Student Worksheet

Iridescent Art NAME ___________________________________

Day 1 – Activity 1: Identifying and Comparing Colors of Light and Pigment

Light can be divided into colors, and pigments have color too. Pigments are chemicals that absorb **light**. Each pigment absorbs a specific wavelength (color) of light, and reflects the others (this is what you see). Pigments can be biological (giving plants and animals color) or non-living (like those that give paint their color). The Primary Colors of Pigments / Paint are Cyan, Magenta, and Yellow (CMY). The Primary Colors of Light are different - Red, Green, and Blue (RGB).
What happens when colors mix? For Light: colors get added together. For pigments: the pigment in paint absorbs, or subtracts, certain wavelengths (colors) of light. For example, a yellow pigment is yellow because it subtracts blue light, and reflects yellow. **There are rules for this:** a colored pigment will absorb (subtract) its complimentary color from white light.

What are the complimentary colors? Use your pigment-colored rulers to figure out the color subtraction rules. You have a cyan, a yellow, and a magenta ruler. Each ruler absorbs, or subtracts, a single primary color of Light (RGB), so if you put two rulers together, two of the primary colors of light are subtracted. The color that is left over is the color you see.

- Over white paper, put two of the rulers together to form an "X". Two of the primary light colors (RGB) get absorbed, and one is left over (reflected, and visible). **Put this leftover color in the rectangular box between the two colors that formed it.**
- Try all combinations, 2 at a time, and use the process of elimination to determine the complimentary color for CMY. (Hint: It is not the "leftover" color).
- Fill out your Color Wheel "Rules". Locate your complimentary colors.

Ruler color 1	Ruler color 2	Resulting color

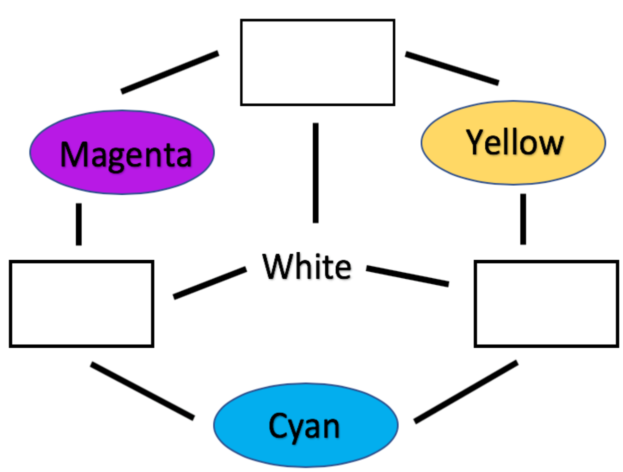
Color Wheel Addition & Subtraction Rules

Question: What are the complementary colors?

Cyan / ________________

Magenta / ______________

Yellow / ________________



Question: can you describe the position of the complementary colors?

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Comparing Colors of Pigment and Colors of Light: The 'Rules' color wheel shows the primary colors of Light (RGB) and the primary colors of Paint (CMY) – and shows the rules for subtraction and addition.

> **Color Subtraction:** A Pigment absorbs, or Subtracts, its complementary color from RGB Light. The color you see is the color that isn't absorbed. Equal amounts of CMY subtracts all the RGB, and results in what we call 'black' (absence of light colors). This is what makes CMY the "primary" colors – equal amounts make black via subtraction.
>
> **Color Addition:** The colors of Light are Additive. White light is Red, Green, and Blue (RGB) mixed (added) together equally – but if you have just two of the primary colors of light, they add together to make the color you see (if added in equal amounts, two together will make a secondary color of light: Cyan, Magenta, Yellow). On your Color Wheel Rules, the color formed by adding two of the 3 primary light colors (RGB) is found in between those two colors.

Practice with Color Subtraction (Pigments): Fill out table 1, which illustrates color subtraction for the primary colors of pigments. For each photograph of a plant or animal write out the color subtraction. For example, why is a bluebird blue? White light shines on feather pigments that reflects Blue, but absorb Yellow (its complement). Yellow is Red + Green. If Red and Green are absorbed, all we will see is the Blue that gets reflected.

We can write this as:	**White Light**	**–**	**Color Absorbed**	**=**	**Color Reflected**
This is the same thing:	RGB (white light)	–	(R + G) (yellow, expressed as primary light colors)	=	Blue (reflected)

Organism's color	**Color Reflected**	**Color(s) absorbed**	**Color Subtraction** **White – Color Absorbed = Color Reflected**
Bluebird = Blue	Blue	Yellow (= R + G)	RGB – (R + G) = B
Cardinal = Red			
Goldfinch = Yellow			
Leaves = Green			

Table 1. Students explore color and practice the rules of color subtraction for pigments.

You need to know color subtraction in order to figure out which primary paint colors to mix together to make the secondary paint colors (RGB).

Question: What primary paint colors do I need to mix together to create Red?_________________

Question: What primary paint colors do I need to mix together to create Orange?______________

(* Hint: do I need equal amounts of each color?)

<u>Practice with Color Addition (Light)</u>: Color addition happens when the colors of light (not pigment) are mixed: White light is Red, Green, and Blue (RGB) mixed (added) together equally. Unlike colored pigments, the colors of light are <u>additive</u> – you add 2 primary colors of light together to make a Secondary Color of Light (Cyan, Magenta, Yellow).

Check your rules sheet by adding light colors, two at a time, using flashlights and colored film.

Do the colors of light and the colors of pigment mix in the same way?

Can you think of any instance where you can take two colors of paint, and mix them to create a third color - and then take the same two colors of light and mix them to create the same third color?

Try it: put equal amounts of Red and Green <u>Paint</u> together (you just need a tiny amount). According to the addition rules for the Colors of <u>Light</u>, if you add red and green light

What color SHOULD you get? (Red Light + Green Light = ______________________)

What color DO you get? (Red Paint + Green Paint = ____________________________)

Why do you think this is?

Day 1 – Activity 2: Engage with Bubbles and Explore Wave Interference

1. Blow some bubbles outside, or over a carpeted area (soap bubbles on tile flooring will make it slippery). If you can, hold a bubble on a bubble wand or straw in front of a piece of black paper. **Describe what you see:**

A soap bubble is like a water sandwich – it is two layers of soap film with a layer of water in between. Light can reflect off either the top or bottom layer as some light passes through the top layer of soap, gets refracted by the water, and then reflects from the bottom layer. The iridescence of a soap bubble comes from light striking the thin bubble film from many angles. The light absorbed by the thin film of soap is **reflected** and **refracted**, and splits into various colors depending upon the thickness of the film, the angle that light enters, and the amount of **interference** (some light reflects from the top layer of the soap film, some light reflects from the bottom layer). When the waves meet, they interfere. As the light waves travel through the bubble they collide with each other. If they collide crest to crest, then they reinforce each other's impact and effects, causing **constructive interference**, and bright colors in that wavelength. But if the waves meet crest to trough, they cancel out each other's effect, and the result is **destructive interference**, and dimmer or missing colors in that wavelength. Eventually, the soap film evaporates and becomes too thin to create interference of visible wavelength; at this point the bubble appears colorless – then pops!

2. Using colored pencils, sketch your soap bubble:

3. Now add to your drawing: what do you think happens when light strikes the soap bubble film? Does it Reflect? Refract? Both? Draw several light waves striking your bubble film, and show where they go after striking the bubble.

Iridescence
In 1634, Sir Theodore de Mayerne, physician to Charles I, observed that the 'eyes' on the wings of the peacock butterfly "shine curiously like stars, and do cast about them sparks of the colour of the Rainbow; by these marks is it so known that it would be needless to describe the rest of the body though painted with a variety of colours."

Sir Theodore was describing **iridescence** – a gorgeous, glossy rainbow that makes the plant or animal seem to shimmer with color, color that seems to change as the angle from which you are looking changes. Iridescence can occur in a couple of ways – diffraction through structural elements (like the scales of a butterfly wing or rod-like lattice of a peacock feather), or when light travels through a thin film. When white light strikes a thin, transparent film, some of the light reflects off the top surface of the film and some of the light reflects off the bottom surface (Figure 1). Light striking the thin film is separated, combined, then reflected, but the wavelengths coming from the top versus bottom may **interfere**, and may be in phase, or slightly off. As the waves travel through the film they interfere, or collide with each other, and a rainbow effect called iridescence is created (Figure 2). If the waves collide crest to crest, then they reinforce each other's impact, causing constructive interference and a brighter intensity. If the waves meet crest to trough, they cancel out each other's effect, and the result is destructive interference, and dimmer colors.

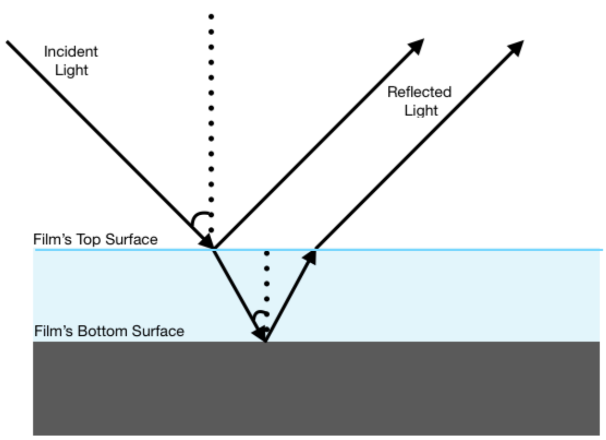


Figure 1. Thin films reflect and refract light.

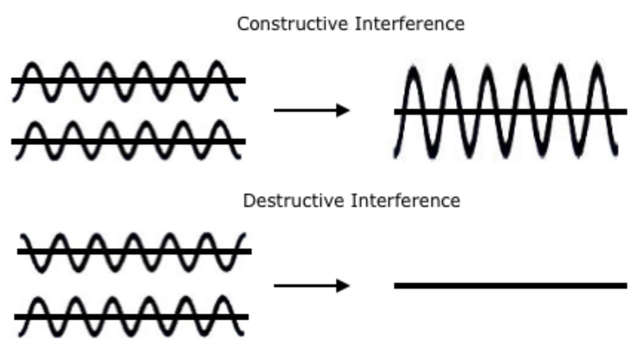
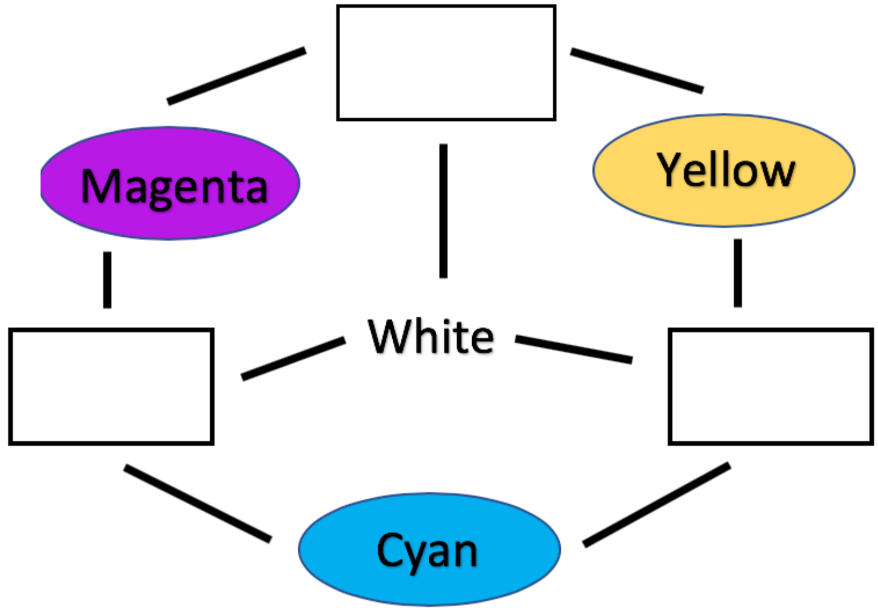


Figure 2. Constructive and/or destructive interference will occur when waves meet.

3. Do the Wave Graphing Exercise now – it is on a separate worksheet. It will help you to understand the relationship between amplitude and brightness as you calculate and plot the wave that results when two waves meet.

COLOR RULES
(“cheat sheet”)



Complementary Colors:

Cyan / ______________   Magenta / _______________   Yellow / ________________

Primary Colors of Pigment

___________ ___________ ___________

(all 3 in equal amounts = ____________________)

Mixing Primary Paint colors is done by

____

Example:

Magenta + Yellow = ___Red__
= RGB – G – B = Red
White light – Complement of Magenta – Complement of Yellow = **Red**

Cyan + Yellow = __________________

Cyan + Magenta = __________________

Primary Colors of Light

___________ ___________ ___________

(all 3 in equal amounts = ___________________)

Mixing Primary Light colors is done by

____

Example:

Red + Blue = Magenta
(look between Red and Blue on the Color Wheel)

Red + Green = ______________

Blue + Green = ______________

Making Thin Film Iridescence____

Activity 1: **We are going to make iridescent paper**, using a thin clear film to separate light. Do this first on a piece of black sandpaper.

Activity 2: **Now, let's do some experimenting.** We will use science practices to figure out what colors of iridescence we will find if we use different colors of paper as a base. Can you see a pattern?

Following the procedure, **make** thin film iridescence using red, blue, and green paper.

Then, **analyze** the patterns you see in your iridescent paper (fill in data table 3) and make a hypothesis.

Last, **predict**: what do you think the iridescence would look like on yellow paper?

Procedure: making iridescent paper

1. Take a plastic dishpan and fill it with about three inches of water.
2. Over the center of the pan let one drop of clear nail polish fall onto the water.
3. Wait about 30 seconds.
4. Put a 3x3 inch piece of paper into the pan, SLOWLY sliding it at an angle DEEP under the nail polish film, then lift it by one corner to catch the film on the paper.
5. After you have done steps 2-4 several times you will need a small aquarium net to remove excess film from your water, then keep on going.
6. Let paper dry overnight (hang it, or place it on a paper plate or paper towel).
7. Once dry, the paper can be used in your art project by simply cutting out the shapes and sizes you need.
8. After making thin film iridescent paper using red, blue, and green paper, fill out your data table and analyze the patterns you see.
9. Next make a hypothesis to explain your pattern.
10. Last, **predict** – If your pattern, or hypothesis, is true, what do you think the iridescence would look like if you used **yellow** paper?

Hypothesis:

Prediction: what do you think the iridescence would look like if you used **yellow** paper?

Was your Hypothesis supported? ____________________________________

Paper Color (is reflected)	Complimentary Color (is absorbed)	Colors you saw a LOT of in iridescence	Colors you saw only a little of / none of in iridescence
Red			
Blue			
Green			
Yellow			

Table 2. Students hypothesized that each specific paper color will absorb its complimentary color when white light (RGB) shines on the paper. Students then test the prediction for yellow paper by making thin films with nail polish.

DAY 3 - The Art Project

Think of an iridescent animal you would like to create in the next class. You can fold a shape to use as a base, or use origami to make a three-dimensional model to which you will glue iridescent paper, or you can glue or tape iridescent paper to a two-dimensional drawing.

What is your animal? ____

What colors are you trying to achieve? ____

Sketch your animal below, then make enough iridescent paper in the colors you need for your project.