



# Science in School

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*Image courtesy Amit Lahav/Unsplash*

## Colour science with lasers, gummy bears, and rainbows

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Shine a light on the science of colour: create and combine rainbows and explore how colours arise through reflection, absorption, and transmission.

### Introduction

In this article, three activities are presented to help engage students with the concept of **colour**: how light interacts with objects and why colours appear as they do.

In Activity 1, students will create a rainbow from white light through refraction. Activity 2 demonstrates the reverse process: how to combine the seven colours of the rainbow to

produce white. In Activity 3, students will have the chance to investigate how light interacts with coloured objects – something that is important in nature, scientific research, and medicine. For instance, the green colour of leaves emerges as chlorophyll absorbs orange–red and violet–blue colours for photosynthesis, while reflecting green. Moreover, subtle changes in blood colour are indicative of how much oxygen it contains, a principle leveraged by devices such as pulse oximeters, which are routinely used in hospitals.<sup>[1]</sup>

## Activity 1: Make your own rainbow

Isaac Newton demonstrated that white light could be separated into a spectrum of colours (wavelengths) with a prism, just as raindrops in the sky act like tiny prisms, dispersing white light to form a rainbow.

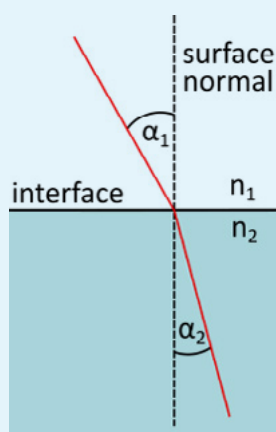
This discovery also laid the foundation for understanding refraction. When light travels at an angle from one material (air) to another (glass or water), it undergoes a change in direction, known as refraction, which is described by [Snell's law](#). Moreover, materials have different refractive indices ( $n$ ) for different colours; therefore, each colour of light is refracted in a slightly different direction (angle). Shorter wavelengths experience a greater change in direction than longer wavelengths.

### Snell's law

Snell's law states that light travelling from one medium  $n_1$  at angle  $\alpha_1$  (incidence angle) to the surface normal will change direction (angle of refraction  $\alpha_2$ ) in medium  $n_2$  in a way that

$$\frac{\sin \alpha_1}{\sin \alpha_2} = \frac{n_2}{n_1}$$

In other words, when light enters a medium with higher  $n$ , it refracts closer to the normal, and when light enters a medium with lower  $n$ , it refracts away from the surface normal.



Refractive index  $n$  determines the speed of light in the medium. The velocity of light  $v$  is

$$v = \frac{c}{n}$$

where  $c$  is the speed of light in a vacuum ( $n=1$ ).

Snell's law is therefore also a consequence of [Fermat's principle](#), in which light travels along the path that takes the shortest time.

Here, we propose to use a square transparent container filled with water as the prism. This modification of the traditional prism experiment enables easy replication in schools and at home, where glass prisms may not be readily available. Even though the container wall causes additional interface

where light is refracted, since the refractive indices of plastic and water are similar and the walls are thin compared to the volume of water light passes through, the effect of the plastic wall can be safely neglected. While aligning the setup may pose a slight challenge due to the limited acceptance angles of the rectangular container, this provides an opportunity to showcase total internal reflection. At larger incidence angles, blue does not refract out of the water container but undergoes reflection at the container/air interface.

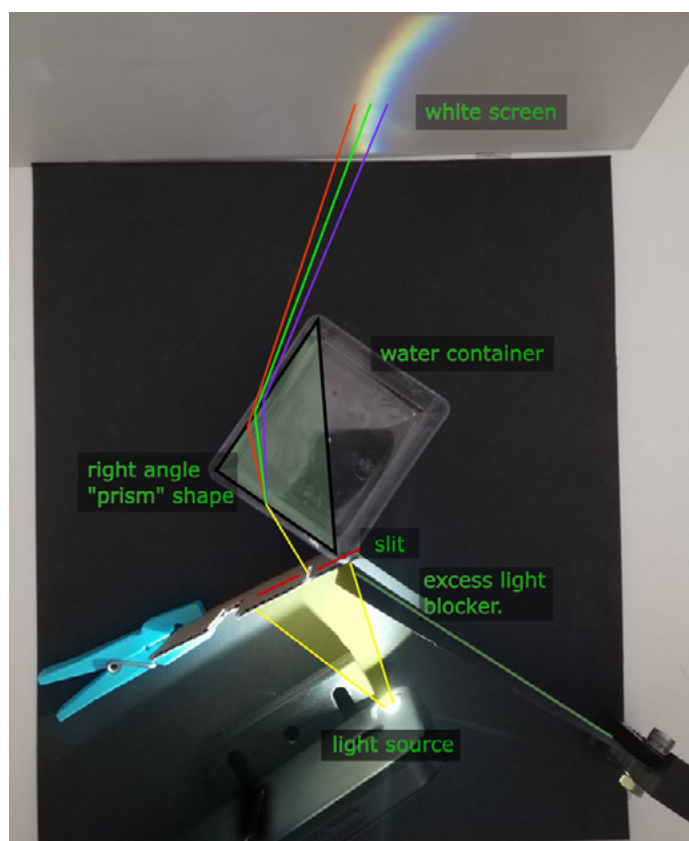


Figure 1: Overview of the setup. A white-light source, in this case a mobile phone torch, is spatially filtered by a slit to form a narrow parallel beam. The walls of the water-filled container act as a prism, and thus, white light is separated into its spectrum, which is then imaged on the white screen.

*Image courtesy of the authors*

This activity is suitable for students aged 11–14 or younger, and takes 30 minutes to an hour.

## Materials

- White A4 paper sheet
- Cardboard
- White-light torch (mobile phone)
- Scissors
- Square transparent plastic/glass container
- Water
- Colourful transparent plastic sheets

## Procedure

1. Cut a slit in the cardboard 1–2 mm wide and 5 cm long. For step 7b, you will need a second slit that is 5 mm wide. It can be in a separate piece of cardboard, even though figure 1 shows both slits in a single sheet.
2. Fill the plastic container with water (as an alternative to a glass prism).
3. Place the torch, slit, and prism in a line, so that light goes through the two neighbouring sides of the water container (figure 1).
4. Follow the light that comes out of the prism and place a piece of white paper (with a standing support or on a wall) to see the rainbow.
5. Try to find the optimal position where the rainbow is most visible.
6. Ask students why the light splits into a rainbow when passing through the container. Discuss and explain the results.
7. Play with the setup and discuss what happens when students:
  - a. Remove the slit. Ask students why we need it.
  - b. Change the slit width.
  - c. Rotate the prism/container.
8. Cover half of the slit with a colourful transparent sheet (figure 1). Ask students what they see on the white screen. Get students to explain what is happening.

## Expected results and discussion

When white light travels through the slit and prism, the colour spectrum should be visible on the white screen. The slit helps increase the separation between the colours of the rainbow because each point across the slit acts as a light source, resulting in a laterally shifted rainbow. If the slit is too wide, the overlapping rainbows will cause a blurry appearance. On the other hand, a narrower slit can decrease the contrast, so a compromise is necessary. If you increase the incidence angle of the white-light source, you will see a wider separation of the colours. If you increase the distance from the prism to the screen, you will see a better colour separation, but the intensity is lower.

Our simple spectrometer simulation is available here: <http://palec.eu.pythonanywhere.com/demo/009>.

## Activity 2: Make a rainbow disappear

In this activity, students make their own Newton disc, which is a simple device that demonstrates the phenomenon of colour mixing.

The Newton disc consists of a circular cardboard or paper disc divided into seven coloured segments, typically in the order of the colours of the rainbow, which is spun to visually combine the colours to white. This offers an engaging way for students to understand the relationship between white and the colours of the rainbow.

This activity is suitable for students aged 11–14 or younger, and takes 1–1.5 hours.

## Materials

- White A4 paper sheet
- Coloured pencils
- Scissors
- A4 cardboard sheet
- String

## Procedure

Ask students to follow the instructions below or use the [Activity 2 worksheet](#).

1. Draw a circle on the A4 paper sheet and divide it into seven equal slices.
2. Paint the segments of the disc with the colours of the rainbow in the following order: red, orange, yellow, green, blue, indigo, and violet.
3. Glue the painted sheet onto the cardboard and cut out the circle using scissors.
4. Create two holes 1 cm apart near the centre of the disc.
5. Thread a piece of string through the holes and tie a knot to form a loop.
6. Place a finger into each end of the loop and [flip the disc multiple times](#) over the string until the string is thoroughly twisted (Figure 2).
7. Pull your hands apart to spin the disc.



Figure 2: The strings twisted together before spinning  
Image courtesy of Tamaryin Godinho

## Expected results and discussion

When the disc is spun rapidly, the colours appear to merge and create the perception of white or a light shade of grey (Figure 3). The [Newton disc phenomenon](#) is due to the way our eyes and brain process colour information. When the disc spins rapidly, the colours reach our eyes too fast to be differentiated and our brain perceives the combination of these colours as white. So, it's not strictly the light that is being mixed in this case, but the signals from our eyes. The mesmerising effect of the Newton disc will leave students surprised, as if they were witnessing a magic trick!

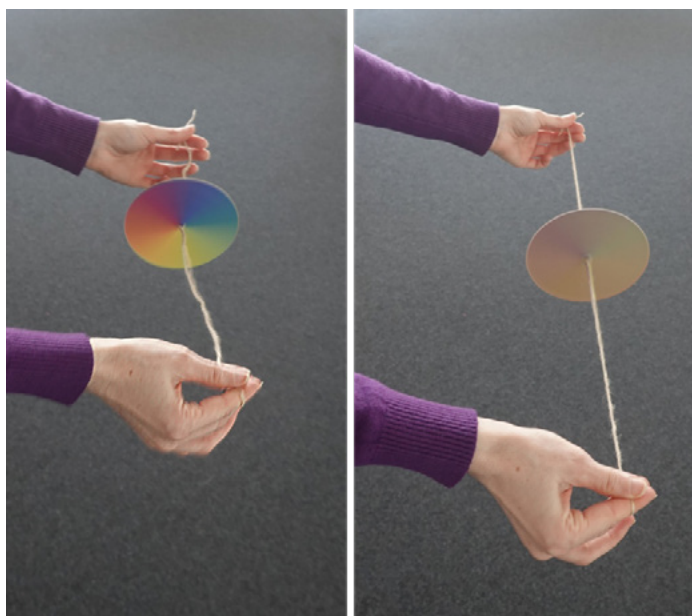


Figure 3: As the spin speed increases, the colours seem to mix to white.

Image courtesy of Maria Paola Pisano

## Activity 3: Lasers and gummy bears

In this activity, students learn that the colour of an object is determined by how it interacts with light – by either reflecting or transmitting certain colours – and thus, colour carries information about the properties of objects. This activity engages students by linking scientific principles to the real-world example of gummy sweets, making science concepts deliciously fun and memorable.

This activity is suitable for students aged 11–14 or younger, and takes 1–1.5 hours.



## Safety note

This activity is safe under following conditions:



1. Only class II laser pointers should be used. By definition, these have less than 1 mW output power and only emit in the visible range. Class II lasers do not cause damage unless the beam is directly stared into.
2. Lasers should only be handled by the teacher, and no one should stand in front of the laser.
3. Natural blinking instinct, or sight shifting, avoids any risk of eye damage.
4. Prioritise safety at all times. Lasers should be acquired from a legitimate and certified manufacturer. If in doubt, assume the laser is more hazardous than the label or marketing materials indicate.
5. Use smooth gummy sweets to avoid reflection off sugar crystals.

Students should not eat the gummy sweets used in experiments. However, feel free to have extra packets of gummy bears to share with your students!

## Materials

- Red and green gummy bears and other gummy sweets of different shapes and colours (e.g., two-coloured red and green gummy sweets, such as gummy worms or strawberries)
- Red laser
- Green laser
- Torch (white light)
- Lego bricks
- Glass microscope slides (to make it very scientific)



Figure 4: Materials used in Activity 3: white-light torch, red and green laser pointers, red and green gummy bears, and two-coloured gummy sweets. Gummy bears and other sweets are placed on glass slides supported by Lego bricks.

Image courtesy of the authors

## Procedure

1. Place four or more red gummy bears side by side on the glass slide, which is lifted off the table using a small block (e.g., Lego brick; figure 4). Repeat for green and colour-free gummy bears.
2. Place a two-coloured gummy sweet, for example, a strawberry (red and green), on one of the slides. Repeat if you have other multicoloured gummy sweets or two gummy bears of different colours, for example, yellow and red.
3. Shine white light at the green gummy bears from above (figure 5). Ask students to identify the colour of the shadows cast by the gummy bears and to explain why.
4. Repeat with the red gummy bears and then any other colours you have.
5. Ask students what they think will happen when you shine the green laser at the green gummy bears, from the side. Then, show them what happens by shining the green laser at the green gummy bears (figure 6).
6. Repeat the procedure described in step 5 using the green laser and red gummy bears.
7. Repeat steps 5 and 6 with the red laser.
8. Shine the green laser at the two-coloured gummy sweet from step 2, from the top, pointing at the green region and then at the red region (figure 7). Ask students to explain what they see.
9. Repeat step 9 with the red laser.



Figure 5: The shadows under red and yellow gummy bears when illuminated with white light

*Image courtesy of the authors*

## Expected results

When shining white light from above onto the green gummy bears, a silhouette or shadow appears beneath each bear. This shadow replicates the colour of the gummy bear itself. For instance, the shadow of the red gummy bear appears red because only red light is transmitted, while all other colours (wavelengths) are absorbed.

When green laser light is directed at the green gummy bears, it passes through, but red gummy bears do not let green light pass because they absorb all colours (wavelengths), except red. The opposite holds true for a red laser.

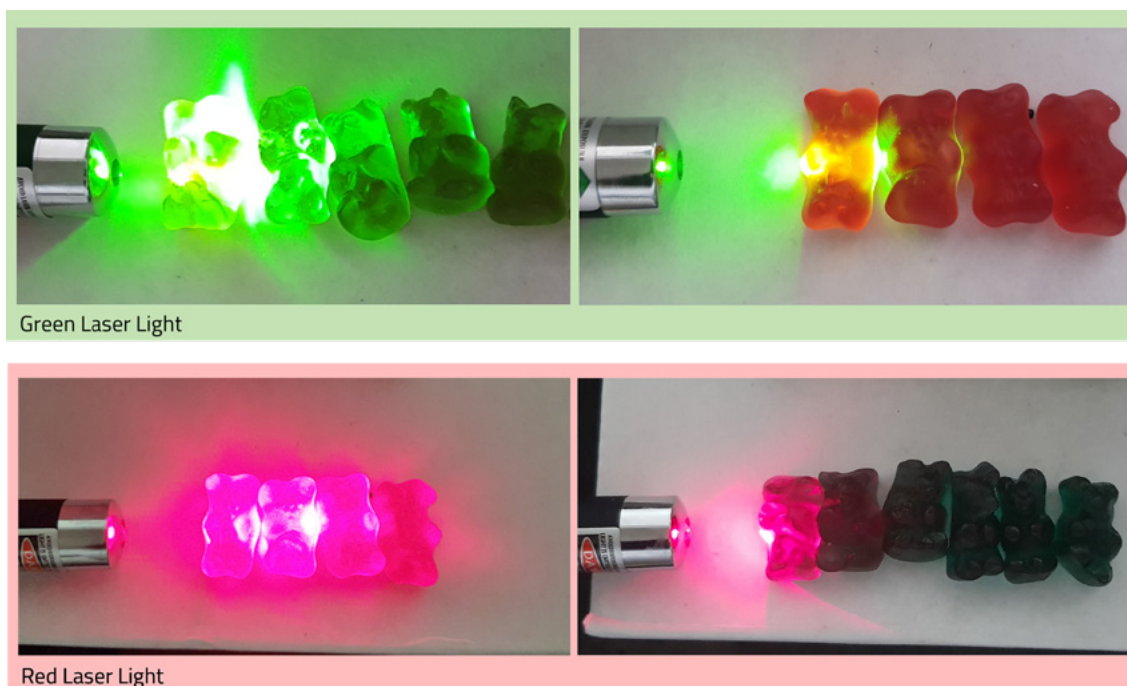


Figure 6: Green light passes through the green gummy bears, causing even the later ones in the row to glow. However, it is absorbed by the red gummy bears, which means that (nearly) no light passes through. Conversely, red light passes easily through the red gummy bears but not the green ones.

*Images courtesy of the authors*

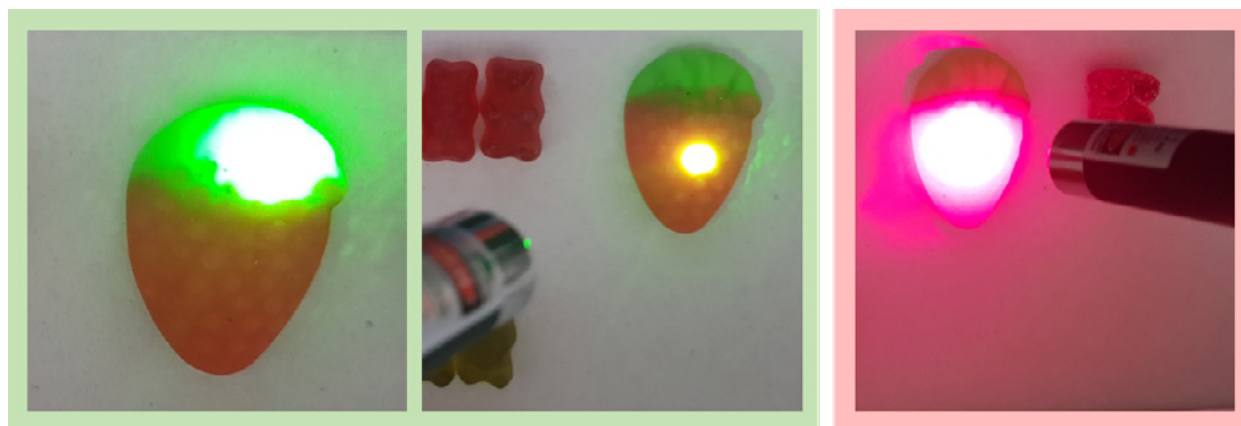


Figure 7: If you point the green laser at the green region of the two-colour gummy sweet, you will see the green light spreading through the green part of the sweet and a glow will be observed, but if you point it at the red region, this will not happen, as the light will be absorbed. The opposite holds for the red laser.

*Image courtesy of the authors*

Note that when green laser light is directed at the green gummy bears, for example, they exhibit a bright-green glow. The gummy bears have some level of translucency or scattering properties, which results in light being redirected in various directions within the gummy bear instead of travelling in a straight path, creating the impression that the gummy bear is glowing.

It is important to note that gummy bears are not perfectly transparent, so even gummy sweets of the same colour as the light will absorb some of it. Furthermore, the colours of gummy bears are typically achieved using food-colouring agents, and the colour may result from a combination of different food-dye colours. For example, some green gummy bears can be made with tartrazine (yellow), brilliant blue (blue), and strawberry flavour (red). Therefore, this type of gummy sweet may not be the ideal model green filter.

## Summary

These easy hands-on experiments using everyday objects will help students understand the different processes that can occur when light interacts with objects, including absorption, reflection, refraction, and transmission. Although the gummy bears do not show the same ideal model transmission/absorption behaviour as the transparent coloured sheets traditionally used for these classes, they provide a real-world hook to help capture students' imagination and encourage them to think about colours in the world around them and not just artificial experimental setups. The slightly different behaviour of the gummy sweets compared to textbook models is also an opportunity to discuss where the differences come from and all the different variables that can contribute to how objects interact with light. The learned

concepts have practical applications in various scientific fields and will promote critical thinking and spark interest in the world of science. <<

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## References

- [1] Chan ED, Chan MM, Chan MM (2013) [Pulse oximetry: understanding its basic principles facilitates appreciation of its limitations](#). *Respiratory Medicine* **107**: 789–799. doi: 10.1016/j.rmed.2013.02.004

## Resources

- Try [these simulators](#) to understand better how light changes direction when crossing different media.
- Learn more about the physiological basis of the [Newton’s disc phenomenon](#).

- Discover the ESO Supernova exhibition panels about [spectroscopy](#) and [filters](#).
- Read an introduction on the electromagnetic spectrum: Mignone C, Barnes R (2011) [More than meets the eye: the electromagnetic spectrum](#). *Science in School* **20**: 51–59.
- Use chromatography to explore the pigments that give leaves their colour: Tarragó-Celada J, Novell JMF (2019) [Colour, chlorophyll and chromatography](#). *Science in School* **47**: 41–45.
- Use a solar bottle bulb to demonstrate light refraction: Wegner C, Ohlberger S (2014) [Light refraction in primary education: the solar bottle bulb](#). *Science in School* **29**.
- Build your own spectrometer to explore the delights of colour: Westra MT (2007) [A fresh look at light: build your own spectrometer](#). *Science in School* **4**: 30–34.
- Turn a cheap webcam into an infrared camera: ESA Education (2022) [Infrared webcam hack – using infrared light to observe the world in a new way](#). *Science in School* **56**.

- Read about the colour blue in nature and the chemistry behind it: Bettucci O (2022) [Colour in nature: true blue](#). *Science in School* **60**.
- Learn about the environmental consequences of light pollution: Henshaw C (2022) [Too much of a good thing – the problem of light pollution](#). *Science in School* **56**.

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