Emitting and Reflecting Light

Figure 1 shows a black and white cat sitting on a table. We can see the cat and the table on which it is sitting because they *reflect light*. To appreciate what colours are, we need to understand the difference between objects that *produce light* and objects that reflect light.

Figure 1: A black and white cat.
(image credit: Hisashi, Wikimedia commons, CC 2.0
https://creativecommons.org/licenses/by-sa/2.0/deed.en)

In Figure 2, we can see the ceiling of a theatre as it is covered in special bulbs called LEDs that are *producing* light of different colours.

Figure 2: Coloured lights on the ceiling of The Capitol theatre in Melbourne.

Write a list showing five objects that *reflect light*. Try to think of objects that are a single colour and note down what the colour is.

Objects that reflect light	Colour
Important to include the Moon as an object that reflects sunlight. Other domestic objects are sensible.	

Now make a list of another five objects that *produce light* and say what colour they are as well.

Objects that reflect light	Colour
Important to include the Sun. Otherwise, domestic lights, mobile LEDs, fires, fireworks, etc.	

Flame tests

If you place a small sample of a material onto a *spatula* and hold it in a *Bunsen flame*, the flame above the spatula changes colour, depending on the material (it does not work for everything).

For example, *sodium* produces a *bright yellow flame*. Chemists can use *flame tests* like this to distinguish the materials present in a sample.

Objects that reflect light	Flame
Sodium	Bright yellow
Potassium	Lilac
Lithium	Red
Copper	Blue-green

The colour produced in the flame is often different from the colour of the sample. A lump of sodium is not bright yellow, nor is copper blue-green.

The colour of the sample comes from the light that *reflects* off its surface. The colour in the flame is produced by glowing atoms of the material, which have broken free of the surface and are being heated in the flame. This is another example of seeing something because it *produces* light (the flame) and seeing it as it *reflects* light (the sample).

An object has a certain colour as it reflects light in a specific pattern. If you warm up the object, it will start to glow. At first the glow will be a dull red colour, which gets brighter as the object warms up. If it does not catch fire or melt, eventually it will glow white hot. Warming the object up makes it emit light, which becomes brighter than the light it reflects, which is why it appears to change colour.

Why do you think that very hot objects glow white?

They are emitting a wide range of colours, which the eye interprets as white.
As an object warms up, so it emits a wider range of colours. A more advanced account incorporates the fact that the range of frequencies emitted moves from IR through to visible as the temperature rises. This should not be expected of the students in Year 8, but could be included if the context presents an opportunity or one of the students mentions it.

Rainbows again

Figure 3: A double rainbow as seen in Finland.

Figure 3 shows a rainbow. Do rainbows produce light or reflect light? Tick a box to show what you think:

Rainbows produce light ☒

Rainbows reflect light ☐

List the colours found in a rainbow, in order from bottom to top, as seen in Figure 3.

Order of colours in a rainbow::

Violet, indigo, blue, green, yellow, orange, red.

In the previous lesson, we learned that the different colours of light are different frequencies of light wave.

Add to your list of colours a note that reminds you that *red light* is *lower frequency* than *blue light*. The other colours in the rainbow are frequencies in between these two extremes.

Missing colours?

Thinking about the colours seen in Newton's experiment (previous lesson), and the colours of the rainbow, it seems as if some colours are missing. There is no black or white in the rainbow, for example. We know why white is not there (it is what we see when all the colours are travelling along together), and we need to think about black shortly. For the moment though, can you think of any other colours that are missing?

Colours missing in the rainbow:

Brown is the most obvious missing colour.

Students may include a range of colours (such as pink) that can be interpreted as shades.

Go back to your list of missing colours and cross off any colours that are really just *different shades* of the *same colour* (for example, pink is really just a shade of red). If it helps, look at Figure 5, which shows the full range of colours from a rainbow. Your list may now be shorter, but it should not be empty.

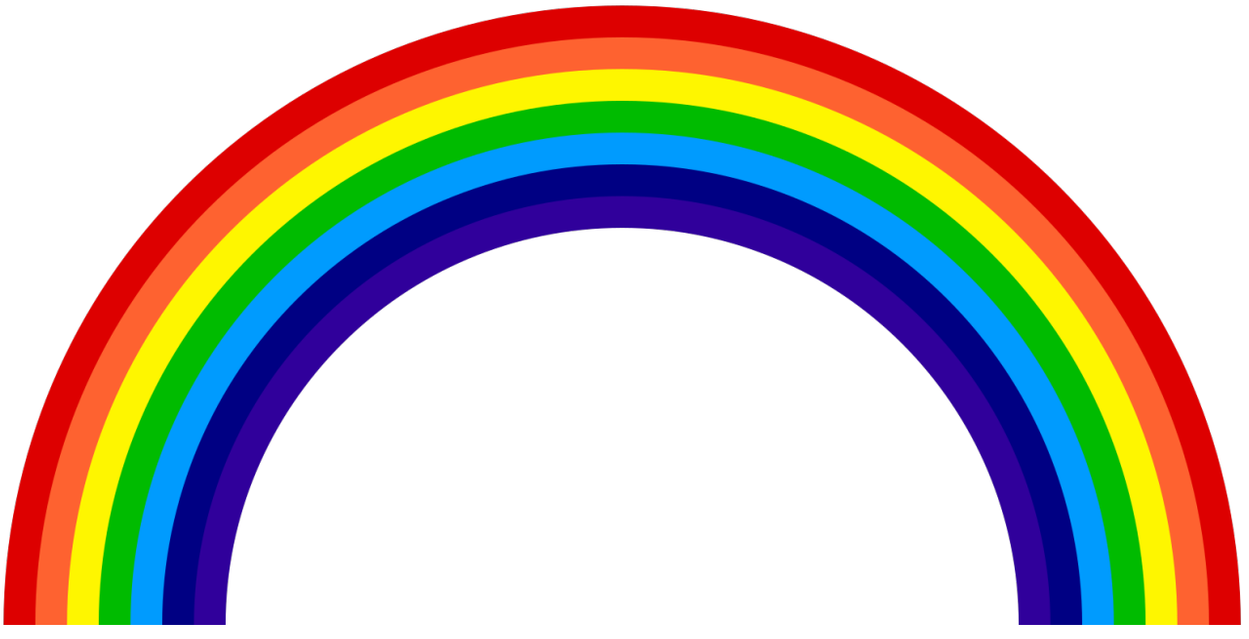

Figure 4: The colours in a rainbow.
(image credit Oren neu dag via wikkemdia commons CC 3.0 https://creativecommons.org/icenses/by/3.0/)

This is very important. Black is not in the rainbow and you never find a glowing object emitting 'black light'. On the other hand, you can have objects that are *white hot*.

If you think about the missing colours that you have written down, you should agree that:

- Objects that reflect light can have colours that are missing from the rainbow. Pieces of paper can be white, black or brown.
- You can have white light, but you can't have 'black light' or even brown light.

Remember that Newton's experiment shows us that white light is what we see when all the colours in the rainbow are travelling towards us together.

White is not a frequency of light, like red, blue, green and the other colours in the rainbow. In that sense, it is not a scientific colour. The fact that we see white when all the rainbow colours (different frequencies) are present is to do with the brain, not the light waves.

If an object is white, what colours do you think that it reflects?

All colours equally well.

If an object is black, what colours do you think that it reflects?

No colours are reflected from a truly black object.

Answer the questions below:

Is there a frequency of light that corresponds to black?

Yes ☐

No ☒

If a colour is missing from the rainbow, can there be a frequency of light that corresponds to that colour?

Yes ☐

No ☒

Do we ever see lights that look like the colours that are missing colours from the rainbow?

Yes ☒

No ☐

In the last lesson, we said that from a scientific perspective, colours are different frequencies of light. That idea is right, but there is more to it than that.

Clearly, we can see some colours that are not frequencies. We need to learn more about how the eye and the brain work in order to understand how we can see colours that are not in the rainbow.

Perhaps our other missing colours are actually somewhere between black and white: colours seen by the brain when there are different mixtures of frequencies present.

Lesson summary

- We see that an object is a certain colour because of the pattern of light that the object reflects.
- If we warm an object, it can change colour as now it is emitting more light than it is reflecting and the light that it emits can be different frequencies from the light it reflects.
- Some colours that we can see are not in the rainbow.
- If a colour is not in the rainbow, then there is no frequency of light corresponding to that colour.
- White light is actually all the frequencies of light together.
- An object looks white if it reflects all the colours of light.
- An object is black if it does not reflect any colours of light.
- The other missing colours are what we see when an object reflects some combination of colours.