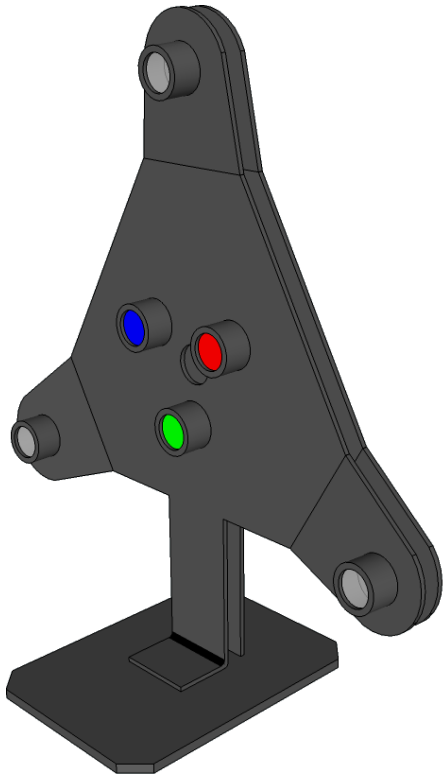
UNILAB® LED.mixer

NFU 730T

LED.mixer

The LED.mixer is a set of primary colour (red, green and blue) LEDs mounted on a sturdy upright base. It is designed to replace traditional ray-boxes and colour filters for traditional colour mixing experiments. It offers a number of advantages:

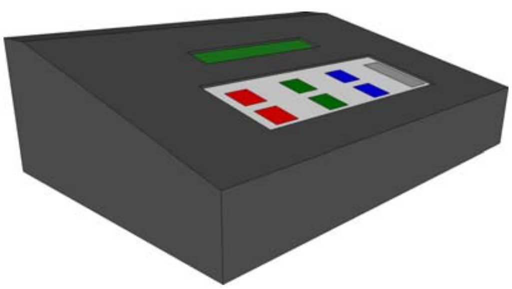
- All-in-one unit, with dedicated control box
- Low, fixed voltage power supply
- Low power – does not run hot
- Long life LEDs – at least 10,000 hours
- "True" colour light, unlike a colour filter
- Bright light – no need for complete blackout



Each LED has a lens that focuses the light into a broad circular beam, and is covered by a diffuser to ensure the spread of light is even.

An aperture screen is included that creates circles of light to be projected on to a screen or wall. These can be overlapped to demonstrate mixing of colours, and recreate the classic colour circles as seen in many textbooks.

A translucent white screen is also included for projecting images on to. It can be viewed from either side, so a demonstration can be performed in front of a large audience circled around the apparatus.

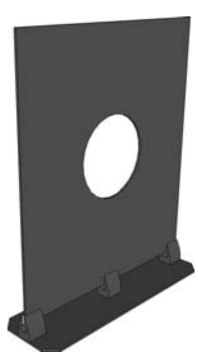


The brightness of each LED is controlled with colour-coded up ↑ and down ↓ buttons.

Precise control is provided, from 0-100% intensity, and an LCD screen shows the current setting for each LED.

The large grey button switches between inner and outer LEDs.

The translucent white screen.



The aperture screen.

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Safety

The LED.mixer should be used under the supervision of a qualified teacher, and with the plugtop power supply provided. A risk assessment is recommended before use.

The LEDs in the product are “ultra bright”. Do not look directly at the LEDs at close range when they are turned on. Do not stare at any bright light source.

When working in low ambient light levels, extra caution should be taken. Advise pupils not to stare at the LEDs. Try to keep experiment times to a minimum. An audience to an experiment should be at least a metre away from the source.

UNILAB can not accept responsibility for injury or damage caused by misuse of the LED.mixer.

Basic Operation

The LED.mixer is supplied with a 5V 1A regulated plug-top power supply. Only this power supply should be used with the device.

Plug the power supply into a mains socket, and insert the plug into the socket on the back of the control box. The mixer has a captive cable terminating in a D-type plug than goes into the control box.

By default, each LED will be set to 0% for safety, as students may be looking at the apparatus when they first plug it in.

The brightness of one can be turned up gradually by pushing the corresponding up button. Alternatively, full brightness can be achieved immediately by pressing the down ↓ button once when the display is showing 0%.

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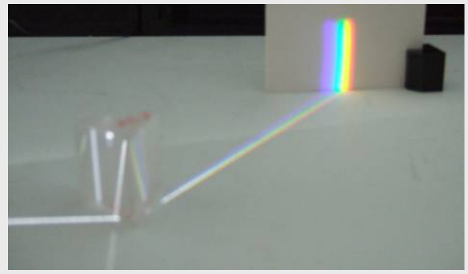
Seeing Colour

What colour is the paper this is printed on? (Or, if you are reading this on screen, what colour is the background of this text?) The answer is not "white" as most people would think, because white is *not* a colour. It is actually a mixture of all colours.



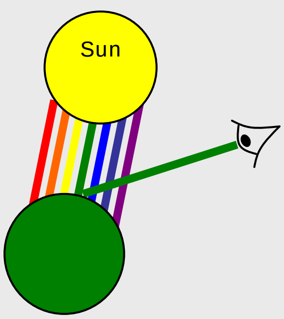
Using a ray of white light from an LED and a prism, it can be shown that white light is composed of all colours. This experiment can be done with the UNILAB LED.white.

What colour is this text? Again, most people would say "black", but black is not a colour, it is an absence of colour. Consider what colour things appear to be in the dark.

Paper, and other white objects, reflect all light that shines on them. If white light is shone upon it, then it will reflect it all.

Ink and other black objects absorb light, so no matter how much light is shone upon them, they will absorb it all, and appear black.

A coloured object absorbs some light, and reflects others. For example, a green ball reflects green, and absorbs all other colours. It is the reflected light that we see, so the ball appears green.



White light from the sun hits the green ball, and only the green light reflects into the eye.

It is possible to make almost any colour by mixing just three. These are called the **primary colours**, and are red, green and blue. We will show that using just these three colours at different intensities, we can produce any colour we want.

Colour Mixing

The term "colour mixing" is perhaps not appropriate, as the mixing of colour is nothing like the mixing of ingredients.

Different colours of light do not "combine" or interact with each other at any point, it is our perception that causes us to see a third colour where two colours meet.

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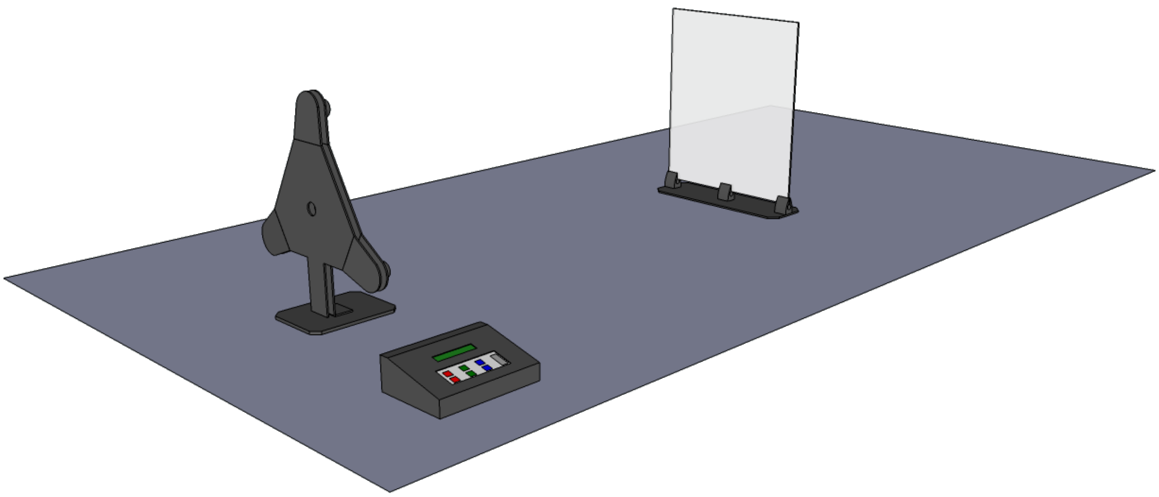
Basic Experiment

Tip: There is a circle cut out in the middle of the mixer. Inserting a finger through this hole makes the apparatus easy to pick up and adjust the position.

Setup the apparatus mixer so that it is facing the white screen. Plug the mixer into the control box, and plug in the power supply, but keep the LEDs at 0%.



Before starting, observe that the screen is white under normal light. We know from our previous discussion that white objects reflect all colours of light that hit them.

Now, darken the room, and increase the brightness of the **red** LED (it does not matter if it is the inner or outer LED). Observe that the screen now appears to be red. This is because there is only red light shining on it, and no other colour. If there is only red light shining on it, there is only red light to reflect, so it appears red.

Turn the red LED to 0%, and increase the brightness of the **green** LED. The screen now appears green for the same reason. Finally, try the same with the **blue** LED.

Now, try increasing the brightness of both the **red** and the **blue** LEDs. Look at the screen, then look at the lights on the mixer. You are shining red and blue light, but getting a third colour, called magenta. Mixing two primary colours together gives a secondary colour. Try blue and green, and you well get cyan, and try red and green, and you well get yellow.

Red	+	**Green**	=	**Yellow**
Red	+	**Blue**	=	**Magenta**
Green	+	**Blue**	=	**Cyan**

Finally, try turning all three LEDs on. Observe that the screen appears white. By mixing three primary colours, we can make light that *looks* white.

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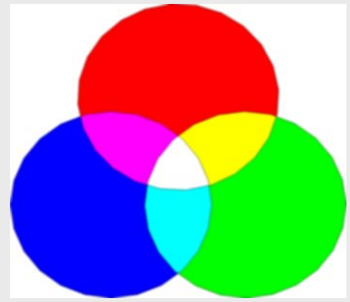
Classic Diagram

In many textbooks you will see the diagram of red, green and blue circles overlapping.

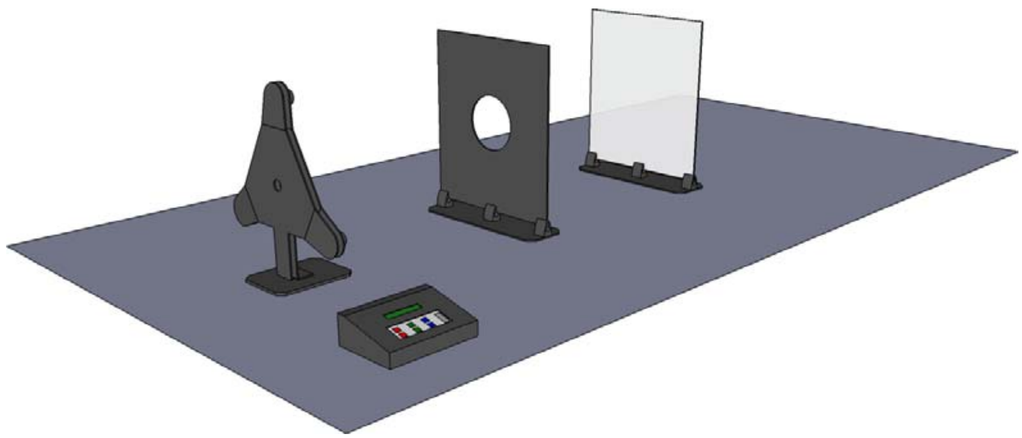
- Where red and green overlap, the area is yellow.
- Where red and blue overlap, the area is magenta.
- Where blue and green overlap, the area is cyan.
- Where all three overlap, the area is white.



Easy to make on paper or a computer screen. How close to reality is it?

This is all very well printed in a book, or even on a computer screen, but must be seen to be believed! With the LED.mixer, we can recreate this effect without "cheating" with inks.

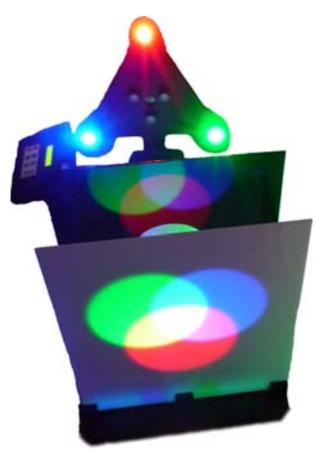
Set the apparatus as in the previous experiment, and place the circular aperture screen between the mixer and the white screen as illustrated.



The black aperture screen creates a narrow circular beam and a circle of light appears when one of the LEDs is turned on. Because the LEDs are in different positions, the circles appear in different positions on the white screen.

> **Tip**: The LED.mixer is bright enough for large scale demonstrations. Use a whiteboard instead of the white screen for a large class demonstration.

You can make the coloured circles of light overlap, similarly to the pattern above. You can adjust the position of the screens to alter the size of the circles.



You may find that, even though the LEDs are at the same brightness, the "white" centre may appear slightly pink or red. This is because the eye is more sensitive to red, so you may need to adjust the brightness of each colour slightly to achieve a convincingly white centre.

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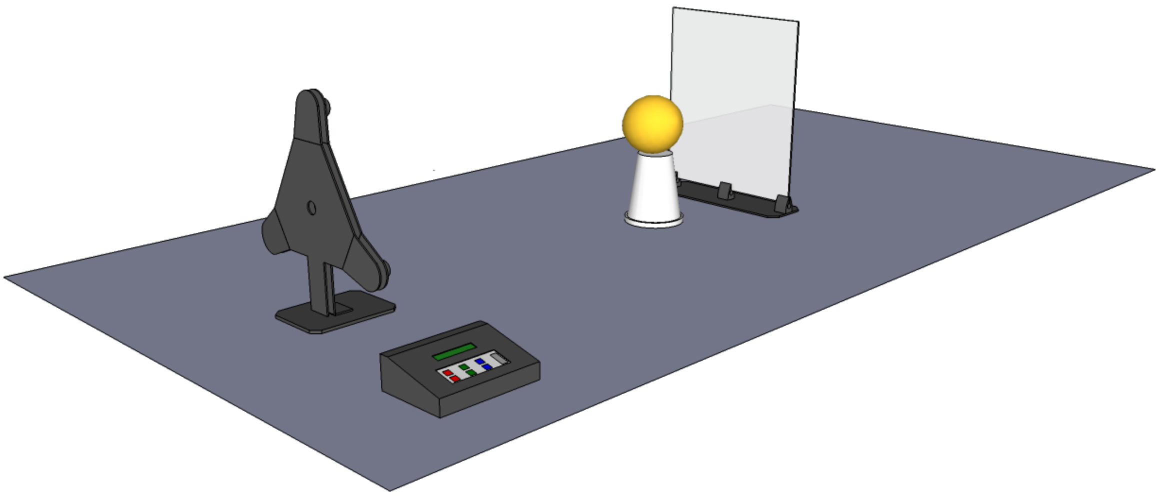
Turn a Lemon into a Lime (or a Satsuma)

Setup the mixer so that it is facing the white screen, and turn the inner or outer LEDs to maximum. Place a lemon in front of the white screen. If possible, lift it so that it is in the centre of the LED pattern, using something white like a polystyrene cup.



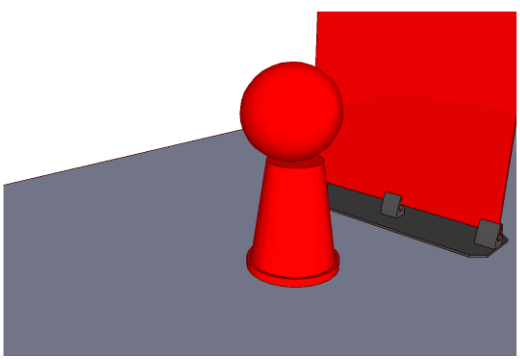
We have red, blue and green light shining on the lemon, and it appears yellow as we'd expect.

We know that we can make yellow light by mixing red light and green light, so the lemon must be reflecting red and green light and absorbing blue light. To demonstrate this turn off the blue LED – it should make little or no difference to the appearance of the lemon.

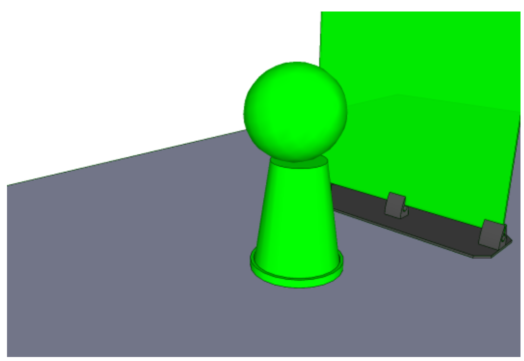
Now, turn the blue LED back to full brightness. Now, before turning off the green light, try to predict what will happen to the lemon.

If it is reflecting red and green light, but there is no green light to reflect, it will reflect only red light. Therefore it will look red or orange, resembling a Satsuma. Similarly, if the red LED is turned off, there will be only green light to reflect, making the lemon look like a lime.

The lemon is not a "perfect" yellow, so you will get colours close to red and green.



Satsuma: Green LED off



Lime: Red LED off

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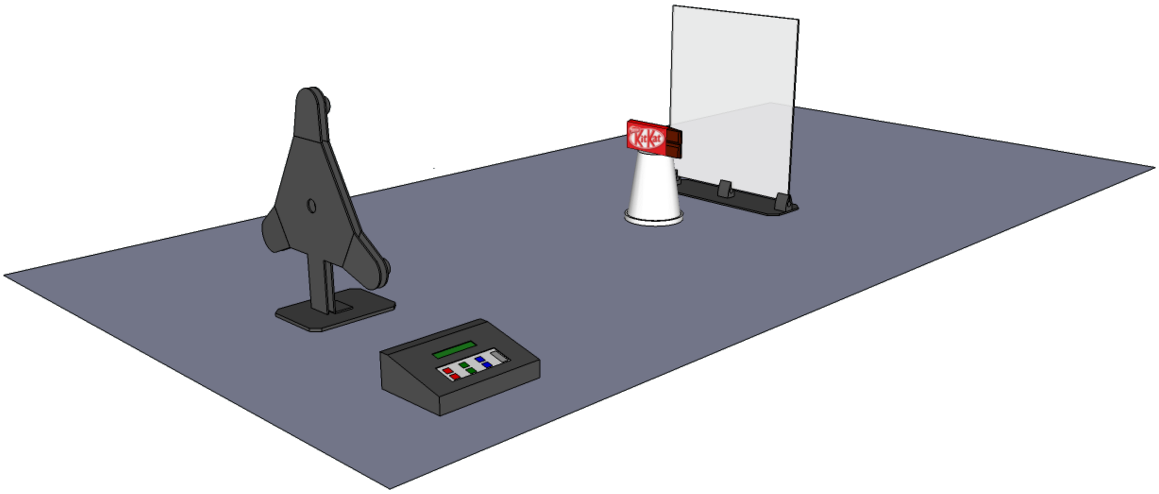
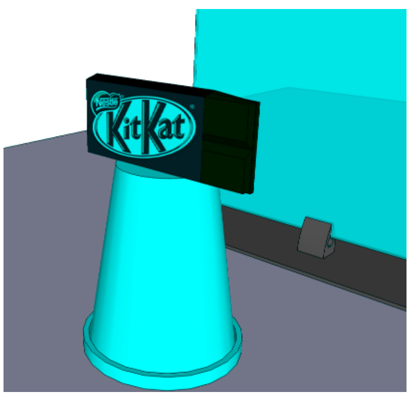
Disguising a KitKat

The setup is similar to the lemon experiment, but the lemon is replaced by a KitKat (still wrapped) or a Coca-Cola can.



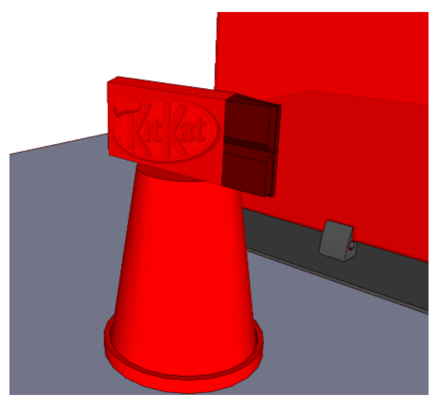
The wrapper or can is mostly red, with a white logo. The wrapper appears red because it reflects red light, whereas the logo appears white because it reflects all colours of light.



Turn the red light off. Now, the wrapper no longer has any red light to reflect, and is absorbing any other colour that shines upon it. The white reflects all colours that shine upon it. As it is receiving blue and green light, it will reflect only these, and so appear cyan.

The contrast between the black wrapper and the cyan logo will lead some to describe it as black and white.

Now turn the red LED back on, and turn the green and blue LEDs off. We know the white logo reflects any colour that shines on it, but as it is only receiving red light, this is all it can reflect. Therefore, the white logo will look identical to the red wrapper or can.

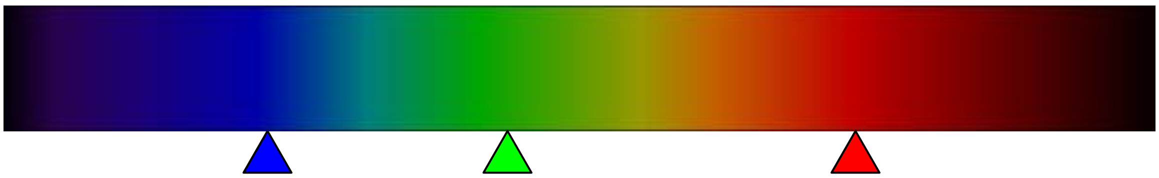


The KitKat wrapper and Coca-Cola cans are ideal because they are easy to obtain and their red is very close to the primary red used by the LED.mixer.

Primary Colours

The LED.mixer uses red, green and blue as primary colours, and thus makes cyan, magenta and yellow as secondary colours. However, there is nothing particularly special about any of these colours.

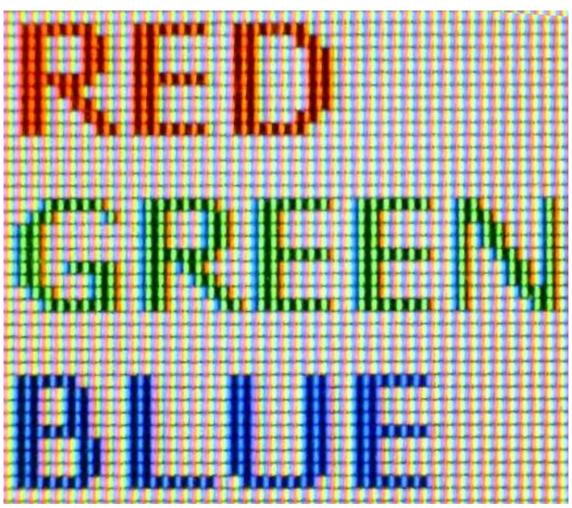
Red, green and blue are simply three colours chosen from the visual spectrum that happen to be able to produce most colours required, but there are colours in our range of vision that this system can not produce.



It has been shown, however, that the human eye is composed of cells sensitive to red, green and blue light that give it the ability to see colour.

Practical Applications

Using a 10x pocket magnifying glass, look at a television or computer screen. You will see that it is made up of many blue, green and red dots. Notice how when an area of the image is white, all three colours are lit up brightly. When there is a blue area, only the blue dots are lit. When there is a yellow area only the green and red dots are lit. TVs and computer screens are basically high resolution colour mixers.



A computer screen showing red, green and blue text on a white background. See how only one out of three dots is lit to make the text.

Cyan, magenta and yellow text on a white background. Note that two out of three dots are lit to produce the secondary coloured text.

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Colour Perception

Our eyes cannot tell the difference between truly yellow light, and a mix of green and red light. The only way to determine is to use an optical instrument, such as a glass prism or diffraction grating.

Thomas Young first proposed in 1802 that the eye is sensitive to three different colours. This is called **trichromacy** and it led to the development of colour photography.

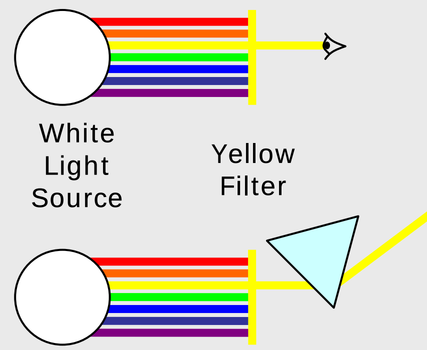
Three types of photosensitive cells, called **cone cells**, were thought to be sensitive to the three primary colours.

The existence of these cells, and the colours they are sensitive to, was demonstrated using individual cells in 1983, by observing the light reflected from a human retina (the light sensitive part of the eye).

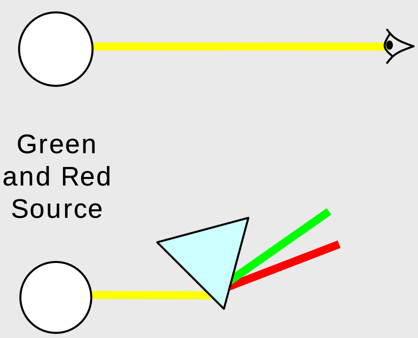
The three types of cones are:

- **L** - long – these respond to long wavelengths (red)
- **M** – medium – responding to medium wavelengths (green)
- **S** – short – responding to short wavelengths (blue)

When these cells absorb light of their preferred wavelength, they transmit an electrochemical signal to the brain, which interprets the signals as colour.



A yellow filter selects yellow light from a white light source. The eye perceives it as yellow, and it is not separated by the prism.



A source emits green and red light. The eye perceives it as yellow, but a prism separates the light into its red and green components.

The cone cells are not very sensitive to light, so the eye has another type of cell called a rod. These are not sensitive to a particular colour, but work well in low light conditions. That is why things appear to be in “black and white” when it is very dark.

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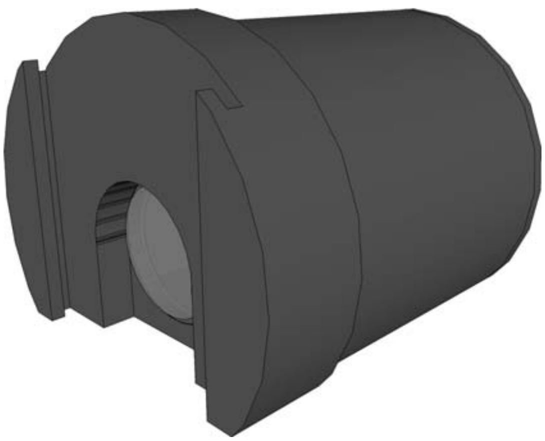
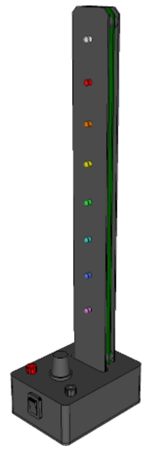
Other products in the UNILAB LED.range



LED.white F4L87348
An excellent replacement for the traditional ray box, with a better spectrum, longer life and cooler operation.



LED.line F4J73433

A robust and attractive device for exploring colour and the relationship between photon energy and wavelength.

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