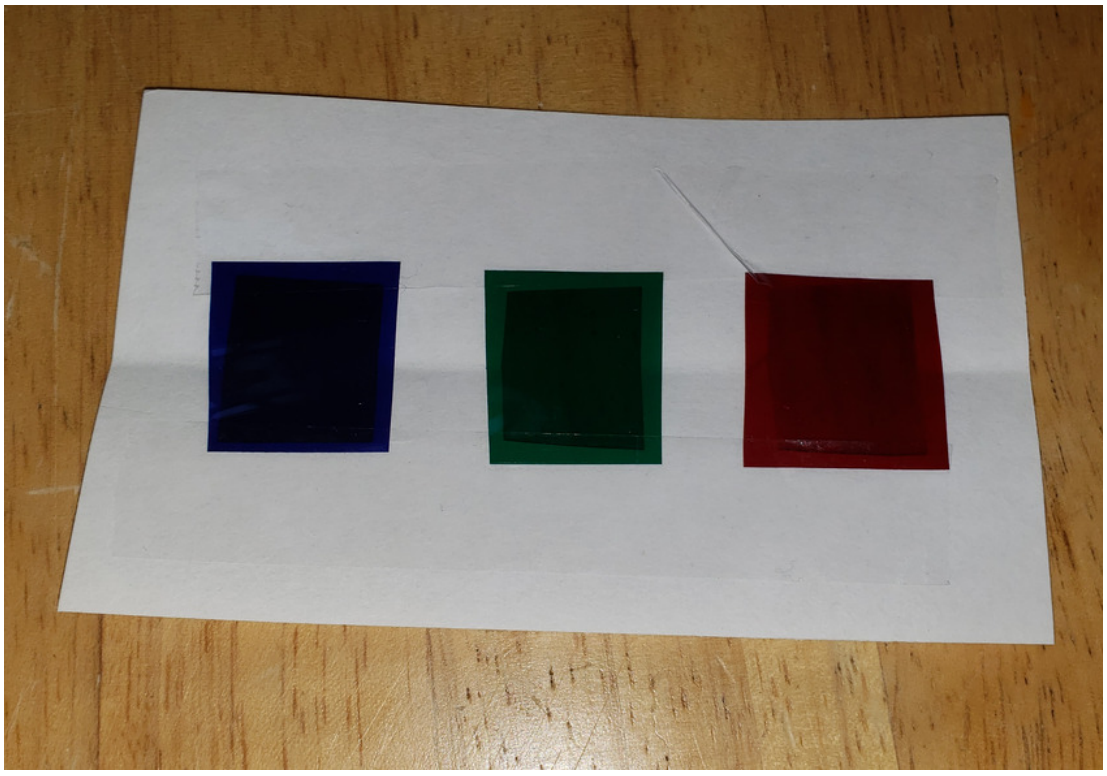
Teacher Prep

Before class, prepare the red, green, and blue gels for students.

- Cut each color filter material into 1"x 1" squares. We recommend using a 1" punch (you can pick one up on Amazon or at your local craft store).
  - We recommend these products for the filter material:
    - All available at www.stagelightingstore.com
      - GamColor Medium Red or Roscoe Medium Red
      - GamColor Grass Green or Roscoe Chroma Green
      - GamColor Primary Blue or Roscoe Primary Blue



Color Filters

Make sure you have access to the slides in Google Drive before beginning this reading.

When astrophysicists look at astronomical objects in space, they use different filters to figure out what they are made of. They have special cameras with filter options, sort of like Snapchat or the camera on your phone. These filters work by removing a certain type of light. Astrophysicists use the filters in the camera to take images of different astrological objects, like stars or planets.

Astrophysicists use the basic principles of light emission to study stars. For example, different gasses, like hydrogen or nitrogen, emit different colors of light. The emission of light is based on what the object is made of. Because certain gasses only give off certain kinds of light, astrophysicists can determine what an astrological object is made of depending on the type of light it emits. For example, if a cloud of gas in space is giving off red light, it might be made of hydrogen gas. Objects appear as different colors because of the way that our eyes see light. When we look at things in the world, like grass or a T-shirt, the naked eye sees the light that is reflected off of the object. The term "naked eye" describes our eye alone, with no telescopes or filters changing the way that our eye sees the light.

After our eyes see the light, the information travels through neural pathways to our brains. Our brains are responsible for interpreting what our eyes see and naming it as a specific color. Our eyes can only detect three colors: red, green, and blue. [Pic from slide #1] These are technically the only colors that we can "see". However, our brain processes the information that is sent by the eye, and mixes the red, green, and blue light to create all the colors of the rainbow! [Pics on slide #2 and #3]

Here's an example: When we see a yellow raincoat, yellow light reflects off the raincoat and enters our eyes. The light stimulates both the red detector and the green detector in our eyes and sends a message to our brain. Our brain mixes the red and the green colors together so that we see yellow light reflecting of the raincoat!

Filters can be used to block the transmission of a certain color of light from the object to our eyes. This prevents our eyes from seeing this certain color of light! Filters are often built into cameras and phones, but we can also create physical filters with transparent filters. A physical filter is a transparent material that absorbs some colors and allows others to pass through.

Here's an example: Looking at the white slide with blue, green, and red. (Slide #4)
Look at the picture using a piece of transparent blue plastic (also called a blue gel).

- Only blue light reflected off the blue ink can pass through the blue filter.
- Red light reflected off the red ink is absorbed (or blocked) by the blue filter, so red ink in the picture appears black.
- You are unable to see blue ink through the blue filter, because you cannot distinguish its reflected blue light from the white background (which also appears blue through the blue filter).

Now look at the slide using a red gel.

Flip through slides 5-8 and try looking at each picture through your different filters.

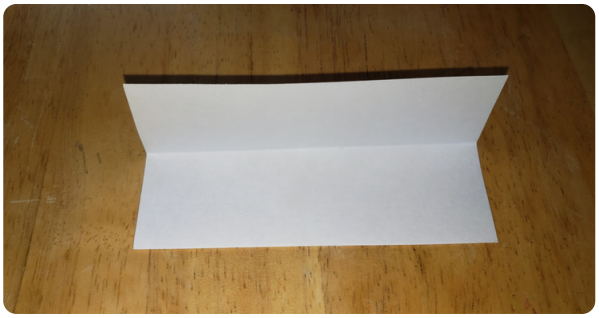
Experimenting with Color Filters

Follow the steps below to create a color filter and determine which colors you can see!

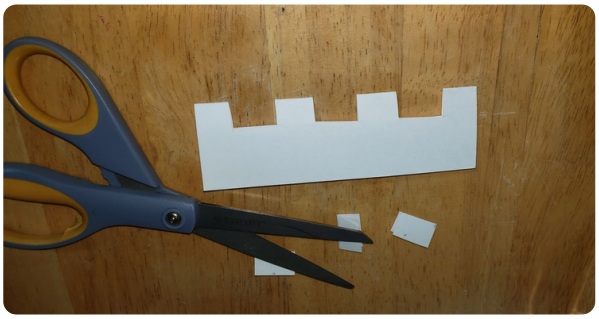
Step One: Build Color Filters

Follow the steps below to assemble your color filters.

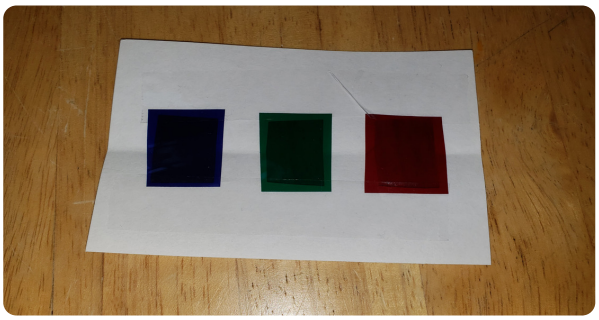
- Fold the index card in half length-wise. (AKA: Hot-dog style!)



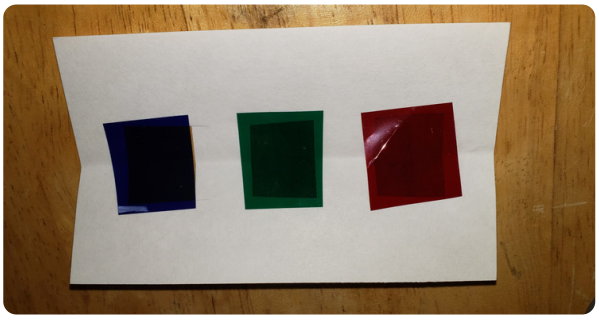
- Cut small squares in the index card where you can tape your color filters. The holes that you create should be smaller than 1 inch by 1 inch.



- Unfold the index card—you should have three square shaped holes in the middle of your index card.
- Place the gel squares over the holes that you cut out.
- Place the red gel on the left, green in the middle, and blue on the right.



- Use clear tape to tape the gels in place.
- Tip: As long as you are using clear (not frosty) tape, it doesn't matter if the tape covers part of the filter material that is covering the hole.



Astrophotography Analysis

Step Two: Make Observations

Follow the steps below to observe objects around you using your gels.

- Look at the people and objects around you through the different colors on your filter.
- Compare what you see through the filter to what you see with your naked eye.
  - Don't forget, "naked eye" means your eye without any filters.
- Flip through slides 4-8 on the google drive link and look at each picture through each lens.
- With your group, make note of the colors that you can see the best through each color filter. For example, when you are looking through the red filter, things that are red look red and things that are white look red. But things that are blue or green look grey or black!

Filter Color	Notes About How I See
Red	
Blue	
Green	

Astrophotography Analysis

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Step Three: Learn the "Rules" for Each Filter

- Look at the slides 9 and 10 in the google doc that your teacher provides to learn the rules of each filter.
- Write the rules below:

Rules for a Black Background	Rules for a White Background
Example: On a black background, I can see red with the red filter, but I can't see red with the other color filters. Blue and green do not show, but I can see white.	Example: On a white background, the red filter turns the background red. The red font blends in with the background. Blue, green, and black all appear black.

Observing Astronomical Objects

Follow the steps below to use your color filters to observe astronomical objects!

Step One: Observing the Crab Nebula

- Access the image of the Crab Nebula on slide 11 of the google drive document.
- Use your naked eye to look at the image of the Crab Nebula. The Crab Nebula is a colorful cloud of gas that was a star long ago.
    - Over 3000 years ago, ancient Native Americans and Chinese astronomers saw the light from the exploding star for several months. The light was so bright that it was even visible during the day.
    - The Crab Nebula really went supernova (exploded) 9500 years ago. Since the Crab Nebula is about 6500 light years away, the light that people on Earth see left the Crab Nebula 6500 years ago. People on Earth saw the light of the exploding star 3000 years ago, 6500 years after the actual explosion.
    - Today, the Crab Nebula looks like a fuzzy light on very dark nights. When astrophysicists use powerful telescopes, they can see that the colorful gasses are still expanding.
    - This image combines the light that can come through a red, green and blue filter. This is called an RGB image.
- Look at the image through your red filter. The shapes that you see through this filter are pockets of hydrogen gas! Even after 3,000 years, the hydrogen gas is still flowing out from the center.
- Look at the image through your blue filter. You can see the light blue core of the nebula where electrons are moving super fast and giving off radiation in the form of blue light.
- Look at the image through your green filter. You can see the green light that shows singly ionized sulfur that was produced when the nebula first exploded 9500 years ago.
- Astronomers can also use filters that help our eyes see types of light that our eyes cannot normally detect.
    - One example is x-ray filters. Our eyes cannot detect x-rays, but special filters can be used to help our eyes see x-rays.
    - Look at slide 12 on google doc. This image was taken using an x-ray filter.
    - The center of the Crab Nebula is generating x-ray radiation that is invisible to the naked eye!

Step Two: Find Your Own Astronomical Objects Online

Follow the steps below to research astronomical objects online and discover what they are made of using your color filters!

- Find other astronomical images online. Look on sites such as:
    - Hubble Images
    - NASA Picture of the Day
    - Center of the Milky Way Galaxy
- Use your color filters and the information given about each image to describe what your astronomical object is made of.

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Astronomical Object Name	Description	Notes

NASA's Micro-Observatory

Follow the steps below to take photos of and analyze an astronomical object using NASA's Micro-Observatory!

Step One: Take Your Own Photos of Astronomical Objects

Follow the steps below to take photos of an astronomical object using NASA's Micro-Observatory!

- Go to NASA's Microbservatory to take your own images of astronomical objects. To do this:
  - Go to https://mo-www.cfa.harvard.edu/MicroObservatory/ (or google "MicroObservatory").
  - Click on Observing With NASA.
  - Click on Control Telescope.
  - Choose a Nebulae or Galaxy to take an image by clicking on it.
  - Choose the Field of View and Exposure time, the program will help you make the best choices.
  - For Filter Selection, choose Multiple Filters so that you can create a color image. NASA telescopes will take 3 images of the object that you chose using three different filters; red, green and blue.
  - Enter your contact information so you can receive an email with your astronomical object.
  - It will take one or two days for a NASA telescope to take your image and send it to your email address.
- If there is time, go back and take images of several other astronomical objects.

Step Two: Analyze Your Images

Follow the steps below to analyze the images you received from NASA.

- When you receive your email form MicroObservatory, click on the links to see your image online. These images look black and white, but one of them was taken using a red filter, one was taken using a green filter and one was taken using a blue filter.
- Determine where your astronomical object is in your image. The telescope doesn't always put the image right in the center. Look at all 3 images. Your object might not look like more than a smudge!
- Determine which image was taken with which filter.
  - Compare the images you have to a colored image of the same object. A good place to look is Wikipedia!
- Use your color filter to help you compare the red, green and blue filter images you took to the colored image.
- Start with your red filter image. To do this:
  - Look at the Red Filter image.
  - Look at the image with your naked eye. It looks black and white.
    - This is the part of the astronomical object that is giving off red light.
  - Look at the Red Filter image through your red filter.
    - The parts of the image that looked white without the filter now look red.
  - Look at the colored image you found online with your naked eye. Compare the places that you see red in this image with what you saw in the Red Filter image.
    - Does it seem like there is a little bit less red in the colored image? This is because some of the red light you saw in the Red Filter image comes from white light. These areas look white instead of red in the colored image.
  - Look at the colored image you found online with your red filter. Compare the places that you see red using the filter to what you saw in the Red Filter image.
    - Does it seem almost the same? It should!
    - All of the places on the image that have red light in them should show red light in both images. Your red filter usually works very well, so most of what you see through your red filter should match the Red Filter NASA image.

- Repeat this process with the green and blue filters. Don't forget that your red filter usually works the best, green and blue don't work as well. But NASA telescopes have much better quality filters so the Green and Blue Filter images are good at showing the correct colors. Because of this some of your results looking through your green and blue filters may not be a little different than the NASA images.
- If you want to create your own 3 color images, go to the How to Create a Simple RGB Image tutorial (on the Tools & Tutorials page of NASA's Microbservatory.)
- Look up information about your astronomical object. Use this information to explain the colors that you can see in the Multiple Filter images and each of the Red, Green and Blue Filter images.