how architects created blueprints!

- Don't like blue? You can dye your prints after exposing them using tea bags! Brew about six black tea bags in water and soak your print in it until it is dyed brown. Rinse with plain water and let dry! What other ways can you experiment with dying your paper with found materials at home?

- You can keep your print on your wall like the art it is, or you can turn it into something else. Create a card featuring your print and write a letter to a friend or design a bookmark! We'd love to see what you come up with. Post it to Rallyhood and share what you've created.

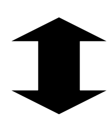
Once you have completed all steps in this activity guide, use your permanent markers to color in the PPG Science of Color patch.

Blank Color Wheel

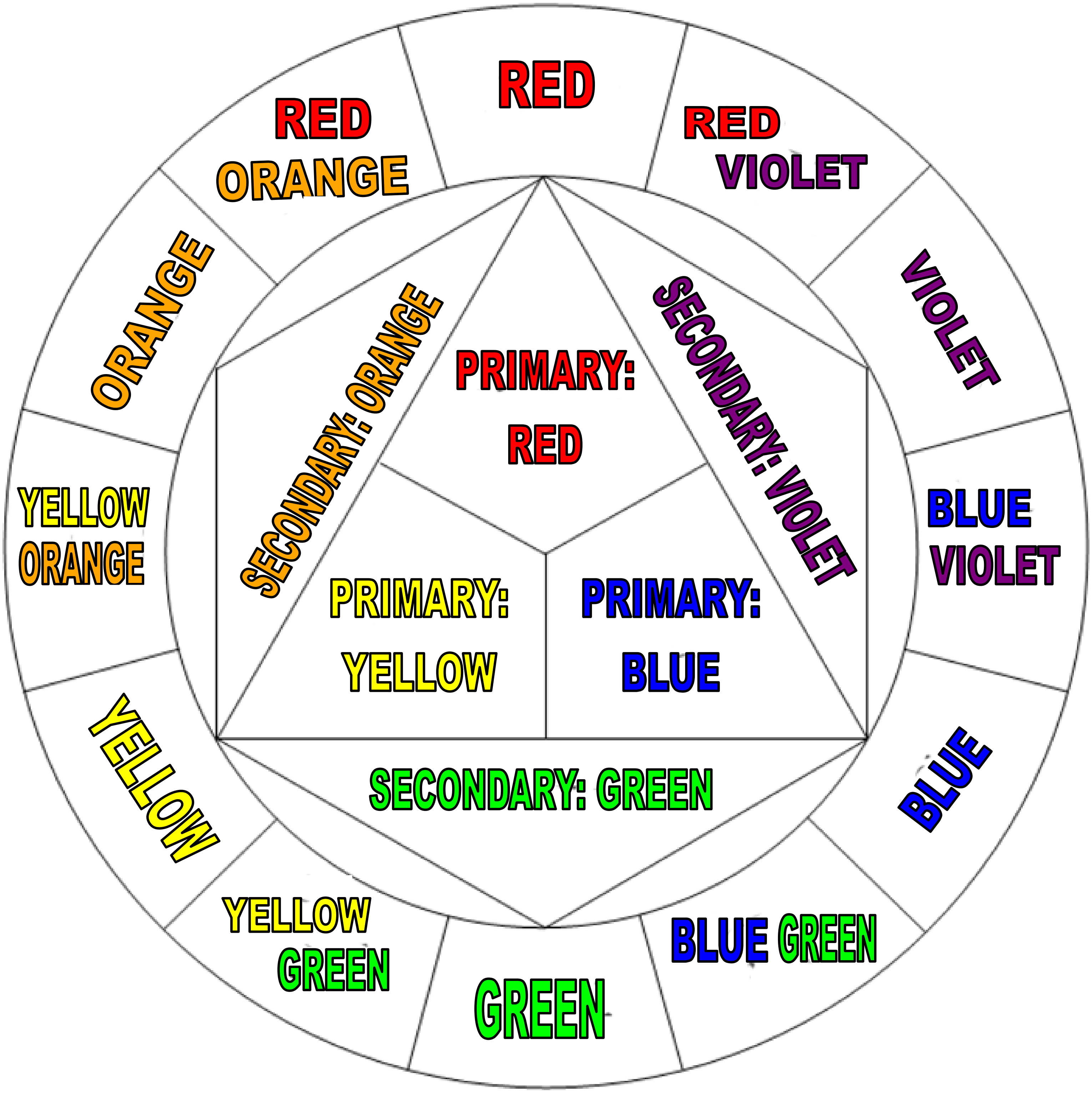


PRIMARY COLORS:
- **RED**
- **YELLOW**
- **BLUE**

SECONDARY COLORS:
- **ORANGE**
- **GREEN**
- **VIOLET/PURPLE**



WHERE THERE ARE ARROWS THE COLOR FROM THE CENTER IS THE SAME AS THE COLOR IN THE OUTER CIRCLE. THESE WILL BE THE PRIMARY AND SECOND-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ORANGE
YELLOW ORANGE
YELLOW
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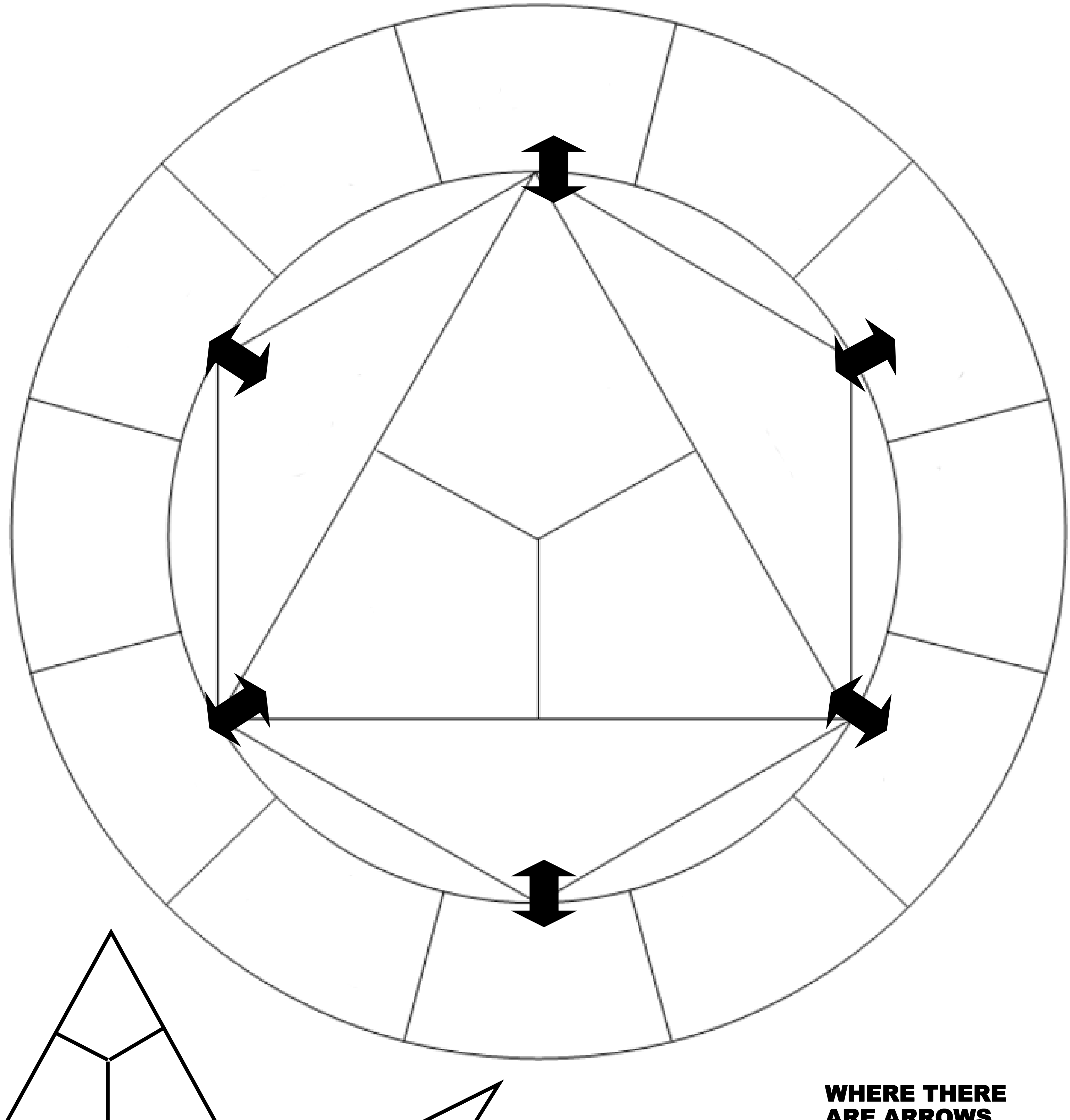
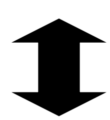
GREEN
BLUE GREEN
BLUE
BLUE VIOLET
VIOLET
RED VIOLET
PRIMARY: RED
PRIMARY: YELLOW
PRIMARY: BLUE
SECONDARY: ORANGE
SECONDARY: VIOLET
SECONDARY: GREEN



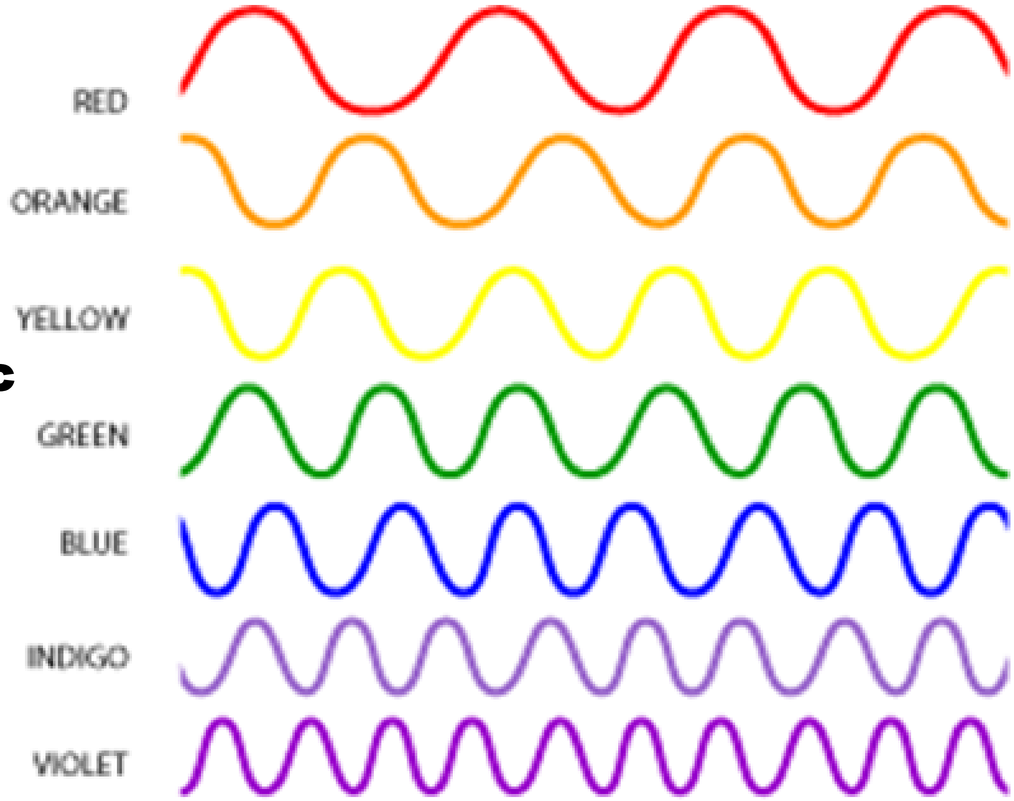
PRIMARY COLORS:
- **RED**
- **YELLOW**
- **BLUE**

SECONDARY COLORS:
- **ORANGE**
- **GREEN**
- **VIOLET/PURPLE**



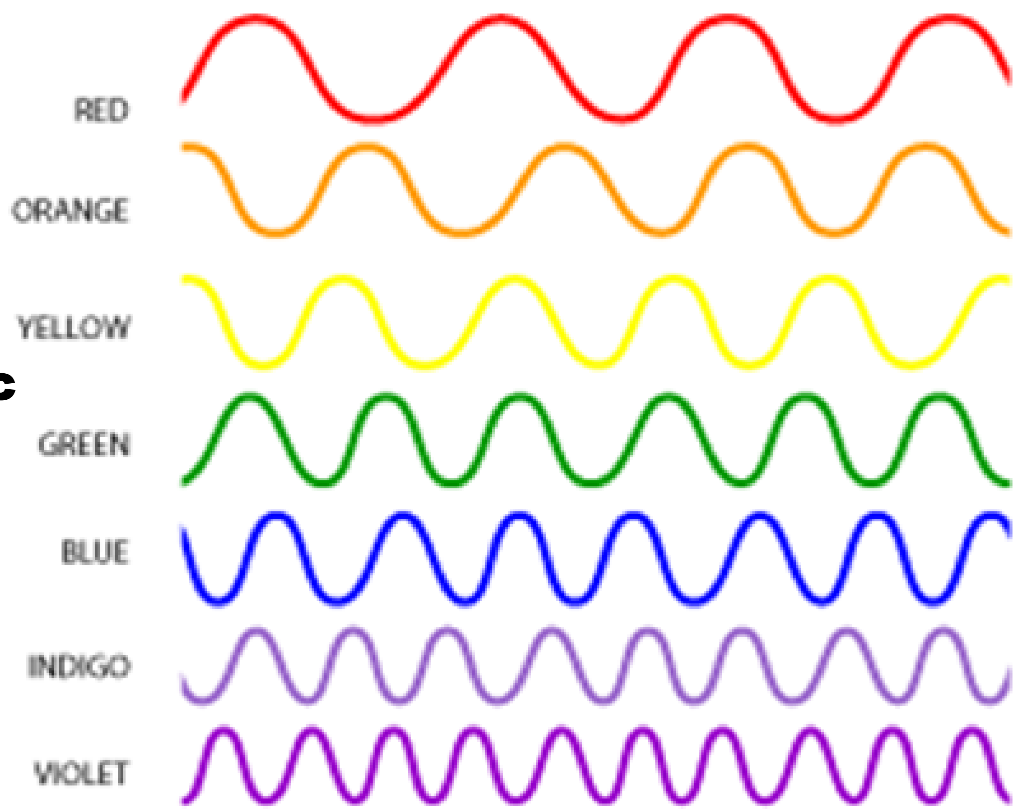
WHERE THERE ARE ARROWS THE COLOR FROM THE CENTER IS THE SAME AS THE COLOR IN THE OUTER CIRCLE. THESE WILL BE THE PRIMARY AND SECOND-

VISIBLE Electromagnetic Spectrum — Wavelengths

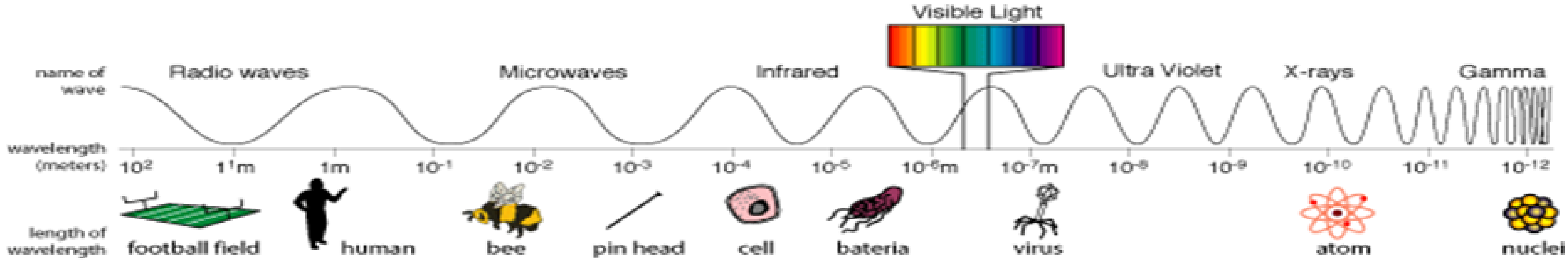


http://science.hq.nasa.gov/kids/imagers/ems/index.html

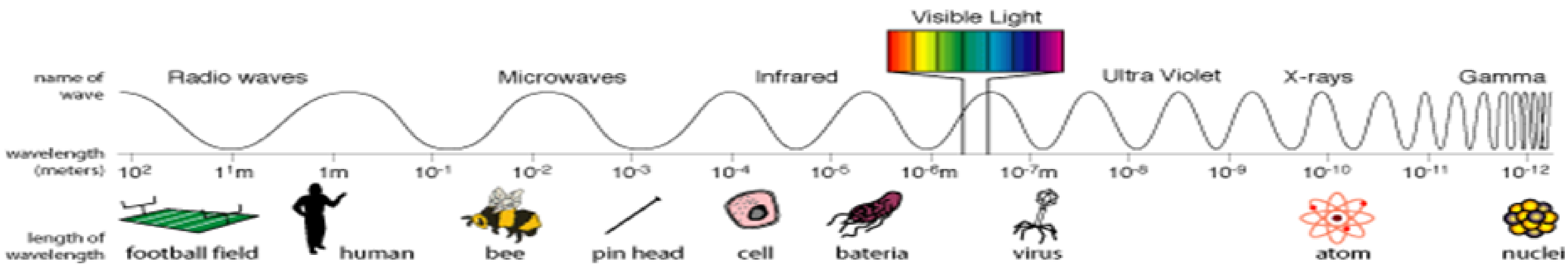
VISIBLE Electromagnetic Spectrum — Wavelengths



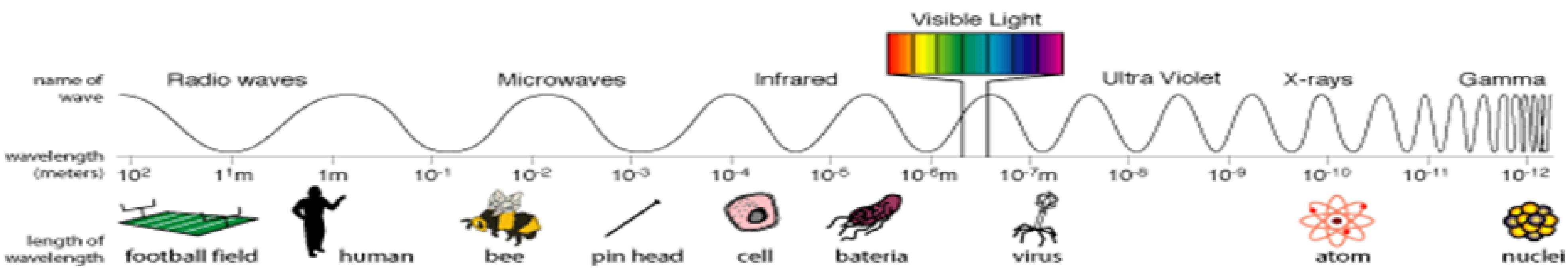
http://science.hq.nasa.gov/kids/imagers/ems/index.html



FULL Electromagnetic Spectrum—Wavelengths http://science.hq.nasa.gov/kids/imagers/ems/index.html



FULL Electromagnetic Spectrum—Wavelengths http://science.hq.nasa.gov/kids/imagers/ems/index.html



FULL Electromagnetic Spectrum—Wavelengths http://science.hq.nasa.gov/kids/imagers/ems/index.html

girl scouts
western pennsylvania