LONGMAN

Exploring Science Extra

How Science Works

Sunscreens

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2 Exploring Science Extra

Introduction

Welcome to the latest *Exploring Science Extra* pack, in which we are taking a look sunscreens just before the summer holidays start. Let's hope that there is some summer in these holidays!

This pack includes a Student Booklet and a Teacher's Guide that outlines some suggested activities on the theme of sunscreens. Some of these activities are supported by Activity Sheets.

As usual, each of the activities is linked to a unit from Exploring Science, making the pack easy to incorporate into your teaching. We hope that the activities will inspire and stretch students, taking them slightly outside of the standard curriculum areas, whilst still developing key scientific skills.

Look out for our next pack, which should be available at the beginning of next term; it's all about fireworks.

Did you know?

How much use do you make of the Skills Sheets at the back of the Year 7 Activity Pack? Why not take the opportunity to refresh your memory about what the 58 Skills Sheets cover? You can use some of them with this pack – for example, in the activity that links with Unit 8A you could use Skills Sheet SS38 *How to find information*. Skills Sheets SS28 *Bar charts* and SS32 *Pie charts* could be used with the Unit 7H activity.

In this pack you'll find an additional Skills Sheet on note-taking (Skills Sheet SS59 *Taking notes from science writing*), which is designed to work with the 7A activity. This Skills Sheet will be useful for any situation in which students need to take and organise notes.

Also, we've updated Skills Sheet SS16 *Hazard warning symbols*. The new sheet is called SS16 *Hazard symbols* and shows the new symbols used in the Globally Harmonised System of Classification and Labelling of Chemicals (GHS). You can find out more about these changes at:

http://www.hse.gov.uk/ghs/index.htm

You can download the new pictogram symbols from the United Nations Economic Commission for Europe website:

http://www.unece.org/trans/danger/publi/ghs/pictograms.html

And, while we're on the subject of hazard symbols, there are some great sites you can use to design and print your own warning signs, such as:

http://www.freesignage.co.uk/

http://www.online-sign.com/

Let us know what you think of the pack! Tell your rep or contact us through the website

http://www.pearsonschoolsandfecolleges.co.uk/Secondary/GlobalPages/ExploringScienceExtra/ExploringScienceExtra.aspx

With all good wishes for the summer term,

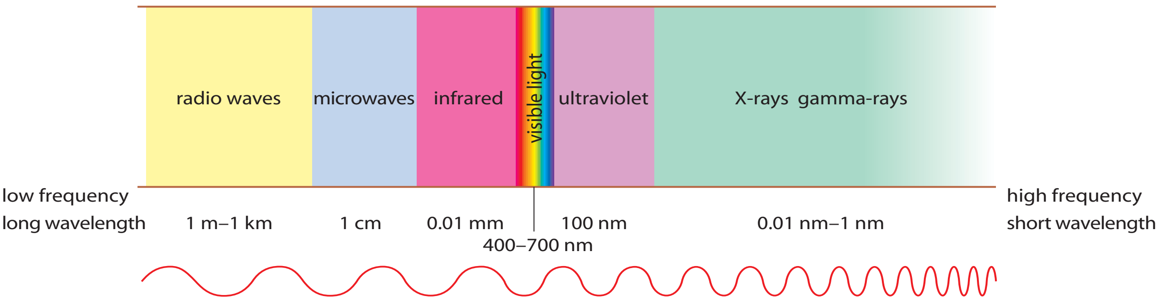
Mark

Mark Levesley, Series Editor

1 UV Radiation

UVA and UVB

You can't see ultraviolet (UV) radiation but it travels in the same way that visible light does – as waves. In fact, UV and visible light are just two kinds of a whole range of waves called electromagnetic radiation. The range (or spectrum) starts with waves with long distances between the tops of the waves. They have long wavelengths. At the other end of thespectrum are waves with short wavelengths. UV radiation has wavelengths of between 100 and 400 nm (nanometres, 10–9 metres).



A *Ultraviolet radiation is part of the electromagnetic spectrum.*

Ultraviolet radiation is subdivided into three groups:

UVA 320–400 nm UVB 280–32 0 nm UVC 100–280 nm

UV radiation comes from the Sun. All UVC and some UVB wavelengths are absorbed by ozone in the atmosphere, so only UVA and some UVB reaches us.

Many insects, such as bees, can see ultraviolet radiation. Some flowers use this to guide bees to their nectar.

UV at ground level

The amount of UV that reaches ground level depends on many factors.

(1) *Variation in ozone concentration affects how much UVB reaches the ground.*

(2) *The angle at which sunlight reaches the ground also affects the amount of UV radiation received. Sunlight angle varies with:*

- time of day – more radiation is received when the Sun is higher in the sky
- time of year – places with seasons (such as the UK) receive more radiation in summer than in winter
- latitude – places nearer the poles of the Earth (such as the UK and New Zealand) receive less radiation over a certain area than places near the Equator.

(3) *The higher up in the atmosphere you are, the more UV you receive, so height above sea level is another factor.*

(4) *Cloud reduces the amount of UV – the thicker the cloud, the less UV reaches the ground.*

B *UV-protective eyewear is essential when skiing.*

Light-coloured surfaces reflect UV, so you will receive more UV when near snow, sea or on a sandy beach.

2 UV and skin

C *The ancestors of these teenagers lived in different parts of the world.*

Getting a tan

One effect of UV radiation on skin is to make it turn a darker colour, producing a sun tan. The UV causes damage inside the cells, and this causes the cells to make a chemical called melanin. Melanin is a dark brown colour, and the more melanin there is in skin the darker brown it is. The melanin is a natural protection against some UV because it allows less radiation to pass through the skin surface.

UVB has a second effect on skin – it results in the production of vitamin D. This vitamin helps the body to make strong bones. A lack of vitamin D produces soft bones, causing rickets in children and osteomalacia in adults.

Ethnic groups that live nearer the Equator naturally have a darker skin than those that live nearer the poles. This is the result of evolution. Having plenty of melanin in places where there is a lot of sunshine provides good protection against skin damage. A lot of melanin in skin when there is not a lot of sun (further away from the Equator) increases the risk of lacking vitamin D.

Neanderthals were a human species that lived in Europe between about 200 000 and 25 000 years ago. DNA evidence shows that they probably had pale skin – an adaptation to living where less UV radiation reaches the ground so less vitamin D is made in the body.

Changing fashion

Until about 100 years ago it was considered unfashionable for fair-skinned people to have a suntan. This is because a tanned skin was associated with working outdoors, such as being a farmer. Wealthy people showed that they didn't have to work by being pale-skinned. Ladies of fashion used cosmetics that contained substances that made them look paler, such as lead oxide (poisonous!) or arsenic (also poisonous!).

Early in the 20th century scientists identified the health benefits of sunlight in preventing rickets. And in the 1920s Coco Chanel, a fashion designer, returned from a holiday with a suntan. This made having a tan fashionable – people who could afford to travel could show off their tans. As holidaying abroad became cheaper, more people spent more time in hotter, sunnier places. So more people could 'afford' a tan.

Unfortunately, developing a suntan can be just as dangerous as using poisonous chemicals to keep skin pale.

3 Too much UV radiation

Skin cancer

Too much UVA causes early ageing of the skin. Too much UVB causes sunburn, where the skin goes red and may blister. Both kinds of UV damage the molecules inside cells that contain the information needed by cells to function – their DNA. UVB can break DNA molecules, and UVA causes reactions in cells that lead to DNA damage. Damaged DNA can lead to cancer.

Although most skin cancers are easily treated by surgery, some are very aggressive and can cause death. Each year there are about 100 000 new cases of skin cancer of which about 12 000 are of the aggressive type. Skin cancer causes about 2000 deaths in the UK each year.

E *Developing skin cancer is linked to exposure to a lot of UV radiation from the sun or a sunbed, particularly when young. Photograph courtesy CDC/ Carl Washington, M.D., Emory Univ. School of Medicine; Mona Saraiya, MD, MPH*

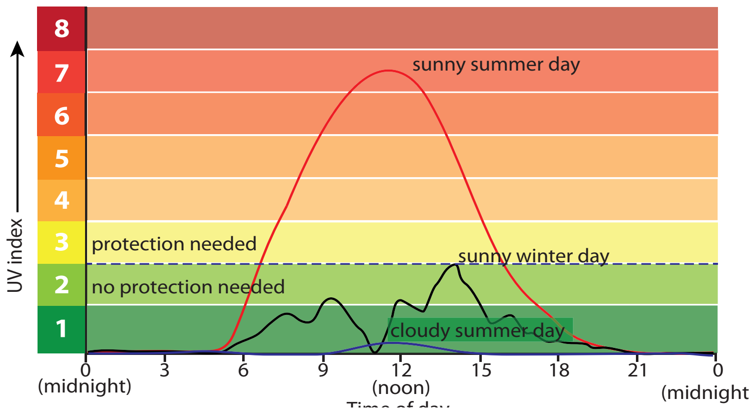
The UV index

The UV index was developed to help everyone realise the danger of getting too much sun. It is a complicated calculation, which includes factors that affect how much UV radiation reaches the ground. It also takes into account the effect of different UV wavelengths on skin – UVB causes more damage than UVA.

The calculation produces a single value that indicates how dangerous the UV is on a particular day in a particular place. Many countries now forecast the UV index along with their weather forecasts.

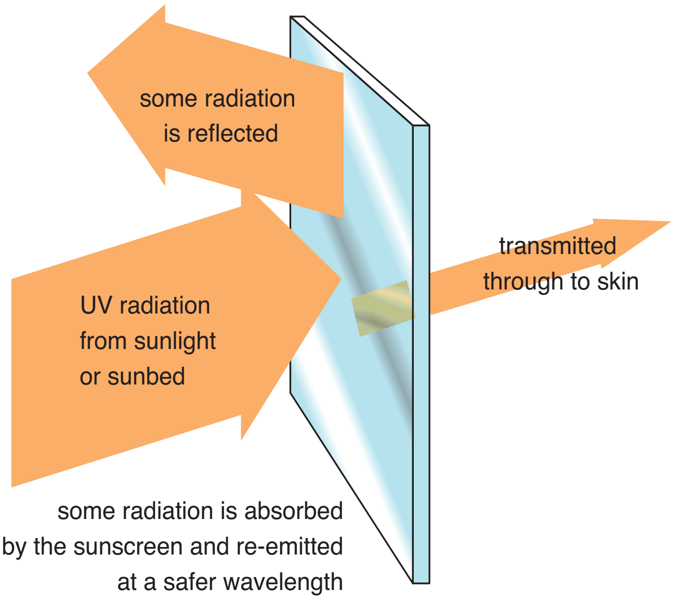
Exposure	UV index range	Health Advice
low	<2	no protection needed
moderate	3–5	protection required: slip on a shirt, slop on sunscreen, slap on a hat seek shade at midday
high	6–7	
very high	8–10	‘slip, slop, slap’ is a must, seek shade avoid being outside at midday
extreme	11+	

In the UK the UV index rarely exceeds 8, but the nearer you get to the Equator the higher it can be. There it often exceeds 11.



F *Typical UV indices for three days in the south of the UK.*

4 Protecting against UV



G *The amount of radiation received by skin depends on the amount that hits the skin, and the proportions that are absorbed and reflected.*

H *The Himba people of Namibia, Africa, cover their skin and hair with otjize, which is a mixture of butter and ochre (a natural colour made from earth). The red colour is attractive, but the ochre also acts as a natural sunblock.*

Sunscreens

We can reduce the amount of UV radiation that gets through to skin by spreading sunscreen over it.

Different kinds of sunscreens work in different ways. White sunblocks reflect a lot more radiation than colourless ones. Transparent sunscreens contain more substances that absorb UV radiation. They then re-radiate the energy at a longer wavelength, in the infra-red part of the spectrum, which doesn't damage skin.

Sunglasses

UV radiation is dangerous to eyes too. Too much UV over a short period can damage the eye's surface in a similar way to skin. An example of this is snow-blindness, which can be caused when on high snowy mountains under cloudless skies.

Over longer periods of time, too much UV can cause many types of damage, such as clouding the lens in the eye, causing cataracts and resulting in blurred vision.

Many kinds of plastic and glass absorb UV (for example, not much UV gets through windows). Plastic or glass lenses in sunglasses absorb some of the UV, and additional coatings can reflect even more UV.

I *Coated lenses in sunglasses can help prevent eye damage in strong sunlight.*

5 What's in sunscreens

Active ingredients

The active ingredients in something are those ingredients that have the main effect.In sunscreens, the active ingredients help stop UV radiation getting through to skin.

There are two types of active ingredients in sunscreens, which have different properties and different effects.

Type of ingredient	Examples	Properties	Effects
inorganic particles	titanium dioxide zinc oxide	form large cluster particles that reflect light	• appear white • reflect and absorb well over whole UV range
organic particles	cinnamates salicylates oxybenzone	tiny particles do not reflect light	• appear transparent • absorb a small range of wavelengths mainly within UVB, sunscreens contain different ones to give protection over wider range

J *Sunscreens must state their SPF factor.*

UV protection

The SPF (Sun Protection Factor) value on a sunscreen indicates how well it stops UVB radiation getting to skin. The SPF value is the amount of radiation needed to cause sunburn compared with not wearing sunscreen. For example, if you could stay in the sun for 10 minutes before burning without sunscreen, using SPF 6 sunscreen would mean you could stay out for 1 hour before burning.

Sunscreens that have a higher SPF value usually have a greater proportion of active ingredients.

As SPF only measures protection against UVB, most sunscreens now also show a star rating to show how well they protect against UVA.

Other ingredients

The ingredients list on a bottle of sunscreen shows that it contains a large number of chemicals in addition to the active ingredients. The main chemical (first in the list) is usually 'aqua', commonly known as water, which acts as a solvent for many of the other substances. Sometimes an alcohol is included, as a solvent for chemicals that don't dissolve in water.

Some insoluble substances have small enough particles that they stay suspended in the liquid, forming a suspension. Stabilisers help to stop them settling out if the sunscreen is left to stand for a long while. This helps the sunscreen to feel smooth and to spread easily and evenly over the skin.

Other ingredients include moisturisers that help to keep your skin soft and supple, and substances that make the sunscreen waterproof so that it is not easily washed away in water or by sweat.

6 Developing Sunscreens

Nanoparticles

Although inorganic ingredients in sunscreen are the best at blocking UV, the large size of their particles makes the sunscreen look white. Many people prefer colourless sunscreens.

During production, chemists can break the inorganic particles up so they are much smaller – so small that they are called nanoparticles. Nanoparticles are small enough not to reflect light, so they appear colourless.

Nanoparticles are also small enough to be absorbed into skin cells. Some scientists are concerned that they could cause damage in the body. The particles are also small enough to get into other organisms, when sunscreen is washed off into the environment. They might also cause damage here, such as killing corals in the seas, though scientists are still researching this.

K *Hippos sweat a natural sunscreen that often makes them look pink.*

Natural sunscreens

Sunscreens made from natural materials might be better for us and the environment. So scientists are researching a range of sources.

Hippos may spend the hottest part of the day in water, but they need to come on to land to graze. Their skin sweats a natural sunscreen that protects against UV, as well as repelling biting insects, which could be useful for humans. Problems with this are that the sweat is pink and smells of hippo, so this needs development!

Corals need to be near the surface of the ocean so that algae inside them can photosynthesise and make food. This means corals get a lot of UV radiation.

L *Corals can't move to hide from too much sunlight, so they need a natural sunscreen to protect them from damage.*

Some species produce a natural sunscreen that doesn't just protect them from UV radiation, it also protects fish that eat the corals. Scientists are developing the natural chemical to test as a lotion on human skin. One day, it might even be used in a 'sunscreen pill' to take before going out into the sun.

Scientists are also experimenting with ways to produce melanin for use in sunscreens. As melanin is the natural way that our bodies protect themselves from too much UV, this could be a good idea. The melanin is produced chemically, which might mean it's a little different to the melanin inside us. Like all sunscreen chemicals, it will need thorough testing before it is approved for use.

2 Sunscreens

In any work using bright light, especially sunlight, students must be reminded that they should NOT look directly at the light source, in order to avoid damage to the eyes.

Apparatus note

Several of these activities require students to measure UV radiation and its effects. If your school does not have a UV sensor/meter, then photosensitive materials such as 'sunprint' paper or photosensitive beads are a cheaper and useful alternative.

The skin as an organ

***Exploring Science* link: 7A**

Introduce this activity by asking students to consider the skin as an organ, made of different tissues, and the effect of sunlight on these tissues. Explain that in the activity they will develop their skills in note-taking in preparation for formal writing. Provide a context for focusing the work, for example:

- Which tissues or cells in skin does sunlight affect most?
- How does UV radiation affect different tissues in the skin?
- Why do some skin types get more easily sunburnt than others?

Ask students to gather information from the stimulus material in the Student Booklet, from sections 7Aa and 7Ad in the Y7 *Exploring Science* Student Book, and from any other useful sources such as the Internet. Show students how to structure note-taking by using tables, headings or concept maps to organise information. Skills Sheet SS59 on *Taking notes from science writing* also supports this.

Before students begin their research, discuss how the question can be broken down into smaller topics to help with organising their notes, for example:

- Which tissues are there in the organ of the skin?
- How are the tissues arranged in the skin?
- What is the function of the skin and how do the tissues contribute to this function? (Note that much of this will be covered in more detail in later parts of their KS3 work, so need only be considered superficially here to reinforce the idea that tissues in an organ work together.)
- Which cells or tissues are most likely to be affected by sunlight and why?

Once students have gathered their information in note form, they should use their notes to create a short report to answer the original question.

Resources (for the investigation): Skills Sheet 59.

Comparing sunscreens

***Exploring Science* links: 7H**

This activity is a data-handling exercise that focuses on choosing the right method for displaying different types of data. Activity Sheet 1 provides a table of ingredients in some sunscreens and questions about how best to display different aspects of the data. It will help if students have read the information on sunscreen formulations and their active ingredients in the Student Booklet before using the activity sheet.

The activity sheet can be used in various ways. More able students may be able to complete it individually, but may benefit from discussing Questions 2 and 3 in small groups before deciding on the best method of presentation. For other students, class discussion may be more appropriate. Some students may need support with deciding to use a bar chart to show the two active ingredients (those that vary in amount) for each sunscreen in Question 2, and pie charts for each sunscreen in Question 3 as well as calculating proportions for the pie charts.

Alternatively ask students to import the data into a spreadsheet program and use the graphing facilities to produce different types of charts and graphs from the data. They could then compare the displayed data to identify any patterns that are obvious and discuss why a particular form of chart or graph is most appropriate in each case.

Resources: Activity Sheet 1.

2 Sunscreens

Measuring UV variation

Exploring Science link: 7L

Ask students to read the information about UV index in the Student Booklet, and ask them to suggest what causes variation in the index at different times and in different places. You could link this to the idea of choosing the right sunscreen to use at each time and place.

Activity Sheet 2 provides an investigation into how UV radiation levels vary at different times of day and year. The activity focuses on the importance of controlling variables. UV radiation can be measured in several ways:

- newsprint paper turns yellow due to UV radiation over a period of hours on a very bright day, or over a day or more during winter or cloudy conditions
- photosensitive paper or fabric based on potassium ferrocyanide and iron(III) ammonium citrate (blue-print or 'sunprint' paper) will change colour over a few minutes due to UV radiation, and the reaction stopped by rinsing in water. (The paper/fabric can be bought from suppliers such as http://www.amazon.co.uk or as part of simple photography kits for children.)
- UV-sensitive objects, such as photosensitive strips that change colour to indicate when the amount of UV radiation received has exceeded a safe level for skin, or photosensitive beads (from suppliers such as http://www.amazon.co.uk or http://www.philipharris.co.uk).

(For this activity a UV sensor/meter is inappropriate.)

Describe the method you have chosen to students, and include any safety instructions from manufacturer guidelines for purchased materials. Then ask students to use Activity Sheet 2 to help them plan and carry out their investigation. Students will need to decide how to 'save' results from different tests so that they can be compared later. Anything that is still sensitive to light after a test could be recorded by photography or by comparison with a colour chart. Some students may need help considering other variables for control, such as where to carry out the test (ideally away from sources of shadow), and how quickly results are fixed or recorded at the end of a test.

Resources (per student or group): Students may suggest a range of resources in their plans. You will need to consider what is available and to direct students to suitable alternatives if necessary. These resources may include: UV-sensitive materials, e.g. newsprint paper plus opaque folder for storing test papers before and after tests, 'sunprint' paper plus water in suitable container for fixing paper at the end of a test, or UV-sensitive object plus method for recording results at end of test; stopclock or watch; pen or pencil to mark details on test papers; Activity Sheet 2.

Should we cover up?

Exploring Science link: 8A

This activity will enable students to debate the benefits, drawbacks and implications of using sunscreens, using the contexts of production of vitamin D in the skin and the link between UV exposure and skin cancer. Tell students that they are to prepare for a debate on whether we should follow government guidance on applying sunscreens, particularly sunblocks (high SPF sunscreens), on sunny days, or whether there are drawbacks with using sunblocks that should also be considered.

Remind students of the importance of vitamins in the diet by asking them to name a vitamin and to describe the symptoms of dietary deficiency of that vitamin. Introduce vitamin D as one of the few vitamins that are made in the body, although there are also dietary sources. Also mention rickets, the disorder caused by a deficiency of vitamin D, and link this to the role of vitamin D in the body. Then introduce the suggested link between UV radiation and skin cancer using the Student Booklet or other sources. Note there are other health and environmental concerns with sunscreens mentioned in the booklet. Students may wish to include these in their research and discussion.

Ask students to choose one side of the argument for or against using sunblocks and to research information that will help support that argument. For example he World Health Organisation has useful information about UV and health on their website: http://www.who.int/uv/health/en/index.html. Skills Sheet 41 *Debates and speaking* supports this. When students have had time to complete their research, they could carry out the debate, work as a class to produce a table that shows the benefits, drawbacks and implications of using sunscreens or write a paragraph about the issue for a booklet on health guidance for children.

2 Sunscreens

Underwater sunburn *Exploring Science* link: 8E

This activity gives students an opportunity to plan a simple experiment as a group, concentrating on some of the elements of plan design. Ask students to consider whether being in water affects your risk of getting sunburnt or not. The sections in the Student Booklet on what causes sunburn and how hippos make a natural sunscreen might be a useful introduction for this.

Students might suggest that water reflects and possibly absorbs UV radiation, in which case the deeper you are in water, the less UV radiation you will receive. Ask them then how they would design an experiment to investigate how deep you would need to be in water to be safe from sunburn. Suggest simple methods for measuring UV radiation, such as a UV sensor/meter or photosensitive plastic beads.

Encourage discussion about various aspects of the plan, such as whether a transparent container for the water will affect UV transmission. This should introduce the idea of testing out various possible methods to find the most suitable before completing the plan and carrying it out. Students could also consider what is meant by a 'safe' level of UV radiation in this instance. If there is time and opportunity, ask them to find secondary data from books or the Internet to answer this query.

Testing SPF factors *Exploring Science* link: 8K

This activity is a good opportunity to explore how radiation (in this case UV) is blocked (reflected or absorbed) or transmitted through a material. Use the information in the Student Booklet on how active ingredients in sunscreens work to introduce this.

Provide students with a range of sunscreens with different SPF factors, and a method for measuring the amount of UV radiation, such as:

- Each sunscreen could be smeared on to a piece of plastic film that is then placed between a UV source and a UV sensor/meter, to measure UV transmitted. The sensor/meter could also be placed on the other side of the film to measure UV reflected.
- Photosensitive beads or paper could be placed into separate clear, transparent plastic bags or boxes (this must be done away from UV sources) and each sunscreen applied to a bag. The bags are then exposed to a UV source, e.g. outside in sunlight, for a fixed time.

Students may need to be reminded in each case to set up a 'control'.

If students use sunlight as the source of UV, remind them that they should never look directly at the Sun.

students to explain their results in terms of how light is blocked (reflected or absorbed) and transmitted through each type of sunscreen. If appropriate for your students, extend this to discuss the relationship between particle size and reflection, and how absorbed energy is re-emitted at a different but 'safe' wavelength (such as infrared).

Resources (per student or group): range of sunscreens with different SPF factors (ideally select those with different organic and inorganic active ingredients, and include a white 'sunblock'); apparatus for detecting UV, e.g. UV meter or photosensitive beads or paper; UV source, e.g. UV lamp or sunlight; plastic bags; stopwatch or stopclock.

Do sunscreens cause cancer? *Exploring Science* link: 9A

This activity gives students the opportunity to consider the difference between simple correlation of factors and causal correlation. Ask them to read about the link between UV exposure and skin cancer in the Student Booklet. Then introduce the idea of correlation with an obviously spurious example, such as a sensationalist article: '**Ice-cream causes sunburn!** Scientists have shown that as ice-cream sales increase, the number of cases of sunburn increases.' Students should realise easily from this that, although the two factors are correlated, one is not the cause of the other because an unmentioned third factor (sunshine) is involved.

Then give students the following (true) correlation: Several scientific studies have shown that malignant melanoma (a form of skin cancer) is more common in people who use sunscreens than in non-users. Ask them to work in groups to discuss the statement and suggest as many possible explanations for the correlation as they can. Obvious answers include: people who use sunscreen are more likely to spend more time outside than non-users; there may be chemicals in sunscreens that cause cancer; some chemicals in sunscreens may increase the amount of damaging UV getting to cells.

If there is time and opportunity, allow students to research the different suggestions (Wikipedia http://en.wikipedia.org/wiki/Sunscreen_controversy may provide a useful starting point.) Ask students to collate what they find into a presentation (e.g. poster or short essay) to answer the question 'Do sunscreens cause cancer?'

Plastic for sunglasses

Exploring Science **link: 9H**

This practical activity focuses on making predictions using the context of finding suitable plastic for UV-protective sunglasses. Introduce the activity using the section in the Student Booklet on the need to wear sunglasses to protect eyes from excess UV radiation. Then give students Activity Sheet 3.

Students will start by sorting through the plastic samples and making a prediction about which sample they think will be the best at blocking UV radiation. Take time over this stage of the activity, encouraging students to work in groups or as a class to discuss their ideas and to make sure they can produce a scientific reason to justify their prediction. Emphasise the link between a hypothesis and a prediction, and if they have difficulty with making the distinction suggest some suitable phrasing to help. For example, they could use 'depends on' when writing hypotheses, and 'If … then …' for predictions. So the hypothesis 'The UV-blocking ability of a plastic depends on the amount of tint in it' could lead to the prediction 'If the amount of tinting is increased then the amount of UV passing through it will be reduced'.

Students can test the UV-blocking ability of the plastic samples in different ways. A UV sensor is ideal, but students will need to do a pre-trial to find the best distance between the sensor and the sample to give repeatable results. Photosensitive materials can be used instead, but students will need to consider how to measure the 'end-point' and record results (see *Measuring UV radiation* above). Using a UV lamp inside will give a consistent source of UV, but if the sky is clear then working outside in sunshine will give the activity more relevance.

If there is time, students could also test a range of sunglasses that state their level of UV protection to see if the manufacturer's claims are correct.

If students use sunlight as the source of UV, remind them that they should never look directly at the Sun, even with the protection of UV-blocking materials.

Resources (per student or group): apparatus for measuring UV radiation, such as a UV sensor/meter or UV-sensitive materials that respond quickly to UV (e.g. 'sunprint;' paper or photosensitive beads); selection of plastic samples/sheets, if possible include a range of clear plastics of different types, also tinted or coated plastics; source of UV radiation, e.g. UV lamp or outside in the Sun; Activity Sheet 3.

Calculating a UV index

Exploring Science **link: 9J**

This activity links to work on satellite monitoring. It is a data-handling activity that gives students an opportunity to set up and use equations in a spreadsheet program. Activity Sheet 4 supports this.

Ask students to read the sections on UV monitoring and the UV index in the Student Booklet. Note that the method used by national meteorological offices to calculate the UV index is more complex than this, but the principle is the same. More information about the UV index can be found at http://www.who.int/uv/intersunprogramme/activities/uv_index/en/index.html and http://www.epa.gov/sunwise/uvicalc.html.

Then ask students to use Activity Sheet 4. Some students may need help in setting up their spreadsheets and using the Equation tool.

Resources: access to computer and spreadsheet program; Activity Sheet 4.

1 Comparing sunscreens

Displaying data in charts or graphs can help us to see any patterns more clearly, especially when we have a lot if data to compare. Bar charts, pie charts and line graphs are each best used in different circumstances. Choosing the right type of chart or graph for displaying data is important in making patterns obvious.

The table shows the formulations of some sunscreens. The ingredients are measured in grams.

Ingredient	Sunglow	Tropicalis	Bronzwell	Safetan	Sunblok
cetyl alcohol	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g
benzophenone-3	1.5 g	1.5 g	0 g	3.0 g	4.5 g
ethylhexylmethoxy-cinnamate	0 g	3.0 g	1.5 g	1.5 g	4.5 g
stearic acid	4.0 g	4.0 g	4.0 g	4.0 g	4.0 g
glycerin	2.0 g	2.0 g	2.0 g	2.0 g	2.0 g
stearyl dimethicone silicate crosspolymer	10.0 g	10.0 g	10.0 g	10.0 g	10.0 g
triethanolamine	1.0 g	1.0 g	1.0 g	1.0 g	1.0 g
water	78.0 g	78.0 g	78.0 g	78.0 g	78.0 g

1 Look at the table and identify the two active ingredients in all these sunscreens. (Remember that different sunscreens are made to protect against different amounts of UV, and it is the active ingredients that give protection.)

2 Consider the best way to compare the different amounts of active ingredients in each of the five sunscreens. Draw a chart or graph to show the differences as clearly as possible.

3 Now consider the best way to show the proportions of all the different ingredients in Sunglow. (Hint: a calculator will be useful for this.) Draw a chart or graph to show the proportions as clearly as possible.

2 Measuring UV variation

The amount of ultraviolet (UV) radiation that reaches the Earth's surface varies for many reasons. It varies during the day as the Sun's position changes in the sky. It also varies during the seasons in places that are not near to the Equator. Dust and clouds can also block UV radiation from the Sun so that it doesn't reach the Earth's surface.

You are going to plan and carry out an investigation to find out how UV radiation varies at different times of day, and possibly also at different times of year.

Your teacher will explain how you will measure the amount of UV radiation in each test. Take note of any safety issues with the materials you will be using, and make sure you work safely.

In your plan, you will need to consider some or all of the following:

- what other equipment is needed
- which conditions to test
- if repeat tests are needed for each condition.

In particular, you will need to think about:

- what will be the 'end point' of each test – e.g. how long it takes the UV-sensitive material to change to a particular colour, or what colour is produced after a fixed length of time
- how to 'fix' or record the result of a test so that you can compare results from different tests later – this is important if the UV-sensitive material remains sensitive to light after the test
- what other variables may affect test results, and how to control these as far as possible.

When you have written your plan, show it to your teacher who will tell you whether or not you should carry out your plan.

Activity courtesy of the Nuffield Foundation

3 UV-blocking plastic

Sunglasses are often made of plastic, to make them light and comfortable to wear. Different plastics transmit different amounts of UV radiation, so manufacturers have to test many types of plastics to select the best type for making their sunglasses. Tinted coatings may also be added to the plastic – sometimes to make the glasses look more stylish, and sometimes to make the glasses better able to block UV light.

You will be given a selection of plastics to test, to see how much UV radiation they transmit.

Safety

<u>Never</u> look directly at the Sun. Some sunglasses provide high-UV protection, but it is better to avoid the risk of damaging your eyes even if they are protected.

Apparatus

apparatus for measuring UV – you teacher will explain how to use what has been provided
selection of plastic samples
source of UV radiation

Method

A Look through the plastic samples and identify differences between them. Try to arrange the samples according to these differences.

B Use the differences to write a hypothesis about which property of the plastic you think is most likely to affect its ability to block UV (e.g. its thickness, colour, texture). You could start your hypothesis with this phrase: 'The ability of plastic to block UV radiation depends on …'.

C Using your hypothesis, make a prediction about which sample you think will be the most effective at blocking UV radiation. To help you write your prediction you could use the structure 'If… then…', for example 'If the [factor in the hypothesis] is increased, then the amount of UV radiation transmitted through the plastic will … '. Remember to explain your prediction using your hypothesis.

D Your teacher will explain how you are to test the samples. You may need to practise with the apparatus a few times, to make sure you can produce repeatable results with a sample.

E Test each of your samples in the same way and record your results. If you are working outside in sunlight, take several readings with each sample to allow for variation in UV from the source.

Recording your results

1 Draw up a table to display your results clearly.

2 If you took several readings for a sample, calculate an average reading and record that in your table.

3 Use a graph or chart to display your results so that you can clearly see any pattern. For example, arrange the samples in order of effectiveness at blocking UV radiation.

Considering your results/conclusions

4 Describe any pattern in your results.

5 Using the properties of the plastics, try to explain any pattern in your results. Use this to draw a conclusion about which properties of plastics affect their UV-blocking ability.

6 Compare your conclusion with your prediction and comment on any similarities or differences.

Evaluation

7 Identify any difficulties you had with this experiment. Suggest what you could do another time to avoid these difficulties.

4 Calculating a UV index

Weather forecasts in many countries now give UV index predictions in addition to the usual factors such as temperature or rainfall. These UV predictions are intended to be clear, simple guides to how much protection we need against UV radiation.

Many factors are considered when preparing the UV index and some countries use slightly different ways of calculating it. One method is described below.

- Three wavelengths of UV are chosen across the range of UVA and UVB: 290, 320 and 400 nm.
- The ***UV strength*** for each wavelength is a calculation of how strong the UV will be at ground level. The calculation takes into account the amount of ozone in the atmosphere and the sunlight angle. Shorter UV wavelengths are better absorbed by ozone than longer wavelengths and so shorter wavelengths have a lower UV strength number.
- Shorter wavelengths cause more sunburn than longer ones. So each wavelength is 'weighted' to give a value of how much damage it causes. To do this the UV strength value is multiplied by a proportional damage factor that is higher for more damaging (shorter) wavelengths.

An example for a particular spot on the Earth's surface is shown in the table, where the UV strengths have been predicted for a particular day and time:

Wavelength	UV strength	Proportional damage factor	Weighted 'damage' value
290 nm	4	15	60
320 nm	26	5	130
400 nm	30	3	90

The ***total UV effect*** is the sum of all these weighted values, in this case 280. This is then adjusted for height above sea level, because intensity of radiation increases by about 6% for every kilometre above sea level. So if at sea level we use a height factor of ×1.0 (this leaves the UV effect factor unchanged in the equation below), then at 1 km above sea level the height factor would be ×1.06.

The total UV effect is also adjusted for cloud – the more cloud there is, the less UV reaches the ground. No cloud lets all UV reach the ground (we use a factor of 1.0 for this in the calculation), while heavy cloud may only transmit around 30% (giving a factor of 0.3 for the calculation).

If the place we were predicting for was 1 km above sea level and clouds allowing the transmission of 65% of the UV, the total UV effect would be adjusted like this:

$$\underbrace{280}_{\text{total UV effect}} \times \underbrace{1.06}_{\text{height effect}} \times \underbrace{0.65}_{\text{cloud effect}} = 192.9$$

This value is then scaled by dividing by 25 and rounded to the nearest whole number, giving us a ***UV index*** of 8. Compare this with the information in the Student Booklet to see what it means.

Set up a spreadsheet to calculate the UV indices for the following data. Use the proportional damage factor for each wavelength from the table above. You should use cell formulae where possible to speed up the calculations. Use your results to suggest whether a high, medium or low SPF factor sunscreen would be most appropriate to use in each case.

Place	Strength			Height above sea level (m)	Cloud effect as % UV transmission
	290 nm	320 nm	400 nm		
Bondi beach	5	28	32	0	100
London	3	22	27	0	95
Snowdon	3	21	26	1000	25

SS16

Hazard symbols

Many things around a lab have special signs on them warning you of danger. The signs in diamonds below are internationally agreed symbols that you might find on chemicals:

This symbol warns that a chemical may harm your health if you do not use it properly. The word ‘irritant’ might be found near this symbol and means that the chemical may give you a rash if you get it on you or make you choke if you breathe it in.

This symbol tells you that a chemical is corrosive. It will attack your skin if you get it on you.

This symbol tells you that a chemical can cause a serious health problem if you breathe it in (e.g. an allergic reaction, an asthma attack, breathing difficulties).

This symbol warns you that a chemical is flammable. It catches fire easily.

This symbol warns you that a chemical is oxidising. This means that it can provide a source of oxygen for a fire and make the fire worse.

This symbol means that a chemical is poisonous (toxic). Poisons can kill.

This symbol warns you that a chemical is very poisonous to water organisms. Chemicals like this should not be released into the environment.

You may also see warning signs like this:

This is a general warning sign. It may be placed in an area where there is some broken glass or a spilt chemical. Or it may just remind you to be particularly careful when doing something or using particular pieces of equipment or chemicals.

This symbol means that there is a risk of getting an electric shock.

This ‘biohazard’ symbol means that there is a certain living thing in an area that may make you ill.

Some symbols tell you to do things so that you stay safe:

This symbol reminds you to wear safety glasses or goggles when working in a certain area or using particular pieces of equipment or chemicals.

This symbol reminds you to wash your hands after you have done an experiment.

I CAN... • assess risk • plan a safe investigation

SS59 Taking notes from science writing

When you are reading about science and gathering information, such as for writing a report, it is a good idea to take notes. Good notes can help you:

- organise the information you find
- make sure you have covered all the important points
- focus on the key points and ignore unnecessary detail.

Using your own notes will also help you write a report in your own words. This is much better than copying someone else's words as it shows how well you understand what you are writing about.

Skimming and scanning

The first time you read a text, skim through it quickly. Look for:

- main ideas – these may be shown by headings
- key words – what the text is really about
- how the text is structured – from simple to more complex ideas, from old to new (different authors use different approaches in different kinds of writing).

Then scan through the text more slowly to look for any specific information that you need. While you are reading, keep in mind what information you are looking for. If your text is printed out, you may be able to highlight anything useful using coloured pens or pencils.

Making organised notes

When you are scanning, take notes of important ideas that will be useful for your writing. Organising your notes as you make them will help you later. Here are a few ways to organise your notes.

Timeline

If your information needs to be organised chronologically, use a timeline to note key points.

Explain how advances in technology have helped scientists to understand how cells work.

1590
first light
microscope

1665
Robert Hooke
sees plant
cells with
microscope

1833
Robert Brown
sees nucleus
in cells

Table

If you need to organise your notes into a few categories, then a table might be more useful.

Describe advantages and disadvantages of friction in cars.

Advantages	Disadvantages
brakes – allows car to slow down	car working parts – causes overheating
between road and types – allows car to grip the road	brake pads, tyres, engine parts – wears things away

SS59 Taking notes from science writing

Lists with headings

If you have a lot of information that can be grouped into several categories, a list with headings can be useful. This makes writing a report easier because you already have the headings for your report.

Describe how environmental conditions differ in woodlands, deserts and the Arctic.

Environmental conditions

1 Woodlands
  temperature – quite steady
  water – lots
2 Deserts
  temperature – extreme between night and day
…

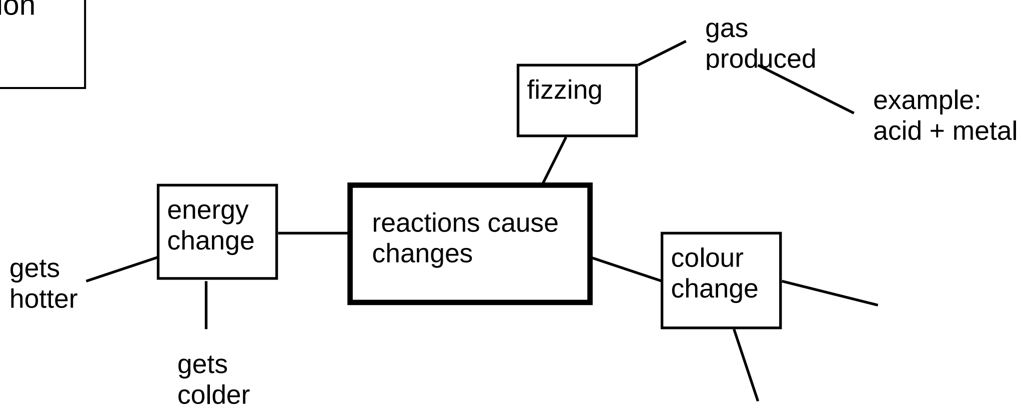
Concept maps

If the information cannot be organised easily, then a concept map can be the most useful way of recording notes. This makes it easier to add new groups of notes to those that you have already recorded.

Concept maps can easily get cluttered, so start with a clean sheet of A4 and write the title for your report in the middle.

- Add ideas as branches to the map.
- Try to group similar ideas and link them with lines or arrows.
- Use just one or a few words for each note, to keep the map as tidy as possible.
- Highlight the most important idea in each group – these can make good headings for your writing.

Explain how we can tell when a reaction has happened.



I CAN... • take notes • structure my notes