



# *SSERC* *Bulletin*

No. 234 ■ Winter 2010/11

Ideas and Inspiration supporting Science & Technology for all Local Authorities

*Clock Face Designing: Software review*  
*Know an exceptional science technician?*

*Higher Pitched*

*Health & Safety - Mercury in Schools*

*Alternative Photography*

*Effervescent Enzymes!*

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Anyone who has designed a clock face using a CAD system would know the problems of firstly deciding a diameter for the dial, then constructing the 12 x 30° hour positions (showing off using polar coordinates!) deciding on the hour text/graphics then trying to obtain the correct position and so on. Now this process has become a lot easier thanks to Ekits Clock Designer Software (version 4). This costs £14.95 for a single copy, £49.95 for a site licence version. See [www.ekitsonline.com](http://www.ekitsonline.com)

What strikes us about this software is the ease at which its use would fit into a graphics lesson applying the principles of colour theory, for example, clock faces



Figure 1 - Design possibilities.

could be designed with an emphasis on primary, secondary or tertiary colours. Analogous, triad, warm and cool colours can all be explored using this software giving quick printouts of clock dials. Dials may then be discussed, compared and contrasted. Dials may be printed out (large (195 mm), medium (170 mm), cd size (120 mm) and custom size for graphics use, or for the actual manufacture of a clock in the craft workshop. A 12 page Macromedia Flash player file give details of how to build your clock is provided.

Clock faces can be very quickly designed, printed and built using this software (Figure 2). They can be based on a library of backgrounds or by using your own photographs/illustrations (Figure 1).

The CD has two help guides available in pdf format, a 2 page 'quick start guide' and a 16 page 'User Guide'. Helpfully the software contains a series of printable pupil worksheets (Figure 3).

Version 4 of the software is available with 188 backgrounds, 29 pictures, 64 division styles and 150 number styles. This may be further enhanced with your own photographs and graphics.

### Conclusion

This software provides cheap, quick and easy clock face designing for all pupils. Pupils can investigate colour theory but also manufacture a useful clock based on a quartz movement. Dials may be personalized using photographs of family, holidays or pets. Software already provides a useful range of background graphics and photographs. Supporting worksheets based upon the theme of 'time' for pupil use are available on the CD. The software has limited but useful configuration possibilities.



Figure 2 - Make a clock – easy as 123.



Figure 3 – Example of a worksheet.

Software runs on a Windows based PC with either Windows 2000/XP, a minimum of 64 Mb ram and 64 Mb free HD space. Software ran successfully on a Windows 7 platform.

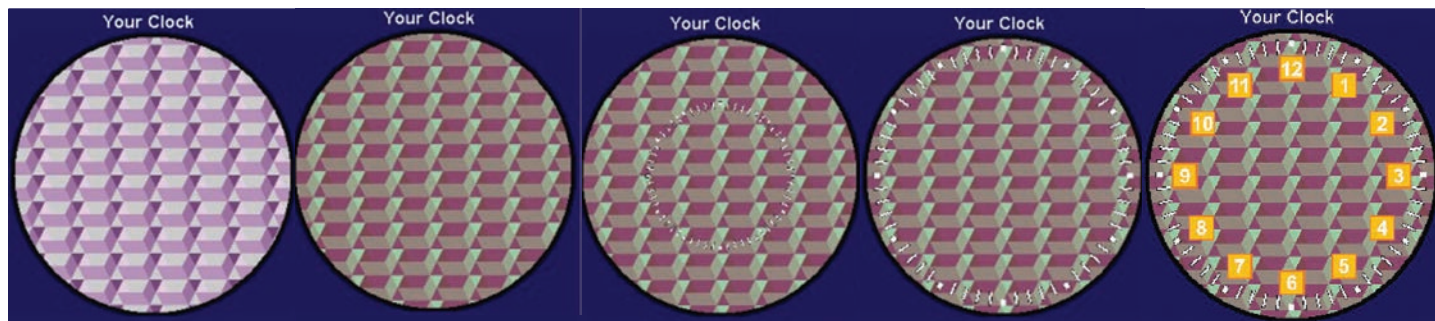
The ability to save clock face designs is limited to an internal 'ekits clock file' format (.ekf), however, using the 'Windows' control icon on the design interface, then selecting 'file' the image can be exported as a bitmap (.bmp) file. The bitmap image displayed before saving does shows clock hands, but only the dial is saved as a bitmap file for further use or processing.

### Links to Curriculum for Excellence Technologies – experiences and outcomes:

Early  
 ■ 'I explore software and use what I learn to solve problems and present my ideas, thoughts, or information' **TCH 0-03a**

## The Design Sequence:

1. Add a Background (scale if necessary)
2. Modify Colour
3. Select Division Style
4. Scale divisions
5. Add and Scale the Number Style



### First/Second

■ I can create, capture and manipulate sounds, text and images to communicate experiences, ideas and information in creative and engaging ways. **TCH 1-04b / TCH 2-04b**

■ I explore materials, tools and software to discover what they can do and how I can use them to help solve problems and construct 3D objects which may have moving parts. **TCH 1-12a**

■ I can use drawing techniques, manually or electronically, to represent objects or ideas, enhancing them using effects such as light, shadow and textures **TCH 2-15a**

### Third

■ I enhance my learning by applying my ICT skills in different learning contexts across the curriculum **TCH 3-04a**

■ By using problem-solving strategies and showing creativity in a design challenge, I can plan, develop, organise and evaluate the production of items

which meet needs at home or in the world of work **TCH 3-14a**

■ Having explored graphical techniques and their application, I can select, organise and represent information and ideas graphically **TCH 3-15a**

### Fourth

■ I can approach familiar and new situations with confidence when selecting and using appropriate software to solve increasingly complex problems or issues **TCH 4-03a**

■ I can use ICT effectively in different learning contexts across the curriculum to access, select and present relevant information in a range of tasks **TCH 4-03b**

■ Throughout my learning, I can make effective use of a computer system to process and organise information **TCH 4-04a**

■ I can create graphics and animation using appropriate software which utilises my skills and knowledge of the application **TCH 4-09b**

■ I can confidently apply preparation techniques and processes to manufacture items using specialist skills, materials, tools and software in my place of learning, at home or in the world of work. **TCH 4-13a**

■ Showing creativity and innovation, I can design, plan and produce increasingly complex items which satisfy the needs of the user, at home or in the world of work **TCH 4-14a**

■ When developing or enhancing representations of ideas or items, manually or electronically, I can apply my knowledge of colour theory, justifying the choices I make **TCH 4-15b**

■ I can confidently use appropriate software to represent my ideas and items in the world around me, showing creativity, imagination or innovation **TCH 4-15c**

■ I can understand and use computer aided design/ computer aided manufacture, exploring its applications **TCH 4-15d**

## Know an exceptional science technician?

Congratulations to Rosemarie Hogg of Fortrose Academy who has won a Salters' National Award for Science Technicians. Rosemarie says she was "astonished" to learn that she had been chosen for the honour and continues, "As sole Science Technician, my job is enjoyable, varied and interesting – never boring! It is rewarding work and science staff have always been most appreciative of my efforts."

Nick Forwood of the Academy's physics department is certainly appreciative. "She is very unassuming and really feels that she is not

different from many other science technicians," he tells us, "however, we all know differently! "

In 2011 The Salters' National Awards for Science Technicians enters its eight year and is now annual. The Awards are open to Science Technicians in schools and colleges catering for students 1) up to age 18, and 2) Science Technicians with five or more years experience.

The aim of the Awards is to acknowledge publicly the immense contribution that Science Technicians make to the well-being and success of schools

and colleges and, in particular, to Science Departments. The Salters' Institute, who run the award scheme, hope very much that the Awards will heighten the awareness of the importance of Science Technicians to education in this country. The closing date for nominations is 1 March 2011. If you know a technician who fits their criteria then please nominate them for an Award. Further information and a nomination form can be obtained by visiting the Salters Institute website [www.saltersinstitute.co.uk](http://www.saltersinstitute.co.uk) or by contacting the Publicity Co-ordinator on Tel: 020 7628 5962 ext. 260 or Email: [publicity@salters.co.uk](mailto:publicity@salters.co.uk)



An experiment on the Doppler Effect for the new Higher Physics qualification.

Teachers have made it clear that the new content in the forthcoming course should be supported by practical work. Here we look at an experiment on the Doppler effect that could be used in the Cosmology part of the Our Dynamic Universe unit.

For a full guide to the experiment, showing how to use the Audacity software to analyse sounds, please go to our website [1].

You will need: a computer running Audacity [2], a computer microphone and a Doppler Ball or similar [3]

Place the Doppler ball beside the microphone and switch the ball on. Record a few seconds of the sound made by the ball using Audacity. You should see something that looks like Figure 1 appear.

Select part of your recording and follow the instructions in the downloadable guide to analyse the frequency of the sound (Figure 2).

Another way to find the frequency of the sound is to zoom in on a recording like the one shown in Figure 1. Keep zooming until individual waves can be seen, then use the time scale to find the time for, say, ten waves. From this, the frequency can be found.

Now place the microphone on the floor. Swing the Doppler ball to-and-fro, so that it passes close to the microphone at its



Figure 1 - A typical recording.

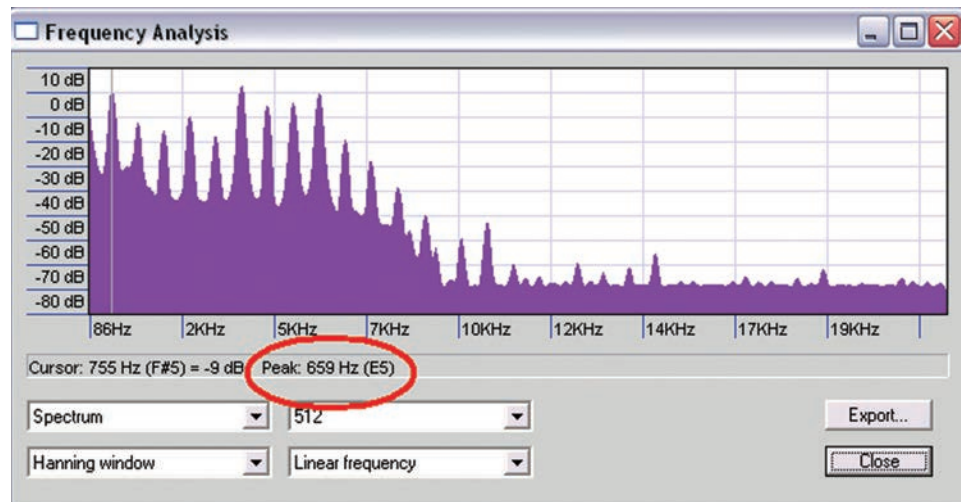


Figure 2 - analysing the frequency of the sound.

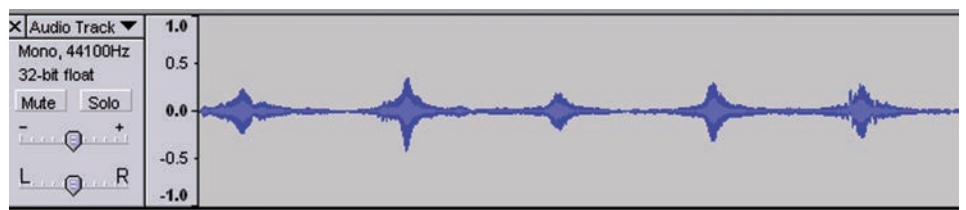


Figure 3.

lowest point. Doppler Balls are usually whirled around the head, but we found that using one like a pendulum gave better results for this experiment. Record a few seconds of sound. Your recording should look like the one shown in Figure 3. Each time the pendulum approaches and passes the microphone, we see that the sound gets louder, then quieter. We need to show that the frequency changes too. Select one of the sound segments and zoom in on it until it looks like the image in Figure 4.

Select an area before the peak, as shown in Figure 5.

Find the frequency of the sound using the method illustrated in Figure 2. This

frequency should be greater than the frequency of the sound from the stationary ball. Repeat for the sound after the peak. The frequency here should be smaller than the frequency of the ball when it was at rest. The method of finding the time for ten waves to get the new frequency was less satisfactory in the situation where the frequency had been Doppler-shifted.

Figure 6 below shows the formula for the frequency shift.

$$f = \frac{v}{(v \pm v_s)} f_s$$

A number of issues relating to the use of mercury in schools have recently come to light and which need some clarification.

In September's School Science Review (SSR) [1] it was stated that mercury in schools is banned.

The ASE Safeguards Committee, on which SSERC is represented, has written to the SSR to assure them that it is not. Through SSERC SafetyNet [2], we advise that wherever possible you try to find an alternative but if there is none then you may continue using mercury as recommended in the Uses & Control Measures [3].

There was an incident in a Scottish school recently where a mercury thermometer fell off the wall where it was mounted and the bulb broke, spilling the mercury. Although the amount was very small it still had the potential to form concentrations of toxic vapour in the atmosphere which would be many times more than is safe. Matters were complicated by the fact that, having broken on a carpet, it was not cleaned up properly. Problems were further compounded when a school cleaner then used a vacuum cleaner. Not

only did this risk spreading the mercury more widely, it meant that the vacuum cleaner had to be disposed of as well as the carpet.

We would therefore remind everyone that any mercury spillage, no matter how small, should be cleared up carefully as advised on the SSERC website [4]. Furthermore, we would suggest that it is not a good idea to have mercury-containing devices mounted on walls in classrooms (or elsewhere in schools) and that any should be replaced with devices not containing mercury.

Perhaps a reason for the premature announcement in the SSR is the consultation that is taking place by ECHA (European Chemicals Agency) on behalf

of European Commission regarding the banning of mercury in measuring devices within the EU. The consultation closes on 24th December but it seems almost certain that such a ban will indeed come in to force in 2014. You can view a summary of the proposals [5] or if anyone has time on their hands and wishes to read through the full proposals on the ECHA website [6].

The main impact for most schools will be on mercury usage in thermometers and barometers. There may be a delay in implementation of the regulations for these devices but, even if not, there are no plans to force establishments to dispose of mercury containing devices they already possess. It will merely be impossible to buy new ones.

## References

- [1] School Science Review, *Faraday's rotating wire – the homopolar motor: time to update?* by Geoff Auty, September 2010, Vol.92, No. 338, p116.
- [2] <http://tinyurl.com/HazChem-mercury>
- [3] <http://tinyurl.com/HazChem-UCM-mercury>
- [4] <http://tinyurl.com/HazChem-spillage-mercury>
- [5] [http://echa.europa.eu/doc/restrictions/info\\_note\\_hg\\_in\\_measuring\\_devices\\_en.pdf](http://echa.europa.eu/doc/restrictions/info_note_hg_in_measuring_devices_en.pdf)
- [6] [http://echa.europa.eu/doc/restrictions/annex\\_xv\\_restriction\\_report\\_mercury\\_en.pdf](http://echa.europa.eu/doc/restrictions/annex_xv_restriction_report_mercury_en.pdf)

## ► Figure 6 – Doppler Effect formula

Where:

$f$  is the observed frequency  
 $V$  is the speed of sound  
 $V_S$  is the speed of the sound source  
 $f_S$  is the frequency of sound emitted by the Doppler Ball.

This can be used to estimate the speed of the ball as it approached the microphone. Other methods can be used to verify this speed, for example conservation of energy.

Note that a Doppler Ball gives out a fairly pure tone. We have yet to try this experiment with a buzzer unit but suspect that the tone produced might be too messy to use.

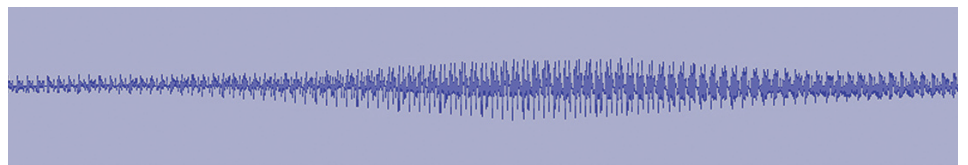


Figure 4.

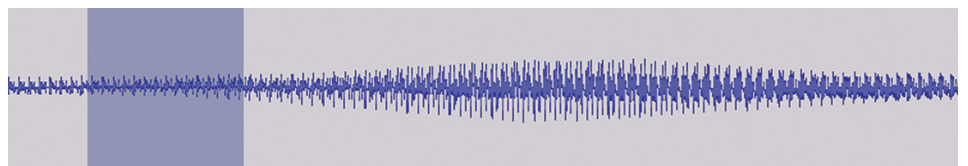


Figure 5.

## References

- [1] <http://tinyurl.com/Higher-Pitched>
- [2] [http://www.sserc.org.uk/members/SafetyNet/bulls/218/Audacity\\_intro.htm](http://www.sserc.org.uk/members/SafetyNet/bulls/218/Audacity_intro.htm)
- [3] Lascells Doppler Ball, available from Timstar, product code SO76360, Instruments Direct, product code PH103240 - [http://www.indes.co.uk/physics/doppler\\_ball.htm](http://www.indes.co.uk/physics/doppler_ball.htm)

### Introduction

Since the beginnings of civilisation, human beings have had an urge to create art, and for as long as they have had this urge, they have harnessed science in its assistance. From Neolithic man's utilising the pyrolysis of wood to create charcoal for his cave paintings to the myriad of synthetic pigments available to the artists of today, science, in particular chemistry, has been an indispensable assistant.

In no field has this been more the case than that of photography; an art form that has had enormous impact on our civilisation. Our record of the late 19th century is much richer and more complete than that of the early 19th century, in part because of the use of photographs to document historic events, places and people.

### History of photography

The story of photography really begins with the camera obscura (ca. 1580 AD). This was a dark room with a lens mounted in one wall which projected a scene onto the opposite wall. An artist could sit in the room and trace the image to produce a very accurate record of the scene. You might want to take a trip to the one in Edinburgh [1], next to Edinburgh Castle. Rather than concentrating on the optics of producing a temporary image, here we look at the development (sorry!) of the chemistry involved in making these images longer lasting.

Beaudelaire described photography as a 'bastard child left by chemistry on the doorstep of art'. A bit harsh, perhaps but he has a point. The conception of this child was probably in 1725 when Johann Schulze discovered that silver nitrate was light sensitive. A sheet of paper soaked in silver nitrate would turn black wherever light hit it as silver ions were reduced to silver metal. The image was not fixed, however, in the sense that when the photograph was brought into daylight, the whole image would turn black.

It took a gestation of almost 100 years though for the prodigal child to come to term. In 1819 William Herschel discovered that sodium thiosulphate (known then as hyposulphite, hence the photographer's term 'hypo') was found to remove the unexposed silver halides, leaving a permanent or "fixed" image behind.

The first photographic process was invented by Joseph Niépce around 1822, which he used to make the earliest known permanent photograph. The process, called Heliography, used bitumen, as a coating on glass or metal, which hardened in relation to exposure to light. When the plate was washed with oil of lavender, only the hardened image area remained. (Figure 1).

The first widely used photographic processes were developed independently in England and France and both used silver compounds. In 1834, Henry Fox



**Figure 1** - The first successful permanent photograph. View from the window at Le Gras (1826)  
[http://en.wikipedia.org/wiki/View\\_from\\_the\\_window\\_at\\_Le\\_Gras](http://en.wikipedia.org/wiki/View_from_the_window_at_Le_Gras)

Talbot created permanent (negative) images using paper soaked in silver chloride and fixed with a salt solution. He then created positive images by contact printing onto another sheet of paper. In 1837, Louis Daguerre created images on silver-plated copper, coated with silver iodide and "developed" with warmed mercury. The Daguerrotype was initially more popular but soon the ability of Fox Talbot's negative process to allow production of numerous prints from a single negative made it the dominant process and the basis for all photography until the rise of modern digital imaging.

Silver processes were improved continuously throughout the 19th and early 20th centuries. Silver bromide replaced the earlier silver chloride and iodide processes beginning in 1885. Today almost all photographic film consists of silver bromide on acetate film. Almost all photographic paper is silver bromide on various papers.

### Alternative processes

As we have discussed, most photography is based on silver salts as the light-sensitive agent. For the classroom, however, these processes have a few drawbacks, not the least of which is the cost of the silver-based reagents. There are, however, several non-silver processes that were developed in the early days of photography and it is these that are of more interest to the chemist-photographer.



John Heinrich Schulze.

William Herschel.

John Heinrich Schulze.



Platinotypes are based on platinum chloride – hardly a cost-cutting reagent! Gum bichromate is a process growing in popularity but it uses dichromates, which are on SSERC's restricted chemicals list and are not generally recommended for use in schools, so we'll leave that alone. Cyanotype and Anthotype processes, though, are more promising, using respectively light-sensitive iron and botanical compounds.

## Cyanotypes

This was yet another process invented by William Herschel, also in 1842. It uses iron salts to create a blue pigment – Prussian blue. The blue colour was its weakness from the point of view of popularity with the public but the images were stable, clear and easy to make and proved a big hit in the reproduction of architectural drawings – hence the word 'blueprint'.

There has been a renewed interest in this process over recent years and there are dozens of different recipes. Most of them



**Figure 2** - A cyanotype image showing brush stroke and shadows of the paper clips that held it in place.



**Figure 2** - A cyanotype image showing brush stroke and shadows of the paper clips that held it in place.

## Fisch's ferro-prussiate

### Advantages

Easy to do and relatively cheap. Images are stable

### Disadvantages

Images have a pronounced blue cast

(though they can be easily stained by e.g. tea)

### Method

1. Dissolve 145.5 g of iron(III) (ferric) chloride in 100 cm<sup>3</sup> of water. (This is close to being a saturated solution so will take some dissolving)
2. Weigh 25 g of 2,3-dihydroxybutanedioic acid (tartaric acid) and dissolve in 100 cm<sup>3</sup> of water
3. Mix solutions 1. and 2.
4. Add up to 47 cm<sup>3</sup> ammonia (0.880), stirring constantly, until neutral – Health & Safety data from Hazardous Chemicals [2]
5. Label this Solution A.
6. Weigh 20 g of potassium hexacyanoferrate(III)-3-water (ferricyanide) neutral – Health & Safety data from Hazardous Chemicals [3] and dissolve in 72 cm<sup>3</sup> of water.
7. Label this Solution B.
8. Add all of solution B to solution A with constant stirring.
9. When it is cool, pour into a dark bottle and store in the dark until use.
10. This should give about 275 cm<sup>3</sup> – enough for around 50 A4 sized sheets – depending on paper.
11. Use a brush or sponge to coat your paper and allow to dry in the dark.
12. Sandwich your negative against the paper (hold in place with a clip frame – or even Sellotape@!)
13. Place the picture in direct sunlight for about 15 minutes (some experimentation will be needed)\*
14. Remove and wash the paper in cold running water until all the yellow, unreacted salts are gone. Allow to dry.
15. If you want to speed it up, expose for a much shorter time (2-3) minutes and soak in vinegar (distilled malt vinegar) before washing)

are based on iron(III) ammonium citrate though the newer ones use iron(III) ammonium oxalate. These are not chemicals commonly found in a school chemistry store and, while less expensive than silver salts, they are not especially cheap to obtain.

There is, however, an alternative – Fisch's ferro-prussiate – which we have been testing with some degree of success.

## Anthotypes

This long neglected process, originally invented by Sir William Herschel in 1842, is extremely simple. An emulsion is made from crushed flower petals or any other light-sensitive plant, fruit or vegetable. A coated sheet of paper is then dried, exposed to direct full sun-light until the image is bleached out. The process does have a couple of disadvantages (see p8).

## Negatives

Thanks to modern technology, negatives are now quite easy to produce. Take any image you like and use a photo editing

program to convert it to black and white and then invert the colours. This can then be printed onto acetate film by an ordinary printer found in any school.

If you don't have access to bespoke software such as Adobe's Photoshop, there is a free program called Paint.Net available online which will do all sorts of things for you – including making negatives.

Or you can simply get pupils to draw patterns on an acetate sheet using felt pens (or even a polythene document sleeve) and use those as negatives - or even cut out silhouettes from paper.

## Paper

The choice of paper seems to be quite critical for the Gum bichromate and Cyanotype processes. Ordinary A4 will not work! The cheapest viable option seems to be watercolour paper: available fairly inexpensively from many suppliers – or talk nicely to your school's art department.

**Anthotypes****Advantages**

very easy, very cheap

**Disadvantages**

It is rather slow (exposure typically takes 1-3 days or more depending on conditions). The images fade when exposed to bright light

**Method**

1. Take a flower (Research is still ongoing. Red roses work but very slowly. According to [alternativephotography.com](http://alternativephotography.com), red poppies or peonies work well, as do the leaves of laurel, common cabbage and some grasses)
2. Crush the plant material to a fine pulp in a pestle and mortar adding distilled water (or alcohol) as you go.
3. Filter the liquid.
4. Coat a sheet of paper with your emulsion and let it dry in the dark
5. Contact print your picture. A clip frame is an easy, cheap way to keep your negative in place. – or you can simply use Sellotape®.

*By exploring radiations beyond the visible, I can describe a selected application, discussing the advantages and limitations.*

**SCN 3-11b**

*I have collaborated in activities which safely demonstrate simple chemical reactions using everyday chemicals. I can show an appreciation of a chemical reaction as being a change in which different materials are made.* **SCN 2-19a**

*Through experimentation, I can identify indicators of chemical reactions having occurred. I can describe ways of controlling the rate of reactions and can relate my findings to the world around me.* **SCN 3-19a**

*I have collaborated with others to find and present information on how scientists from Scotland and beyond have contributed to innovative research and development.* **SCN 3-20a**

**Higher**

These reactions could slot into Unit one of the higher, either in part i) Following the course of a reaction or more specifically in part ii) Factors affecting the rate of a reaction where it is specifically recommended to demonstrate a photochemical reaction

**Cross-Curricular links**

Art: as a form of photography, there are obvious links e.g.

*I have experimented with a range of media and technologies to create images and objects, using my understanding of their properties.* **EXA 3-02a**

Technology: as well as obvious links with ICT in the production of negatives there may well be opportunities for further links – making the paper that the prints are made on for instance.

**Conclusion**

Here at SSERC we have only recently started looking again at these interesting and largely neglected processes. The cyanotype in particular seems to have some interesting possibilities, as well as some interesting chemistry, so you can look forward to something more on this at some stage in the near future.

**Light**

Most research has been done on the Cyanotype process. The peak sensitivity of the reagents in this process is in the near ultraviolet (UV) (around 475 nm). Sunlight is a convenient source of UV (indeed, daylight on a cloudy day will work too, albeit with longer exposure times).

The Gum bichromate process is also UV sensitive. As for the anthotypes, we have yet to determine but it would seem likely that it will vary depending on the particular pigment.

**Educational value**

1. This provides an opportunity to demonstrate, in an entertaining way, a photochemical reaction.

2. As these processes are relatively slow – the cyanotype reacts over a few minutes – it can provide a method for looking at reaction rates of a photochemical reaction

3. Because the cyanotype process works with UV light, it provided a method of investigating UV exposure or sunscreens. (Take an acetate sheet, put stripes of different sunscreens or different dilutions of sunscreen on and expose).

**Links to Curriculum for Excellence (CfE)**

*By exploring reflections, the formation of shadows and the mixing of coloured lights, I can use my knowledge of the properties of light to show how it can be used in a creative way.* **SCN 2-11b**

**References and resources**

[1] <http://www.camera-obscura.co.uk/>

[2] <http://tinyurl.com/HazChem-ammonia>

[3] <http://tinyurl.com/HazChem-Kferricyanide>

Alternative photography.com – as the name suggests, a website dedicated to renewing and refining all sorts of old, forgotten photographic processes.

<http://www.alternativephotography.com/wp/>

Project Vedos – a project carried out at Satakunta University of Applied Sciences / Fine Art, Kankaanpää, Finland. Its main goal is to study and teach alternative printing processes in photography and printmaking. <http://193.166.40.90/>

Cyanotype: Mike Ware Alternative Photography – Dr Ware is the undoubted expert in the chemistry of this long-neglected process. Most research will lead back to him eventually so take a short cut.

<http://www.mikeware.demon.co.uk/index.html#anchor930646>

Anthotype

<http://www.apug.org/forums/forum42/42719-anthotype-questions.html>

<http://photo.net/black-and-white-photo-film-processing-forum/00ILXh>

Gum Bichromate (plus a load of other interesting projects)

<http://cavemanchemistry.com/oldcave/projects/photo/index.html>



## Background

Enzymes, by virtue of the myriad of functions with which they are involved, are necessary for life. Consequently, studying enzymes and the roles which they play continues to be an integral part of many science curricula. In that regard, Curriculum for Excellence (CfE) is no exception and one of the Sciences Experiences and Outcomes at Level 4 [1] relates to practical work involving measurement of enzyme properties:

*I have taken part in practical activities which involve the use of enzymes and microorganisms to develop my understanding of their properties and their use in industries. [SCN 4-13b]*

In this short article, we present an experimental protocol that we believe to be both robust and accessible and which, therefore, should prove useful in supporting the delivery of outcome SCN 4-13b. Further experimental details will be made available on the Science 3-18 website [2]. The protocol which follows is adapted from one produced by Roger Delpech of the Haberdashers' Aske's Boys' School - the original article can be downloaded from the SAPS website [3].

The enzyme *catalase* is found in nearly all aerobic cells (animals, plants and microbes). The function of catalase is to protect the cell from the harmful effects of hydrogen peroxide which is generated as a by-product of cell metabolism. Catalase speeds up the breakdown of hydrogen peroxide into molecular oxygen and water.



The following protocols use a very simple yet elegant method to demonstrate the above reaction. When filter paper discs are added to hydrogen peroxide they initially sink to the bottom of the container. If, prior to their immersion in the hydrogen peroxide solution, the discs have been in contact with a source of catalase (for example, if they have been soaked with suspensions of living cells or in contact with living tissue) oxygen will be produced. Some

of this oxygen becomes trapped in the fibres of the filter paper making the discs buoyant and they eventually float to the surface of the solution. The time taken for the discs to rise to the surface can be used as a measure of reaction rate and hence the amount of catalase present.

## Experimental

We suggest here two ways of using this technique:

- investigating whether living and non-living materials contain catalase
- investigating the effect of catalase concentration on the rate of reaction

### Catalase activity in living and non-living materials

The aim of this activity is to provide a simple method by which students can investigate catalase activity from a number of sources including living (plant and animal) and non-living materials. By pooling class results, students should be able to conclude that (i) catalase is found only in materials which contain live cells, and (ii) the activity of catalase varies depending on the source selected.

- We recommend a control experiment in which a piece of filter paper, which has not been in contact with any of the samples to be tested, is added to a Universal bottle containing 20 cm<sup>3</sup> of 1% hydrogen peroxide solution (IRRITANT). The disc should sink to the bottom and remain there.
- Using a scalpel or a knife make a fresh cut on the surface of plant or animal material to be tested. Using tweezers hold a filter paper disc against the test surface for 10 seconds and then add the disc to



curriculum for excellence:  
sciences  
experiences and outcomes  
[www.curriculumforexcellencescotland.gov.uk](http://www.curriculumforexcellencescotland.gov.uk)



the Universal bottle containing 1% hydrogen peroxide solution. The disc will sink to the bottom. However in this case if oxygen is produced, indicating catalase activity, the disc will float to the surface. Students need to be ready to time how long it takes the disc to float to the surface. Alternatively the time taken for a disc to rise a given distance could be used for measurement (this would be particularly useful if catalase levels in a given sample were low).

- Further trials using a variety of plant or animal or non-living surfaces can then be undertaken.
- Students can design a table for results and make comparisons of catalase activity in living / non-living materials and plant / animal tissues. Table 1 shows previously published results for a variety of plant materials [3].

Catalase activity present		Catalase activity absent
apricot	parsnips	apple
banana	potato	citrus fruits
cherry	radish	peaches
broccoli	red cabbage	rhubarb
carrot	turnip	tomato
cucumber	fresh flowers	senescent flowers
onion	leek	

**Table 1** - Catalase activity in some fruit and vegetables (taken from [3]).



**Figure 1** - A single drop of a 1% suspension of yeast has been added to a filter disc and then placed in a 1% solution of hydrogen peroxide. Photographs were taken at (approximately) 3 s (A), 8 s (B) and 13 s (C).

Liver contains a lot of catalase and this can be related to the role of the liver in the removal of toxins from the body. It would be interesting to use a variety of different animal tissues (e.g. kidney, muscle) and make comparisons of catalase levels. However, it is worth noting that the biological significance of catalase is quite complex; for example it appears that some organisms deficient in catalase can survive with little or no harmful consequences [4]. Some additional information on the role of catalase in plants is available [5].

### The effect of catalase concentration on the rate of reaction

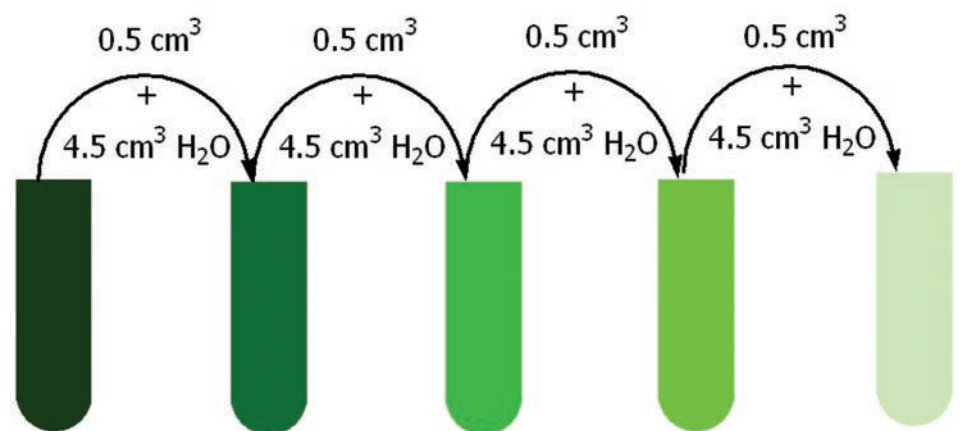
The aim of this activity is to provide a method by which students can investigate the effect of increasing catalase concentration on the rate of breakdown of hydrogen peroxide. Yeast or algal suspensions are convenient sources of catalase.

Figure 1 shows a set of images when a drop of a yeast suspension has been added to a filter paper disc and placed in hydrogen peroxide solution.

The concentrations of yeasts and algal suspensions can be easily varied. It is reasonable to assume that the greater the concentration of the yeast or algal

suspension the more catalase would be present in a fixed volume and so the concentration of yeast or algae can be used as a measure of enzyme concentration. In the protocol that follows we will only refer to suspensions of the alga *Scenedesmus quadricauda*.

For this protocol we recommend that your students carry out a serial dilution from a starting stock of algae. Depending on the year group with which you decide to use this activity the extent of explanation you give will be important; for example with 'Higher' students carrying out the serial dilutions could be done as part of an investigation.



**Figure 2** - Preparation of serial dilutions from a stock solution of *Scenedesmus quadricauda*

Bearing in mind that you will need only small volumes of material for the assay you will not need to prepare large volumes of each dilution.

We recommend making dilutions to 5 cm<sup>3</sup> although smaller volumes would, in most cases, be entirely adequate. So 0.5 cm<sup>3</sup> of a stock solution is diluted to 5.0 cm<sup>3</sup> with water and 0.5 cm<sup>3</sup> of that solution is further diluted to 5.0 cm<sup>3</sup> etc. (shown schematically in Figure 2)

- A pipette is used to place one drop of the algal suspension on to a filter paper disc - clearly more accurate measurements of the volume added would add rigour to the experiment.

- Using tweezers add the disc to a Universal bottle containing 1% hydrogen peroxide solution. The disc will sink to the bottom. If oxygen is produced, indicating catalase activity, the disc will float to the surface. Students need to be ready to time how long it takes the disc to float to the surface.

- The process is repeated with the range of serial dilutions.

- As a control, the process should also be repeated with a drop of water on a filter paper disc.

- Pupils can record their data in tables and graphs and draw conclusions about enzyme activity against concentration.



Learning and Teaching Scotland has informed us that they are making resources available on line to support the new Higher science qualifications. Some of the materials have been developed with substantial input from SSERC. We look forward to having a good look at everything on offer when we have appropriate access.

The new CfE-inspired Highers in Biology, Chemistry, Human Biology and Physics will be available for early adoption in Scottish schools from June 2011. Learning and Teaching Scotland (LTS) have commissioned resource writers to produce a wide range of support materials for these new qualifications. These customised support materials will be presented in a variety of engaging, modern formats including scientific animations, short films, Powerpoints, interviews and web-links, as well as a range of more traditional paper-based resources. The materials will be accessed from the National Qualifications website [1]. Latest news of developments may be found on the National Qualifications Sciences blog [2] and resources on the

National Qualifications Sciences Glow Groups [3]. Theoretically, Glow users will be able to access all the Sciences Glow Groups but we, at present, cannot.

## Higher Biology/ Higher Human Biology

The following resources have been produced for both the Biology and Human Biology courses:

- Extensive teacher support notes covering the whole course.
- A wide variety of active learning activities.
- Nine 'case studies' on topical issues. These case-studies are either practical-based or research-based or involve studying first-hand experimental data. An example of a practical case-study on PCR, which was developed with support from SSERC, is already available in the Biology Glow group. Full details may be seen in SSERC Bulletin 233, Autumn 2010 [4]
- An 'Evolution' support pack adapted for the new Higher from an Edinburgh University resource.
- A skills development resource on effective web research in Biology.



Figure 1 - National Qualifications Support at LT Scotland

## Higher Chemistry

- A teacher support pack on the new style 'Open-ended questions'.
- Three topical 'Researching Chemistry' support packs looking at areas such as biodiesel, antioxidants and alcohols. Each support pack consists of a teacher's guide, a technician's guide and a pupil's guide containing a selection of possible investigative activities. The support of SSERC in developing these resources is gratefully acknowledged.
- Five skills development resources on 'carrying out web-based research', 'planning and carrying out an experiment', 'processing and analysing data',

▶ The data in Table 2 show the time taken for filter paper discs to float to the surface after the addition of 1 drop of a given algal suspension. We contend that this is a nice experiment and one which offers enormous scope for further investigation (some suggestions are included in [3]).

Concentration of algal stock (%) (undiluted stock = 100%)	Time (s)
100	*
10	21
1	85
0.1	160
0.01	270

Table 2 - 1 drop of a given dilution of *Scenedesmus quadricauda* was added to the surface of a filter paper and placed into a Universal containing 1% hydrogen peroxide solution. The time taken for the filter paper to float to the surface was recorded. \*The catalase activity in the undiluted stock was such that the filter paper did not sink to the bottom of the Universal.

## Summary and Conclusions

The method for the assay of catalase as described in this article offers scope for practical work at various levels of the secondary sector. A full range of curriculum links is available at [www.science3-18.org](http://www.science3-18.org). The resources required to undertake the practical are minimal and should be readily available / accessible to schools and colleges.

## References

1. Curriculum for Excellence: Sciences - Experiences and outcomes – available at <http://www.ltscotland.org.uk/learningteachingandassessment/curriculumareas/sciences/eandos/index.asp> (accessed 1st December 2010).
2. Science education 3-18 website - <http://tinyurl.com/Effervescent-Enzymes> (accessed 13th December 2010); please note that to access the full suite of resources on this website a log-in ID is required.
3. Delpech, R. (2003) Microscale Investigations with Catalase – available at <http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/SS24.pdf> (accessed 4th December 2010).
4. Catalase - available at <http://en.wikipedia.org/wiki/Catalase> (accessed 5th December 2010).
5. Dann, L. Why do plants produce the enzyme catalase? Available at <http://www-saps.plantsci.cam.ac.uk/records/rec580.htm> (accessed 4th December 2010).

## Technical Details

1. Hydrogen peroxide is readily available from chemical suppliers.
2. The filter papers used were Whatman AA (13 mm) and purchased from Fisher Scientific. With an educational discount a pack of 1000 discs costs approximately £30. However, other filter papers will also work and can be conveniently cut to size with a cork borer or similar.

- ▶ 'writing a scientific communication' and drawing conclusions and evaluating'.
  - Additional notes for teachers plus PowerPoint presentations to support new content areas.
  - A series of animated PowerPoint presentations to support the 'Periodicity, Polarity and Properties' unit.
  - A PowerPoint plus a set of pupil questions with answers to exemplify a new style of exam question from the 'Consumer Chemistry' unit.

## Physics

- A teacher support pack on the new style 'Open-Ended Questions'.
- Two topical 'Researching Physics' support packs looking at seismology and skin-cancer. The support of SSERC in

developing these resources is gratefully acknowledged.

- Additional teachers' notes on areas of new content.
- Pupil questions covering the whole course, with answers provided.
- Pupil summary notes.
- Suggested lessons across all course content, including lessons to develop specific transferable skills.

The new resources are being shared via the 'National Qualifications Sciences' Glow group as soon as they become available, to allow early-adopting schools to prepare for the new Higher curriculum. Subject-specific Glow groups within the main NQ Sciences group also provide opportunities to share and discuss news, information and good practice (via the blog and the forum), as well as to look for CPD opportunities.

Resources are also being published on the appropriate subject area of the National Qualifications site [1] on the LTS website in their finalised form.

## References

- [1] <http://www.ltscotland.org.uk/nationalqualifications/>
- [2] <http://ltsblogs.org.uk/nqscience/>
- [3] <https://portal.glowscotland.org.uk/establishments/nationalsite/NationalQualificationsGroup/NQSciences/default.aspx>
- [4] <http://www.sserc.org.uk/members/SafetyNet/bulls/233/PCR/PCR.htm>

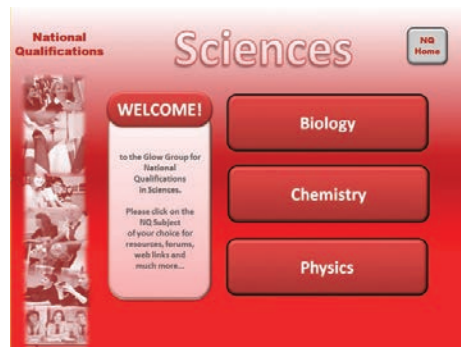


Figure 3 - National Qualifications Sciences Glow Groups

In addition, practitioners are encouraged to regularly check the NQ Sciences blog for latest news updates and information relating to the new Highers [2].

Many of the new resources being produced to support the CfE-inspired Highers could also be appropriately used in the delivery of the current Higher Sciences, and teachers are encouraged to familiarise themselves with what is available at the earliest possible opportunity.

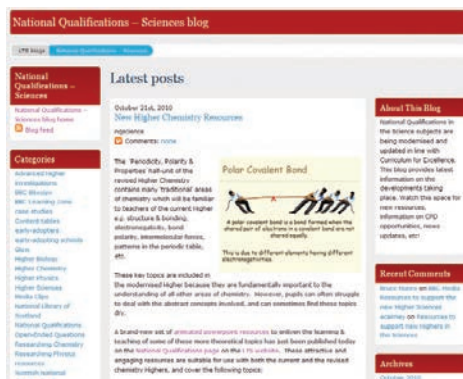


Figure 2 - National Qualifications Sciences Blog

## Websites and publications round up (precede each web address with http://)



[www.science3-18.org](http://www.science3-18.org) – Curriculum Resources and CPD



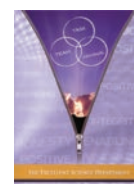
£25 +VAT from SSERC



distributed to schools



[tinyurl.com/DS-Equipment](http://tinyurl.com/DS-Equipment)



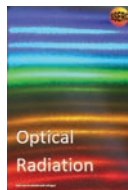
available free from SSERC



[www.science3-18.org/sserc](http://www.science3-18.org/sserc) – Health & Safety and Bulletins



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