Creating Science - Rainbows

Can you make new colours, or see the rainbow inside every light? ***#CreatingScienceMakingRainbows***

Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Physical sciences 1: Light and sound are produced by a range of sources and can be sensed.
- Physical sciences 5: Light from a source forms shadows and can be absorbed, reflected and refracted

Also:

- Realise light travels in straight lines.
- Learn that rainbows aren't bows – they are circles.
- Learn that white light is made up of the rainbow colours.
- That pink is NOT a colour of the rainbow!

Science inquiry skills

- Planning and conducting 3: Participate in guided investigations to explore and answer questions (ACSIS025)

Science as a human endeavour

- Nature and development of science 7: Scientific knowledge has changed people's understanding of the world and is refined as new evidence becomes available (ACSHE119)

Cross curricular outcomes

Visual arts

- Content outcomes year 3: Use materials, techniques and processes to explore visual conventions when making artworks (ACAVAM111).

Science vocabulary words

Tier 1 (Everyday words) - light, colour

Tier 3 (Specialised vocabulary)

- Spectrum – a rainbow. It contains millions of colours, though we usually order them by the traditional ROY G BIV - for red, orange, yellow, green, blue, indigo, and violet. The names of the last three colours have changed meaning over time, and it is more accurate to call them light blue, dark blue, and purple.

- Holographic diffraction grating glasses – a special kind of plastic has been engraven using lasers at the very, very small level to create a series of grooves. This causes white light entering into the glasses to split up into its component colours, as different colours of light bounce out at different angles. Similar patterns can be seen on CDs or when one looks at a light though a fine grating, such as some umbrella fabric.

Warning

- Sharp, cutting implements are used in this activity, please use all appropriate caution.
- Colour spinners can be very frustrating to figure out, but are very satisfying once masters. They have been a childhood toy for centuries before computers came along.
- Bright light can be dangerous, take care with torches.
- Using water in any activity can be dangerous. Take adequate precautions to prevent and respond to spills.

Preparation

Colour Spinners

- A means of colouring, such as felt tip pens or crayons. Paint may also be used but takes a long time to dry and is messier.
- Ridged cardboard for every student. Younger groups will need them cut out beforehand.
- Around 1 meter of string for every student.

Making a Rainbow Demonstration

- A mirror that can get wet, hand mirrors might be quite good.
- A glass (or clear plastic) container that can fit the mirror.
- Water to fill the container.
- A hand held torch.
- A hose.
- Holographic diffraction grating glasses (available at www.creatingscience.org).

Learning Intent (student friendly)

'We are learning to' (WALT) – make, and understand, rainbows

Success criteria

'What I'm looking for' (WILF) – good rainbows, and a critical understanding of how rainbow colours are made and named.

Student learning goals

Help students make a self-monitored learning goal for this lesson.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

Students can either make a rainbow spectrum using the materials provided, or are able to combine different colours back into white light again using a colour spinner. Excelling students will be able to also explain why the phenomenon works.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity is well suited to this age group, but they may need adult assistance.

Middle:

This activity is well suited to this group, but they may need help to see the goals of the activity.

Teen:

Measuring angles of incidence and refraction are possible at this point. You can even derive the speed of light through the prism from such information, though it may be quite a challenge!

Engage

- ⇨ Note the Learning Intention of this lesson for students.
- ⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

If age appropriate – sing the rainbow song[1] ("Red and yellow and pink and green!" Etc). Ask, what's *scientifically wrong* with this song?

Make a rainbow, and have students tell you what colours they see. You could:

- Make a rainbow with water and a mirror (see appendix).
- Make a rainbow using sun and a hose (see appendix).
- If all else fails, look one up online.

Notice - there is no pink in a rainbow (or brown for that matter…)

[1] Songwriters: Arthur Hamilton. Sing A Rainbow lyrics © Warner/Chappell Music, Inc.

Explore

⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

In the 1670s, Isaac Newton was one of the first scientists to propose that white light was actually made up of different colours. His book 'optics' helped make him famous as a scientist. In it he made several rules for light that we still use today, for instance:

- Light always travels in straight lines.
- Light is made up of different colours. He called them Red, Orange, Yellow, Green, Blue, Indigo, and Violet; we use the mnemonic ROY G BIV to remember them. Today we might call the blue 'light blue', the indigo 'dark blue' and the violet 'purple'.

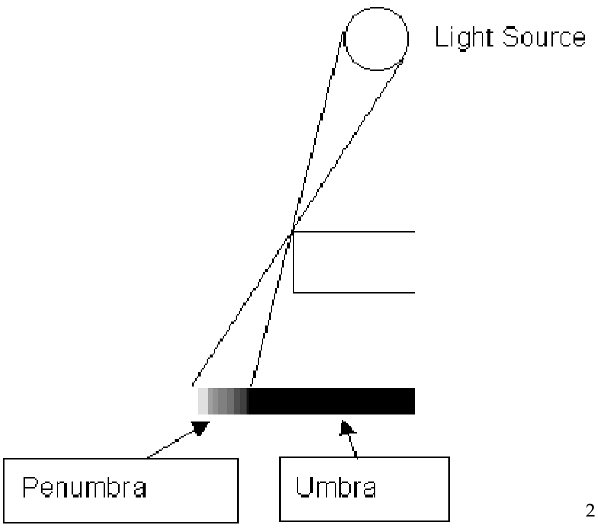
Can you think of a way to test these ideas? Are Newton's ideas still a good way to describe the behaviour and qualities of light?

Explain

Shadows

Making shadows is one way to test if light travels in a straight line. When your hand blocks a beam of light it stops.

However, just about every source of light we know of is large. That means they produce not only a shadow (called an 'umbra') but a half shadow (called a penumbra).



[2]

For example, when you can see only a portion of the sun, you are in the penumbra.

[2] Images taken from http://glasnost.itcarlow.ie/~powerk/C4Graphics/Notes/node12.html 25th of February, 2013

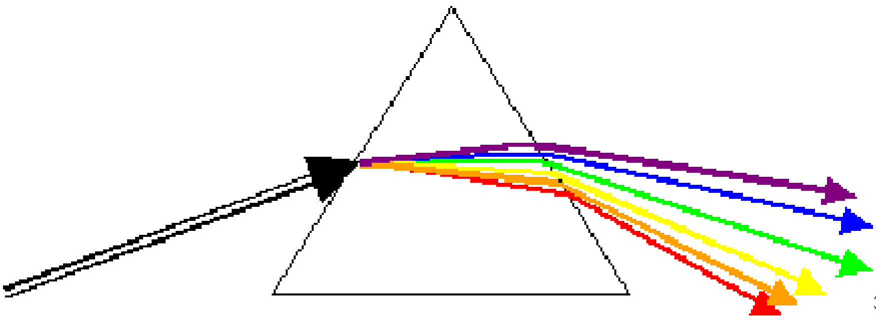
Colours of the Rainbow

Making rainbows is one way to test the ideas about colour.

Why are rainbows made of different colours?

We now agree with Isaac Newton that white light is made up of different colours. White light is the colour our mind makes up when it sees an even spread of the colours that make up a rainbow. So how do we make a rainbow?

- Light changes direction when it enters a different substance, like water or glass. (This is actually because light slows down in some substances).
- However, each colour changes direction a different amount. The red changes direction the most, the purple the least. Thus each colour spreads out, and we see a rainbow!


[3]

Interestingly, pink is not in a rainbow. We think it might be the colour our mind makes up when it sees a blend of purple and red colours – two rainbows back to back from opposite ends of the spectrum. Usually that would be green, but the mind knows it's not green, so it makes up a new colour: pink! Well – the scientific consensus is still out on this one…

Elaborate

⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

Shadows

Making shadows is one way to test if light travels in a straight line. When your hand blocks a beam of light it stops.

However, it was noticed long ago that light does not travel in straight lines at all, but in curved lines (but it's not something we can usually notice). For example, in *gravitational lensing*[4] light from a distant galaxy can bend around a nearby galaxy, so that we see several images of the further galaxy! Einstein believed that light travels in a straight line, but space itself can curve. In a black hole the gravity it so strong the light curves back around and never leaves!

But for regular classroom measurements light is treated as travelling in a straight line.

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[3] As for 2 above

[4] See http://imagine.gsfc.nasa.gov/docs/features/news/grav_lens.html for more detail.

Rainbows

Making rainbows is one way to test some ideas about colour.

- Try getting a stream of *sunlight* to form a rainbow through a clear cup – very tricky!
- Many other cultures have different ideas about what colours are in the rainbow, and some say newton chose seven colours because it was more 'perfect' than six – not a very scientific reason! The Shona language of Zimbabwe apparently speaks of only three colours; roughly taken as purple, orange and red[5]. How many colours do **you** see?
- Teal is clearly in most rainbows and spectrums between green and blue, but we don't name it and act as if it isn't there! By some definitions, there are millions of colours in a rainbow!

Helping students realise that they can name the colours of the rainbow is a great way to illustrate the creation of scientific knowledge. Do we all see the same colours, or can some people not see certain shades?

Did you know that 1 in every 12 boys has some red/green colour-blindness? On average, that's one in *every class*. However, this may also have a benefit – seeing less colours helps snipers and assassins overcome camouflage, and may help those colourblind to recognise shapes and shades of the colours they do see more effectively – great news for hunters.

For a long time one of Newton's ideas - that light was like little balls that flew in straight lines - was the standard for science, but it still couldn't explain some things. It wasn't until Thomas Young shared the idea that light could be treated like a wave that things such as supernumerary rainbows[6] could be explained. And yet the science of rainbows still has a long way to go!

- This song of colours is very… early childhood… but at least it gets it right!

Making Light White Again

Did you know that mixing every colour wavelength of light together again can create the experience of white light in our minds? It's very tricky, but it can be done!

⇨ Try the activity "mixing colour" from the appendix.

Evaluate

⇨ Review with students what they feel they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

⇨ Review the Learning Intentions of this lesson with students. Were they met?

At the end of each class, review the learning objective and see how we did. Ask:

[5] From http://www.unl.fi.upm.es/consorcio/archivos/publicaciones/alejandria/alej_031-23.pdf taken 25th of February 2013.
[6] See http://en.wikipedia.org/wiki/Rainbow#Multiple_rainbows for more cool kinds of rainbows!

- Did you achieve your learning goal?
- What did You learn?
- What worked to help you achieve it?
- What might you do better next time?
- (If needed) where can you go for extra help or information?

Assessment

Prior learning:

Take time to focus on planned content material during the engage phase, for example,

⇨ Have students draw a rainbow, then have them draw a *scientifically accurate version* of the rainbow. Younger children may even benefit from being allowed to see a spectrum to copy from – they will still have many things to learn even then!

Be sure to watch out for the following common alternative conceptions:

- Rainbows in bubbles and oil slicks are the same as rainbow glasses [Spectrums caused by Holographic Diffraction Grating Glasses are not to be confused with Thin Film Interference, such as what causes the colours in insect bodies and wings, bubbles, and the thin film of oil.]

Formative:

As students are learning, help them self-monitor their own learning and achievements.

Gather student discussions during the engage and explore phases, keeping notes, and asking students questions that help to draw out the learning.

Ask students:

- What colours do you see in the rainbow?
- Why do we use the ROY G BIV colours? Who do they think came up with this?

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do.

Have students draw a poster of the light as it travels through the mirror, or the water spray from a hose, to make a rainbow. Remember to include straight lines!

So what?

- I can decide for myself how many colours are in the rainbow, as long as I OWN that knowledge.
- Understandings about colour and light science have changed over time, and still are far from finished!

Creating science

Science understanding

As we learned about colour and making light, we observed that:

- Physical sciences 1: Light and sound are produced by a range of sources and can be sensed.
- Physical sciences 5: Light from a source forms shadows and can be absorbed, reflected and refracted

Also:

- Realise light travels in (almost) straight lines.
- Learn that rainbows aren't bows – they are circles.
- Learn that white light is made up of the rainbow colours.
- That pink is NOT a rainbow colour!

Science inquiry skills

As we learned how to make or combine mysteries to answer the questions of what colours are in the rainbow, or to combine colours to make white light, we were:

- Planning and conducting 3: Participate in guided investigations to explore and answer questions (ACSIS025).

Science as a human endeavour

- Nature and development of science 7: Scientific knowledge has changed people's understanding of the world and is refined as new evidence becomes available (ACSHE119).

Tips from the Masters to make it work:

Spin it fast enough, and red, blue and yellow look white!

Wind up the spinner by swinging it in little circles first.

Making rainbows – the technique

The result: It's very hard to make a solid spectrum this way!

Making Rainbows

What colours are in a rainbow? Decide for yourself!

Make a Rainbow – Glass and Globe style

1/ Get a clear cup, filled with water.

2/ Put a safe mirror on an angle under the surface (illustrated).

3/ Shine a torch at a low angle on the mirror.

4/ With some practice and tweaking, turning the mirror and the light, you may see a reflected rainbow on the roof!

In spite of any claims to the contrary in countless science books – this is the brightest rainbow you are likely to get:

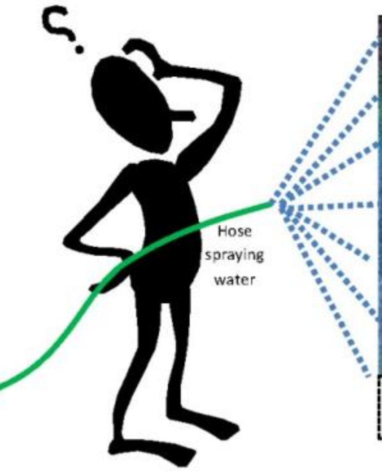
Make a Rainbow – Sun and Hose style

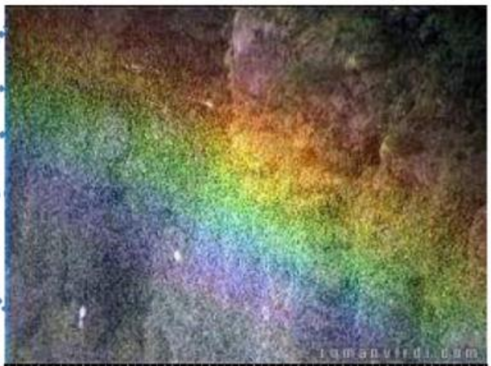
Easy as can be!

1. Make sure the sun is shining behind you.
2. Squirt a spray of water out in front of you, usually just off to the side a bit
3. And hey presto, you will see a rainbow!

Again, each tiny little drop bends the light. Different colours will bend different amounts, and because there are so many drops each will present a slightly different colour. All those colours are in the sunlight all the time, we only get to see them when they're broken up. We use this trick to send information to television, or information down fibre optic cables, even to see what far away stars are made of!

Follow the rainbow around, what do you see? **Rainbows are actually *circles*!** (The horizon just cuts off the bottom half)





Rainbow made of the sun's reflection

Mixing colour

Can our mind and eyes mix together different wavelengths of light to make entirely new colours?

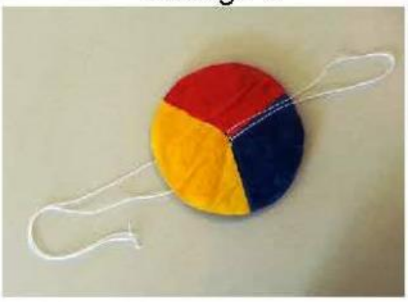
Step 1: Get some red, yellow and blue paint
Step 2: Mix a little of each together, what colour do you get?

These are call subtractive colour mixing – each colour absorbs different wavelengths of light, so mixed together they absorb almost every wavelength, leaving you with almost black.

But can you use the same colours to make almost white? Then you'll need them to be adding together their wavelengths of light. Try this trick using texta colours for less mess!

1. Glue a circle of paper on to thick cardboard, and texta it with three even colours (in this case, red, yellow and blue).

2. Pierce the cardboard with two holes near the centre, and thread about a meter of string through it.



3. Spin the wheel around a few times. You can get the wheel spinning by itself by pulling then relaxing the sting.

With practice you'll get it flying along!

Why it works:

The theory is that when our eye receives wavelengths of every length, it avoids confusion by making it appear white. When you spin the card around lots of different colours are being received by your eye at one. Instead of trying to make them all appear, it blends it into a new colour in your eye. With luck and practice, it might even look white!

Creating science:

Did you know that red, blue and yellow are not the only primary colours? You might find your spin wheel works better with cyan, yellow and magenta, just like computer printers use. Or perhaps you should try every colour of the rainbow since that is the original white light.
What primary colours to televisions use?

You've noticed there is no pink in a rainbow, so how do we see pink? Can you make a spin wheel that doesn't use pink, but looks pink when it is spun around?