NATIONAL SCIENCE & ENGINEERING WEEK

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Colour chaos!

Part of the British Science Association's National Science & Engineering Week activity pack series. **www.nsew.org.uk**

BIS Department for Business Innovation & Skills

BRITISH SCIENCE ASSOCIATION

About this pack:

This activity pack is full of activities on the theme of colour. Find out how to make a rainbow, how a caterpillar avoids being eaten, how cabbages can be used as magic ink and why red plus green equals yellow!

For more information on National Science and Engineering Week or for further activity packs, please visit **www.nsew.org.uk**

N.B. If you are printing this activity pack out you will need a colour printer for pages 7 – 9.

Educational Links

The activities and challenges within this pack can be used to complement, or contribute to, the Science and Art & Design sections of the National Curricula in England, Wales and Northern Ireland, and the Scottish 5-14 Guidelines in Environmental Studies and Expressive Arts. We recommend that you consult the National Curriculum on the website (www.nc.uk.net/), and the 5-14 Guidelines (www.ltscotland.org.uk/5to14).

Acknowledgements

The British Science Association would like to thank Planet Science for the use of some of their excellent experiments, and Lizzie Burns, Medical Research Council artist; Richard Ashworth from the Colour Museum in Bradford; Laura Brimson from the London College of Fashion; Ron Lewin from ICI Dulux and Alex Adams for their help in putting this pack together!

For further experiments and activities on the theme of colour and loads of other fantastic topics check out www.planet-science.com

Activity 1:
Catch a rainbow

You will need:
milk
washing up liquid
shallow bowl
red, yellow and blue food colouring

Pour a cup of milk into the bowl and carefully put three drops of red colouring into one side. About a third of the way around put three drops of blue food colouring and another third of the way around put three drops of yellow food colouring. Do this very carefully, without moving the bowl, so that the three colours do not mix. Next squeeze a drop of washing up liquid into the centre of the bowl and record what you see.

What's happening?
The washing up liquid will not mix with the milk (they are immiscible – see Cascading Colours). Instead it floats and spreads across the surface. As it spreads out it picks up the food colouring with it. Where the primary colours, (red, yellow and blue) meet, they combine to form new secondary colours – purple, orange and green.

Activity 2:
Spinning spectra

You will need:
cardboard
coloured pens
compass
ruler
scissors
pencil

Use the compass to draw a circle and, using a pencil and ruler, divide this circle into six segments of equal size. Cut your circle out. Using various mixtures of the primary colours (red, yellow and blue), colour in the different segments of your cardboard circle. Push the pencil through the centre of the circle and spin your top. What do you think you will see when you use certain combinations of colours in the circle? How do your predictions compare to the results?

Activity 3:
Doing the splits

You will need:
small mirror
glass of water
sunny windowsill
white paper

Place a mirror in a glass of water at an angle. Put this on the windowsill and turn the glass so that the mirror is directly facing the Sun. Next, hold the paper at a slant in front of the glass.

Move the paper around until you see the rainbow colours. You may need to move the paper around until the colours come into full focus.

What's happening?
White light travelling in a straight line appears colourless, but there's more to light than meets the eye. White light is actually made up of lots of different colours. All the colours of the rainbow, in fact. You have to split white light to see the different colours, and this is exactly what you have done!

Raindrops also split light. When sunlight shines though raindrops, the different coloured rays spread out at different angles, and you see a curved band of colours across the sky, which you know as a rainbow. The colour of light depends on how long its waves are, so we see different colours because each colour has a different wavelength. In other words, when we see colours, we are really seeing light of different wavelengths. Red light has the longest waves, orange is slightly shorter, and so on. Violet has the shortest wavelengths.

Activity 4:
Light entertainment

You will need:
two torches
red square of cellophane
green square of cellophane
two elastic bands
white wall

Note for teachers: for this to work the cellophane needs to be in exactly the right shades, and you might like to try a few pieces out before you unleash them on the kids. Also the white wall should be very white so you might want to hang up some sheeting.

Cover the first torch with the red square of cellophane and fix with an elastic band.
Cover the second torch with the square of green cellophane and also secure with an elastic band. Shine the torches at the same point on the white wall.

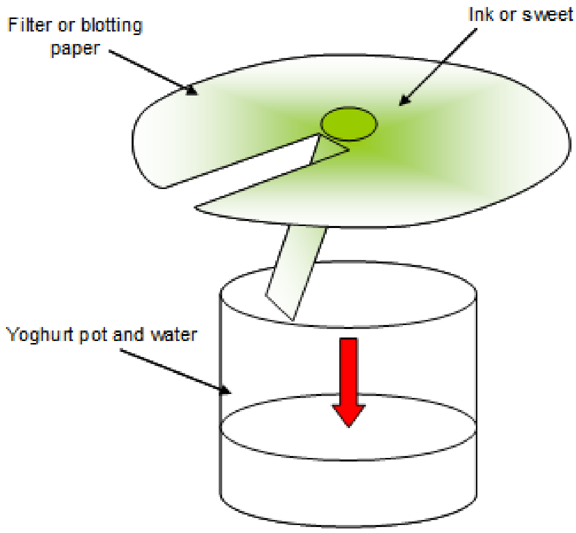
What's happening?
You have just mixed two different coloured lights, red and green. When you shine the torches at the same point on the white wall, you will notice that the spot of light is yellow. This proves that yellow light is made up of green and red light.

Light's primary colours are red, blue and green! By mixing the primary colours you get yellow, cyan (a turquoise colour) and magenta (a fuchsia pink colour). The colours you make when you mix paints are different to the colours that result from mixing light.

You could extend this activity by adding a torch covered in a sheet of blue cellophane. This theoretically should make white light - but it has to be very pure and in practice does not often work. But you can have fun playing around with the secondary colours.

Activity 5:
Splitting sweets

You will need:
1 circular piece of blotting paper or a coffee filter
1 plastic pot e.g. a yoghurt pot
water
washable felt tip pens or coloured sweets e.g. Smarties or M&M's



Put a small amount of water in the bottom of your plastic container. Cut two slits into the side of your blotting paper so that there is a strip of paper which can hang into the pot of water whilst the rest of the paper rests on top of the pot (see diagram).

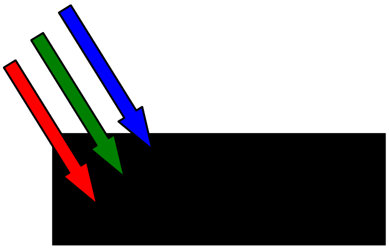
On top of the blotting paper, either draw a large coloured spot or place one of your sweets. Leave this for approximately 5 to 10 mins. Black and brown felt-tipped pens and Smarties produce the widest range of colours.

What's happening?
Washable pens and sweets are used in this experiment as their pigments are water soluble. Although some inks often only appear to be made up of one colour, they are usually composed of a number of different pigments. As the water moves up and outwards onto the circle of paper, the different pigments are carried through the paper at varying speeds. Pigments which are more soluble in water move through the filter paper at a faster rate and will travel further from the centre than those which are less soluble; this should cause a series of concentric, differently coloured circles to form on the paper.

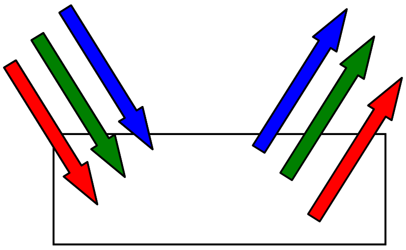
Activity 6:
What is the warmest colour?

You will need:
5 equal sized ice cubes
5 squares of card or plastic of different colours; black, white, red, blue and yellow
stopwatch
sunny day

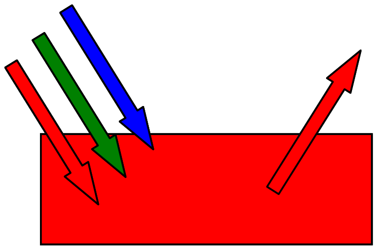
Place your different coloured pieces of card in a sunny spot and place an ice cube on each one. Time how long it takes for each one to melt. Which ice cubes melt first? Why do you think this is?



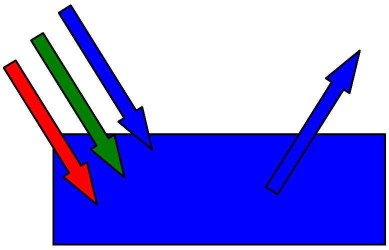
All light absorbed



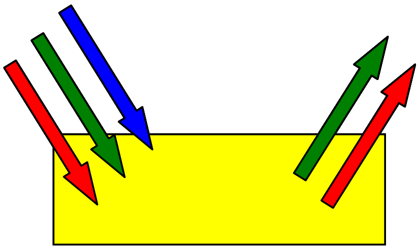
All light reflected



Green and Blue absorbed
Red reflected



Green and Red absorbed
Blue reflected



Blue absorbed
Green and Red reflected

What's happening?

The colour we say an object "is" is the colour it reflects; all the other colours are absorbed. As white is made up of all colours in the spectrum, a white piece of card will reflect all colours and absorb none.

Pigments that absorb light rather than reflect it look black. When light hits the black card, very little of the light is reflected whilst the majority of the light is absorbed.

As the white card reflects all the light and the black card absorbs all the light, the black card should heat up faster and melt the ice cube quicker! On the red card, the green and blue light are absorbed and the red light is reflected. On the blue card, the green and red light are absorbed and the blue light is reflected. On the yellow card, the blue light is absorbed and the red and green light are reflected. As the yellow card absorbed less light than the red and blue, the ice cube should melt more slowly.

Activity 7:
Flowers to dye for!

You will need:

white flowers or celery sticks
water
food colouring
vase

Fill your vase with water and add a few drops of food colouring. Cut the bottom off the stems of your flowers and place them in the vase. Leave your flowers in the coloured water for a few hours and see what happens. It should take between 6 – 12 hours to get the best results.

What's happening?
Water evaporates from the surface of a plant's leaves and petals through special pores called "stomata". As it does so, the plant draws water up the stem from the ground (or in this case the vase) as if it were in a chain. This process is called "transpiration". Water moves up the stem through special vein-like structures called "xylem"; hollow cells stacked on top of each other to form tubes. As the coloured water moves up the xylem and out of the stomata, it dyes the petals along the way. If you cut the stem and look at the cross-section you will be able to see the xylem filled with dye.

Try splitting the stem of your flower in half and putting each half in water dyed a different colour. What do you think will happen?

Activity 8:
Make a rainbow fish

You will need:
coffee filter paper
red cabbage
water
lemon juice or vinegar
bicarbonate of soda
paintbrush
wiggly or paper eyes
silver foil

Prepare some red cabbage water by breaking up the cabbage leaves into small pieces. Pour hot water over the cabbage and leave for half an hour or until the water turns dark purple. Once cool, remove all the chunks of cabbage, soak the filter papers in the cabbage water and leave to dry.

Next, flatten out coffee filter on a plate and cut out a fish shape from it. Dip the paintbrush in lemon juice or vinegar and paint onto the fish. See the colour change? Make up some bicarbonate of soda solution by putting a couple of teaspoons of powder into a little water and mixing it up. Dip in the paintbrush and paint the fish. See the colour change again?

Once the fish is dry, glue on some small strips and triangles of silver foil, glue on a wiggly eye and draw on a mouth and you have your rainbow fish!

What's happening?
These colour changes are all due to acid-base chemistry. The cabbage water is purple initially. When you add an alkali, such as bicarbonate of soda, it will turn blue. Adding an acid, such as vinegar, will turn it red. Red cabbage contains the pigment anthocyanin and the structure of the molecules of anthocyanin changes depending on whether it is in an acid or an alkali solution. This change in structure means that the pigment can actually change colour from bright red in acid to deep blue in alkali.

Red cabbage water is a good simple indicator and can be used to tell you whether something is acidic or alkali but it cannot tell you how acidic or how alkali. For that you need a more sensitive indicator such as universal indicator or methyl orange indicator.

Activity 9:
Cascading colours

You will need:
60 ml cooking oil
60 ml water
small glass
blue, red or green food colouring
pipette
pencil

Pour the water into the glass first and then very slowly add the oil so that it floats on top. Using the pipette, add about five drops of food colouring to the glass. Gently touch each of the drops with the tip of a pencil. What happens to the food colouring?

What's happening?
Oil and water do not mix (they are *immiscible*) and so form two layers in the glass. As the oil is lighter (or less dense), it will always form the top layer. Food colouring is water-based, so it mixes easily with water, but can't mix with the oil. When the food colouring is added to the glass, some drops will float just beneath the surface of the oil and some of the drops will sink. As the colouring reaches the water the drops will immediately break apart and dissolve.

Activity 10:
Caterpillar Thriller

You will need:
100 x 15cm wool in five different colours – red, yellow, blue, green, brown (these will be your caterpillars!)
an outdoor grassy area

Firstly, make sure you have an equal number of each colour of caterpillars. Next get your group leader to randomly distribute these caterpillars over a large designated grassy area (about 12m x 12m).

Split your group into two and make two lines of people on the outside of your caterpillar field. When the group leader shouts "Go", the first people in the lines must run into the marked area and bring back the first caterpillar they see, when they get back to the line, the next person must do the same. This race finishes when all people have found a caterpillar.

Next, put all the caterpillars together and count how many of each colour you have found. Which colour did you collect the most of and which did you find the least of? Which were the easiest and hardest to find? What colour do you think it would be safest to be if you were a caterpillar?

What's happening?
Caterpillars, like most other animals, have to struggle to stay alive and avoid predators throughout their lives. To help them many creatures have evolved camouflage. The closer the animal matches it's background or surroundings, the less chance it has of being seen and eaten by a predator, and the more chance it has on sneaking up on it's prey without being seen.

Which other animals use camouflage to hide? Try painting a picture of an animal, using various camouflage techniques, and seeing how well it can be hidden outdoors.

Activity 11:

Stroop effect

The aim of this test is to name the colours of the following words. Do not name the words themselves; say the colour of the words. For example, for the word "YELLOW", you would have to say "Red".

There are two sets of words. Time how long it takes to name each set and then compare the times. Which set took longer to read?

SET 1

RED	YELLOW	BLACK	GREY	ORANGE
GREEN	BLUE	PINK	PURPLE	BROWN
RED	ORANGE	BLUE	GREEN	BLACK
ORANGE	YELLOW	RED	BLUE	GREEN

SET 2

RED	YELLOW	BLACK	GREY	ORANGE
GREEN	BLUE	PINK	PURPLE	BROWN
RED	ORANGE	BLUE	GREEN	BLACK
ORANGE	YELLOW	RED	BLUE	GREEN

What's happening?

You should have found that the second set of words took longer to read out than the first. The words themselves have a very strong influence on what colour you say, the words are said to "interfere" with the naming of the colours. When you look at the word you see both the colour and the meaning. If both are the same, the colours are quickly and easily named. If the colour and meaning are different your brain has to make a choice between the two mixed messages. As the words are read faster than the colours are recognised, and naming the colours requires more attention, it takes longer for the brain to process the correct answer if the colour and meaning are different.

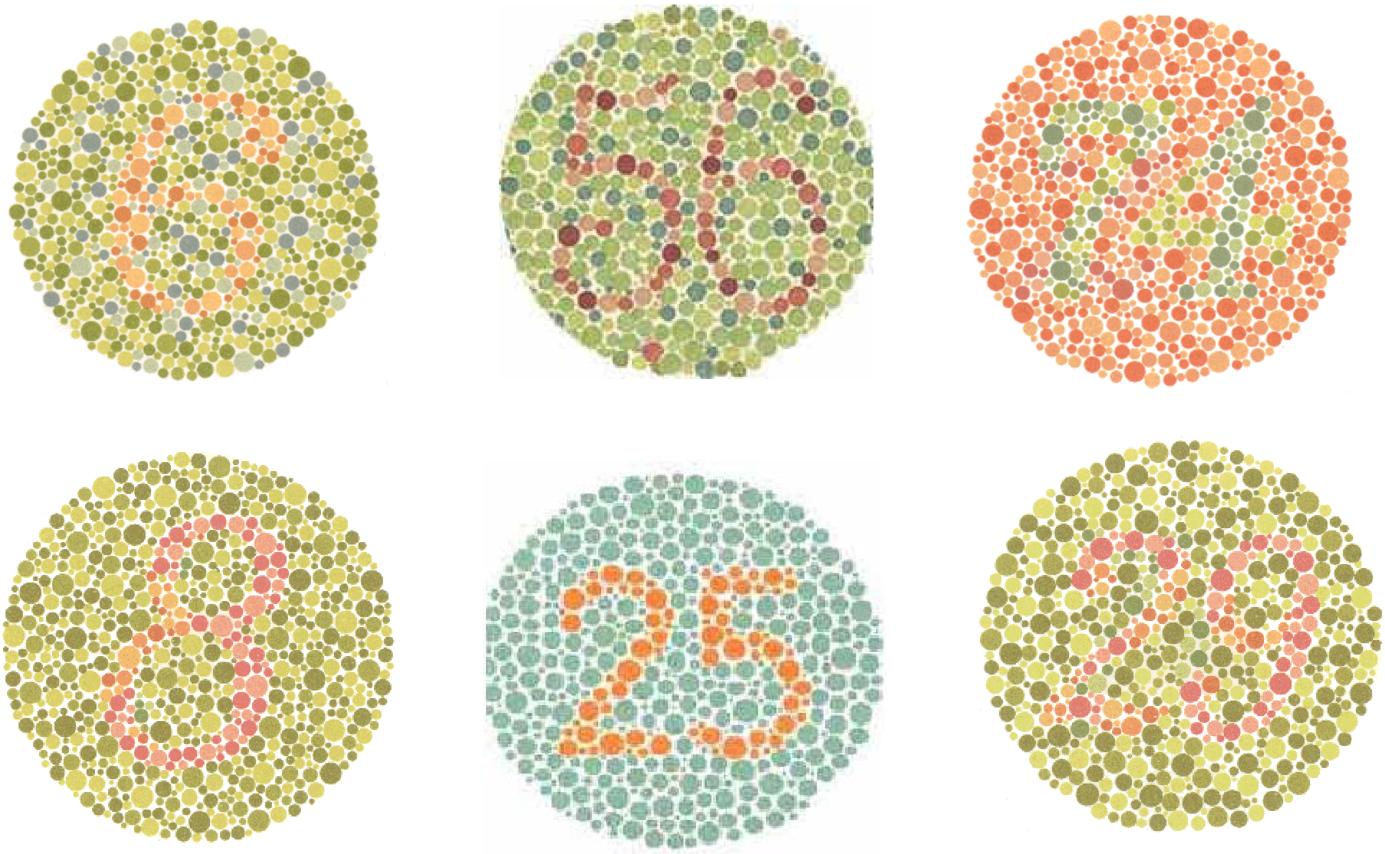
What do you think would happen if you tried this test on a young child who could not read?

Activity 12:
Seeing spots

Defective colour vision, commonly known as colour blindness, is a condition that affects 1 in 12 men and 1 in 200 women. A lot of people incorrectly think that a colourblind person is someone who only sees in black and white, but in fact it is extremely rare to have a total lack of colour perception.

The eye “sees” when light stimulates the back of the eye, or the retina. The retina is made up of two types of cells; “rods” which detect low levels of light and enable us to see in the dark, and “cones” which perceive colour. There are three types of cone cell and each one detects a different wavelength, or colour, of light – red, green and blue. As these colour receptors are not particularly sensitive to light, a human’s colour perception is quite poor in the dark. It is a lack of one of these types of cone cells in the eye that causes colour blindness. For example, a lack of the red receptors would cause red-green colourblindness, the most common variety. A lack of any colour receptors at all would result in black and white vision.

Can you see the numbers hidden in each of the patterns? If not, there is a possibility that you could be colourblind.

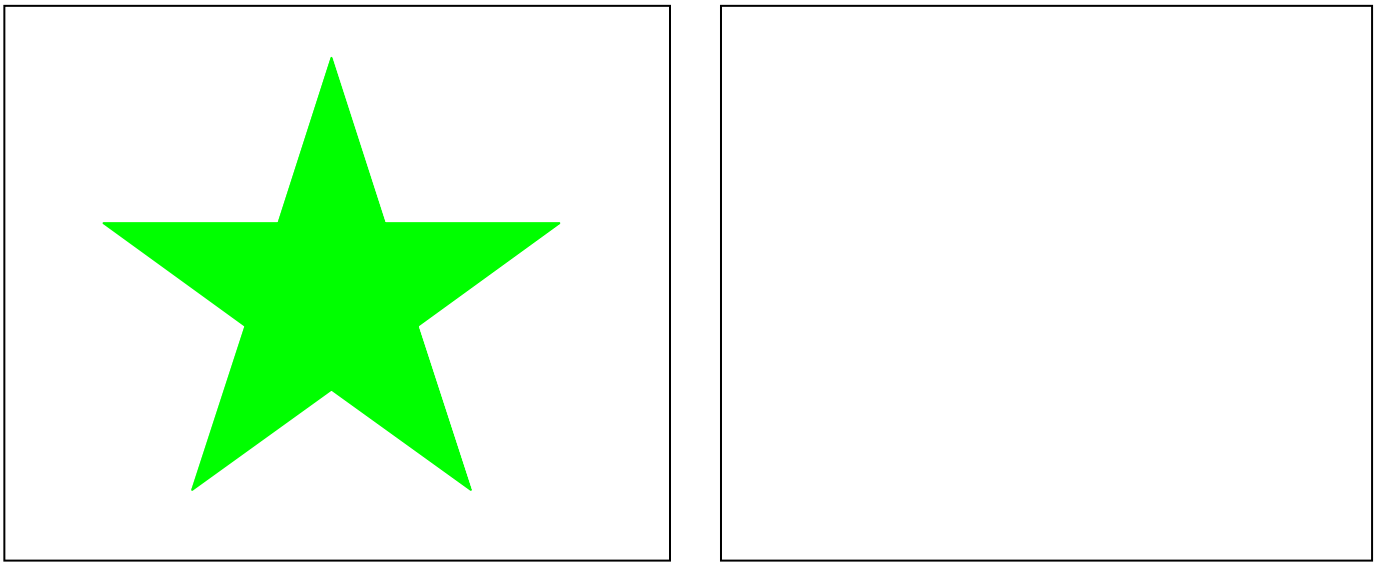


Images based on Tests for Colour Blindness by Dr. Shinobu Ishihara

Activity 13:

Stars in your eyes

In bright light, look at the green star in the box below for about 30 seconds and then look at white box beside it. What do you see?

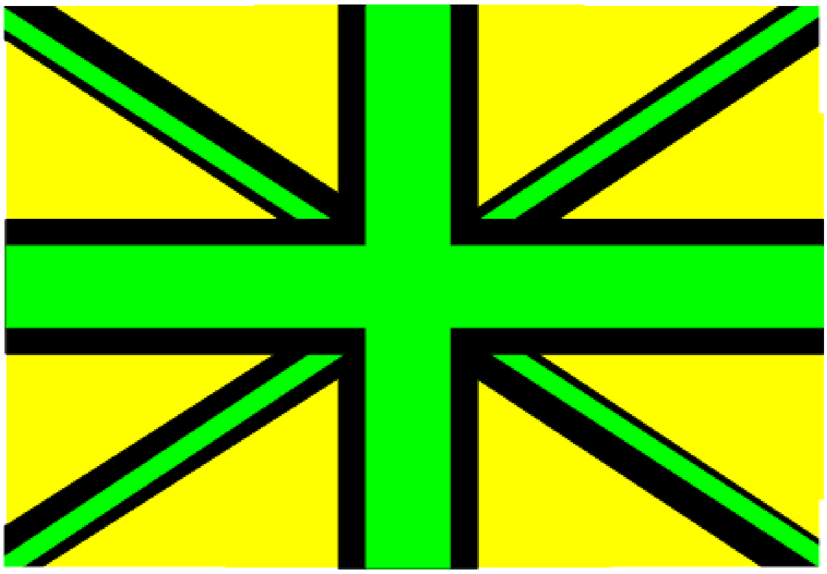


What's happening?

You should see a red star or "afterimage" in the white box (and similarly, you would see a green afterimage for a red star). When you look at a green image for a long time the green cones cells in your eye are stimulated so much that after a while they adapt to the light and lose their sensitivity. When you then start looking at the white box you see white light of the background minus the green (as the green cones are temporarily not working), leaving the red light and red afterimage behind (the red cones are still functioning normally). Other pairs of colours will also give colour afterimages: blue and yellow, and black and white.

In bright light, stare at the flag below for 30 seconds and then look at a white piece of paper....can you see the union jack?

Could you draw any other flags by swapping the colours around to make the correctly coloured afterimage?



Activity 14:
Sprouting seedlings

You will need:
camera film canisters
coloured cellophane
hole punch
sticky tape
soil
cress seeds
water

Make two holes with your hole punch on either side of a film canister about 1cm below the rim. Cover up the holes with various colour combinations of cellophane (red, green and blue). Put about 1cm deep of soil in each canister and plant a few of your cress seeds. Water your seeds with just enough water to make the soil moist. Put the lid on your canister and place it on the windowsill or in a bright sunny spot. After 3 or 4 days, remove the lid and check on what has happened to your seedlings.

Did the seedlings grow better in certain colours of light? Did the seedlings grow towards any particular colours?

What's happening?
Leaves are green because of a pigment called *chlorophyll* that reflects green light and absorbs red and blue light.

If the seedling is only exposed to green light, the rate of photosynthesis would drop and you would see a very low level of growth. This is because the green light is all reflected and there is no red or blue light available to absorb. If the seedling is exposed to red, blue or violet light, all of the light is absorbed by the chlorophyll and very little is reflected. This would lead to a high rate of photosynthesis and growth.

You may have also found that the seedlings tended to grow towards the blue light. The phenomenon of plants growing towards light is called *phototropism*. A yellow pigment, called flavochrome or cryptochrome, is found in minute amounts in plants. This pigment helps transport a hormone called auxin to the dark side of the plant where it causes the cells to become elongated. The growth of the plant cells on one side of the plant causes it to grow towards the light. As the flavochrome is yellow, it absorbs blue light more efficiently than any other colour. This means that the plant will grow towards blue light more readily.

Activity 15:
Colourful combustion

You will need:
test tube racks
test tubes
Bunsen burners
bench mats
distilled water
wire loops (preferably made from platinum or nickel-chromium)
5M hydrochloric acid in labelled test tubes

In tubes labelled with the name of the metal:
Approx. 0.5M solutions of:

barium chloride
calcium chloride
copper(II) sulphate
lead(II) nitrate
potassium nitrate
sodium chloride

Plus four test tubes as unknowns, filled with four of the six solutions above, labelled from 1 to 4.

Safety: Always use good safety techniques. Make sure you are wearing safety goggles, a chemical apron and are supervised by a chemistry teacher.

First test that your wire loop is clean by putting it into the Bunsen burner flame. If the flame changes colour then place the loop into the hydrochloric acid solution, rinse it with the distilled water and try again. If there is a burst of colour, then it is not sufficiently clean. If there is no change in the colour, then the loop is ready to use. If you have more than one loop, use a separate one for each test.

Dip the loop into one of the known solutions and place it into the blue part of the Bunsen burner flame. Make a note of solution and the colour of the flame.

Clean the wire loop and keep testing each of the known solutions until you know the colour of each one.

Solution	Barium	Calcium	Copper	Lead	Potassium	Sodium
Colour						

Next test the four unknown solutions and make a note of their flame colours. Can you work out what metals the solutions contain?

What's happening?
When a solution is heated up it gives off a characteristic colour that can be used to identify the metal within it. For example, sodium will give off a bright orange light which is often seen in sodium street lights or fireworks.

Electrons in the metal ions in the solution absorb the heat of the Bunsen burner and move to a higher energy level, i.e. become “excited”. When these electrons fall back down to their original energy level, or “ground state”, the energy is released in the form of light. Different metal ions have different separations between their excited and ground states and therefore absorb and release different amounts of energy. These different energies correspond to different wavelengths of light. This therefore means that when different types of metal are heated up they create different coloured flames.

In this experiment, you should find the following metals produce the following colours:

Solution	Barium	Calcium	Copper	Lead	Potassium	Sodium
Colour	Light green	Brick red	Blue/green	Blue/white	Lilac	Bright orange

Activity 16:
Rainbow strips

Have a look outside and see if you can find natural objects, such as a leaves or feathers, for each colour of the spectrum and make a rainbow collage. Are there any colours that are hard to find? Why do you think that this might be?

Activity 17:
Colour confusion

Try designing an experiment to see if colour affects people's perception of taste. What food or drink could you use? How are you going to alter the colour and/or taste? How are you going to measure people's reactions?

Activity 18:
Beautiful beasts

How many bright, colourful creatures can you think of? If animals can benefit from being camouflaged and staying hidden, why do you think some animals are so bright and showy? What advantages do you think there could be of being seen?

Activity 19:
Eye spy

Can animals see in colour? Can they see more or less colours than humans? Are there any colours that animals can see, that humans can't?

Thank you for using Colour Chaos!

We hope you enjoyed the activities within this pack. To help us to continue to provide new activity packs, we'd like to ask you to tell us a little about what you did for National Science & Engineering Week.

Please take a few minutes to fill in this form. If you used this activity pack for NSEW, send in this completed form and we will send you a National Science and Engineering Week Certificate.

Organisation: ____

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Which dates did you do National Science and Engineering Week activities on? __________
What did you do?

Please make any comments about this activity pack, National Science & Engineering Week and/or other possible topics for future packs (feel free to continue on a separate sheet of paper).

☐ **Tick this box** to be added to our mailing list. This will keep you up to date with NSEW, including grants, resources and activities. Your contact details will not be passed onto third parties.

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CREST ★ Investigators is a UK-wide award scheme that enables students to solve scientific problems through practical investigation. The activities focus on thinking about, talking about, and doing science. The activities develop students's scientific enquiry skills in an enjoyable context with links to the National Curriculum where appropriate.

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