SSERC Bulletin

Ideas and inspiration supporting science and technology for all Local Authorities

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Increased space at SSERC!

Teachers and technicians who have been to SSERC on courses or just to pop in for advice have probably been in either our meeting room or laboratory, the latter being slightly larger than most school labs in order to accommodate 20 adults.

On September 17th, Dr Alasdair Allan MSP, Minister for Learning, Science and Scotland's Languages opened a new building that greatly enhances our training space. Unit 1, Pitreavie Court had been empty for some time. With considerable support from our local authority partners, in particular Fife and South Lanarkshire Councils, and through funding from the Wellcome Trust, Myscience and the Scottish Government, SSERC was able to lease and refurbish this building.

Just as the SSERC lab in Unit 2 can be thought of as a slightly scaled up school laboratory, the ground floor of the new building has been turned into a scaled up school technology area with the space and machinery to run training for technical education teachers and technicians. The ever-popular Safe Use of Workshop Machinery can now be run in-house, complemented by new courses in Hot Metal Working and Digital Design.

The upper floor has an area that can accommodate large meetings and support primary science and technology professional development, making it possible to accommodate the sorts of numbers of course participants that would previously have required the hire of a hotel function room. Also on the upper floor is

a permanent Glow studio with video facilities. SSERC's interactive "Cookalong" Glow CPD has proved to be very popular but until now has necessitated the speedy construction and subsequent packing away of a temporary studio in Unit 2. The opening event allowed representatives of many of SSERC's partner organisations to not only visit the new facility but to see elements of our experiential CPD courses for themselves. In a short speech, Dr Allan praised the work of SSERC and emphasised the importance of STEM to the Scottish economy.

Demonstration corner

Colour mixing

Figure 1 *- Lightsticks-lanyards are just visible (image taken from http://www.glow.co.uk/six-inch-glowstick.html).*

A number of methods are available to demonstrate mixing of different colours of light. One of the more intriguing methods that we have come across involves the use of so-called Lightsticks [1]. In order to try this demonstration out we purchased a range of different coloured lightsticks (also known as glow sticks) from The Glow Company (www.TheGlowCompany.co.uk).

Each of the lightsticks comes with a lanyard which can easily be removed leaving a convenient hole which allows lightsticks to be joined together. We have adopted the approach previously suggested [1]; using a combination of washers, nuts and a bolt it is possible to create an arrangement similar to that shown in Figure 2.

Once the lightsticks have been assembled as shown in Figure 2 they can be mounted in the chuck of a hand-held electric drill as shown in Figure 3. It is important to make sure that the sticks are firmly held in the drill.

Figure 2 *- Joining' the light sticks together. The angle between the sticks is set to be approximately 120º.*

Once the lightsticks have been 'activated' the drill can be switched on and its speed slowly increased. As the speed increases the colours of the lightsticks will blend together and eventually will appear 'white' in colour as shown in Figure 4.

Clearly different combinations of lightsticks could be used and observed colours compared with those predicted.

The chemistry of lightsticks has been explored on a number of occasions (for example see [2]). Briefly a dilute solution of hydrogen peroxide is mixed with a solution which itself contains a phenyl oxalate ester and a fluorescent dye. The peroxide and ester react to produce phenol and virtually all of the energy released is produced in the form of light.

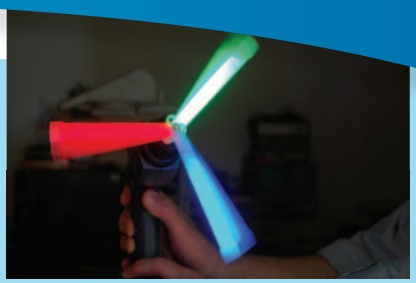


Figure 3 *- Lightsticks mounted in the drill assembly.*

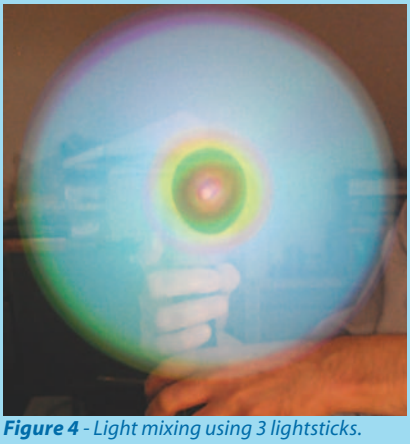


Figure 4 *- Light mixing using 3 lightsticks.*

Safety considerations

In the unlikely event of the lightsticks being released during the activity it is important that the drill chuck points towards an audience and that both the 'operator' and audience wear appropriate eye protection. The drill should only be operated at speeds sufficient to generate 'mixed' colour.

Curriculum links

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*.

Physics - National 3

Colour - 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.

Higher Chemistry

Periodicity, Polarity and Properties - Oxidising and reducing agents.
(b) Molecules and group ions can act as oxidising and reducing agents.

References

[1] Shakhashiri, B.Z. (2011), Additive Color Mixing in *Chemical Demonstrations: A Handbook for Teachers of Chemistry Volume 5*, pp 181-191, University of Wisconsin Press, Madison.

[2] Shakhashiri, B.Z. (1983), Lightsticks in *Chemical Demonstrations: A Handbook for Teachers of Chemistry Volume 1*, pp 146-152, University of Wisconsin Press, Madison.

Eutrophication - investigating the on the growth of

The broad theme of 'fertilisers and food security' in the new Scottish Curriculum was discussed in the previous edition of the SSERC bulletin. Activities about the effects of nutrient deficiency on plant growth and the use and design of fertilisers in food production were presented [1].

Learners need to understand that 'food security' is complex and there are no simple solutions to feeding the world's population in a sustainable way. The use of fertilisers is necessary to increase yield of food crops, but can also lead to a variety of environmental problems. A related theme, 'Human Impact on the Environment', also appears at various levels within the new science courses. 'Human Impact on the Environment' provides a context for learners to explore environmental issues relating to the use of fertilisers [2]. Coincidentally, the unusually balmy climatic conditions of summer 2013 highlighted a phenomenon associated with fertiliser use, making eutrophication very topical and relevant to learners!

Warm summers in Scotland are usually met with great delight and this year has been no exception. However the hot, dry weather also contributed to some unwanted effects in many of our fresh water lochs and ponds. Cyanobacteria and fresh water algae, which live in these ecosystems, increased in number sometimes causing blue-green, or green *blooms*. In some cases these blooms took the form of unpleasant looking scum, or floating mats of algae (Figures 1 and 2).

Algal blooms can occur when there is a combination of warm water (which is still or slow moving) and a high concentration of nutrients from sources like sewage or fertiliser run-off from local fields.
As well as looking and smelling unpleasant, algal blooms can cause health problems for those who come in direct contact with them. Cyanobacteria (blue-greens) in some blooms produce toxins which are dangerous to humans, dogs and many of the organisms which live in the water. At various locations throughout Scotland, notices such as that shown in Figure 3 were posted by local councils near to freshwater leisure facilities this summer.

This year algal blooms occurred in Strathclyde Loch resulting in it becoming unsafe for swimmers. Strathclyde Loch is the venue for the swimming stage of the triathlon event at the 2014 Commonwealth Games. There are, of course, concerns that we might have another warm dry summer next year and if an algal bloom occurred again it would pose problems for the Games organisers [3].

Figures 1 and 2 *- Algal bloom Biggar Pond, Summer 2013.*

effects of fertilisers an algal population

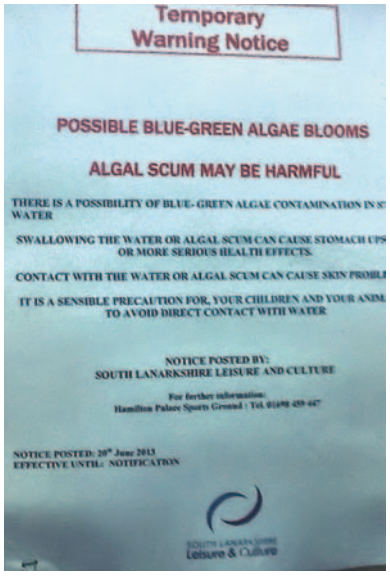


Figure 3 *- Notice posted at Biggar Pond, June 2013.*

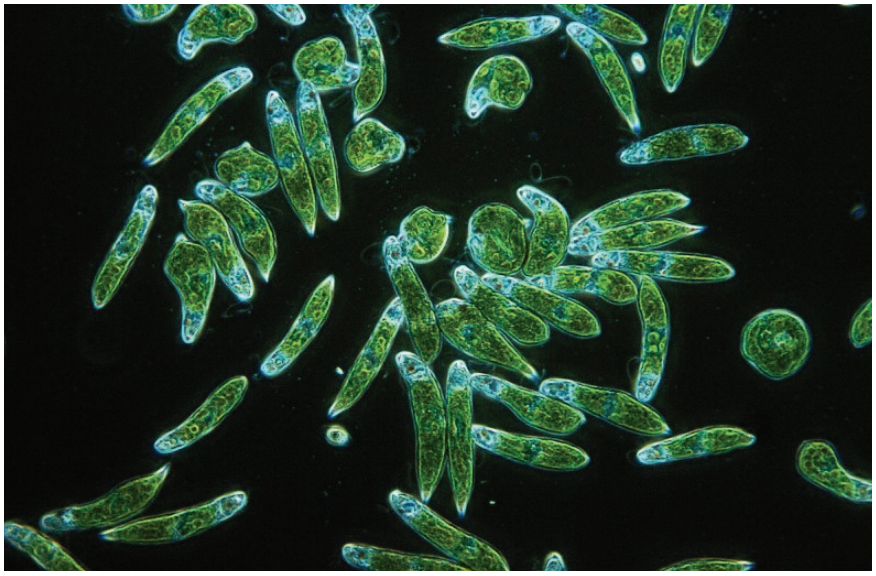


Figure 4 *- Image of Euglena gracilis (Wellcome images [5]).*

The increase in nutrient concentration that leads to algal blooms is known as *eutrophication*. Eutrophication is a process that happens naturally in some ecosystems. Eutrophication can also be increased by human activity when, for example, fertilisers from fields are washed into rivers, streams and ponds. Fertilisers are composed mainly of nitrogen, phosphorous and potassium and if these are washed by rain from fields into a waterway they will provide the additional nutrients which will lead to an increase in algal and plant populations. Warm weather exacerbates the problem by further promoting the growth of these populations leading to the kind of blooms we have seen this summer. Eutrophication can lead to a severe reduction in water quality. The organisms which make up algal blooms that form in high nutrient conditions live for only a short time resulting in large quantities of dead and decaying organic matter. The decay process involves rapid growth of bacterial populations which use up dissolved oxygen in the process of respiration. Levels of dissolved oxygen in the waterways are thus severely reduced and, being deprived of oxygen, fish and other organisms die.

The following practical activity investigates the effect of a plant fertiliser, *Baby Bio*™, on the growth of a population of algae. This classroom practical can serve as a model to represent algal blooms in a large body of water. The activity is adapted from a Society for General Microbiology protocol [4].
The alga used is *Euglena gracilis* (Figure 4) which is a common species of motile freshwater algae that can bloom due to the effects of fertilisers.

The effects of the plant fertiliser on the algal populations can be measured in two ways. By comparing the size of algal populations grown with and without fertiliser using a:

- colorimeter to compare absorbance of algal suspensions;
- light microscope to determine the concentration of algae.

Two populations of *Euglena gracilis* are set up. One population is grown in distilled water while the other is grown in a solution of plant fertiliser. The two populations are observed at regular intervals over a period of 3 - 4 weeks.

Materials

- Measuring cylinder
- 2 x conical flasks
- Distilled water
- Baby Bio™ (or other suitable liquid plant fertiliser)
- Colorimeter
- 2 x cuvettes
- 3 x plastic pipettes
- Access to a discard jar
- Culture of Euglena gracilis [6]
- Control cuvette 1 - containing distilled water. Control cuvette 2 containing fertiliser solution. (These should be retained and frozen after each colorimeter reading).

Method

Setting up the algal cultures

1) Label the conical flasks: Flask 1 - Distilled water; Flask 2 - Distilled water and fertiliser.
2) Put 250 cm^3 of distilled water into each flask.
3) Use a plastic pipette to put 3 drops of fertiliser into Flask 2.
4) Add 25 cm^3 of algal culture to each flask.

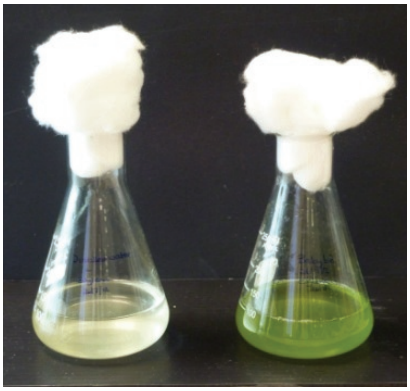


Figure 5 *- Euglena growing in distilled water (left) and in Baby Bio (right).*

Comparing the algal populations using a colorimeter

1) Use control cuvette 1 to calibrate the colorimeter for Flask 1 (665 nm). Retain the control cuvette to be frozen for use with subsequent colorimeter readings.
2) Gently swirl Flask 1 to mix the contents and, using a clean pipette, put 3 cm^3 algal suspension into a clean cuvette. Place the pipette in the discard jar.
3) Place the cuvette in the colorimeter, read and record the absorbance. Empty the cuvette back into Flask 1.
4) Repeat steps 1 - 3 using control cuvette 2 and Flask 2.

This process is repeated once per week for the next 3 - 4 weeks and the absorbance is used as an indication of the size of each of the algal populations. The greater the absorbance, the greater the number of *Euglena* present in the suspension. Changes in colour of the suspensions could also be photographed (Figure 5).

Comparing algal populations by observing hanging drops of the two cultures

In this activity a hanging drop of each culture is made and the *Euglena* are observed using a microscope (see Preparing a Hanging Drop Help Card SSERC website [7]). This method might also be used to compare the two populations each week for about 3 - 4 weeks (Figure 6 and 7).

Figure 6 *- Euglena grown in distilled water.*

Figure 7 *- Euglena grown in Baby Bio™.*

Figure 8 *- Algal bloom on Loch Leven.*

Figure 9 *- Algal bloom on Loch Leven.*

Eutrophication in Loch Leven - a case study

Loch Leven is the largest shallow eutrophic lake in lowland Scotland. From the 1800s, industries increased their demand for a more stable water supply from the loch. Surrounding landowners reclaimed land around the shores of the loch for agriculture. Over the years these activities caused algal blooms and reduced water clarity and biodiversity (Figures 8 and 9). With permission from the Centre of Ecology and Hydrology a case study, relating to the history of the ecology of the loch, has been adapted *(SSERC website link [8])*. In this case study learners are asked questions about the reasons why eutrophication occurred and how it has been managed and controlled. A copy of the original article is also available for teachers and for students, who might use this material as the basis for an assignment or project.

References

[1] SSERC 2013, *SSERC Bulletin 244*, Autumn 2013.
[2] SQA (2012). Course Unit Support Notes for new National Qualifications are available on the SQA website at http://www.sqa.org.uk/sqa/41328.html (accessed 21st September, 2013).
[3] *The Herald*, Saturday 24th August, 2013. Available at http://www.heraldscotland.com/news/home-news/toxic-algae-outbreak-raises-fears-for-2014-games-event.21956567.
[4] The Society for General Microbiology, 2012, *Algae: a practical resource for secondary schools.*
[5] Image available from Wellcome Images. Available at http://wellcomeimages.org/ (accessed 21st September, 2013).
[6] *Euglena gracilis* available from: *Sciento Organisms for Biological Sciences*. Available at http://www.sciento.co.uk/.
[7] The SSERC website is available at www.sserc.org.uk. Please note that to access all resources on the website you will need to register and be provided with a log-on ID and password. Available at http://www.sserc.org.uk/index.php/biology-2/biology-resources/biology-national-4149/n4-life-on-earth/3394-fertiliser-design-and-environmental-impact-of-fertilisers.
[8] The SSERC website is available at www.sserc.org.uk. Please note that to access all resources on the website you will need to register and be provided with a log-on ID and password. Available at http://www.sserc.org.uk/images/Biology/Life_on_Earth_Nat4/Eutrophication/Loch%20Leven%20for%20pupils.docx.

Curriculum links

National 4, Unit 3 Life on Earth

[4] Fertiliser design and environmental impact of fertilisers. Investigate the effects of fertilisers e.g. algal blooms.

National 5, Unit 3 Life on Earth

[5] Human Impact on the Environment
b. Fertilisers can leach into fresh water, increasing algal blooms. This leads to a reduction in oxygen levels.

Thermal imaging is cool

For the last three or four years, we have been showing teachers how to convert webcams to "see" into the infrared.

There are a good number of engaging activities that can be carried out with these devices, but we always ended up telling teachers that they won't pick up the radiation emitted by a person because its frequency is too low for a silicon sensor. "For thermal imagery," we'd say, "you need something costing thousands of pounds."

Now, we'd tell them something slightly different. The FLIR i3 (Figure 1), at £895 ex VAT, is not a device we'd dare describe as cheap when we know that some departments have around a tenth of this left from budgets after photocopying, but it is relatively inexpensive.

Figure 1 *- FLIR i3 thermal imaging camera.*

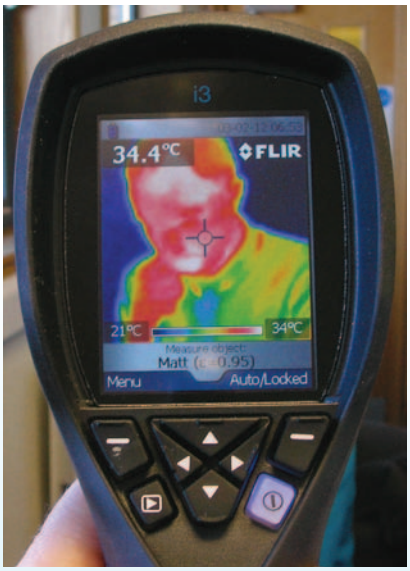


Figure 2 *- FLIR i3 screen.*

The i3 has a sensor called a microbolometer. Simplistically, each pixel is a resistance element that is highly sensitive to temperature. We are not talking megapixels here - our FLIR has a resolution of 60 x 60 pixels, or 3.6 kilopixels. It is sensitive to temperatures from -20 °C to 250 °C. Thus it covers body temperature and the temperature of one's surroundings. The camera displays images on a 2.8 cm LCD screen (Figure 2) and can take pictures on to a supplied memory card. It cannot be hooked up to a monitor to give large, real-time images. The i3's field of view is 12.5°. It can spot meter temperatures and claims an accuracy of ±2% or ±2 °C. Its image refreshes 9 times per second and the user can select from three different colour palettes. Reassuringly, it has been tested and found to be able to survive a drop of 2 m.

So what could it be used for? The obvious suggestion is to use it to look at heat loss from buildings (Figure 3), though children would need some help in interpreting results - for example, glass is opaque to this wavelength range.

We could also look at people (Figure 4) and discuss the use of thermal imaging in search and rescue and health care. Our tester climbed into a rubbish bag and was still visible to the FLIR i3.

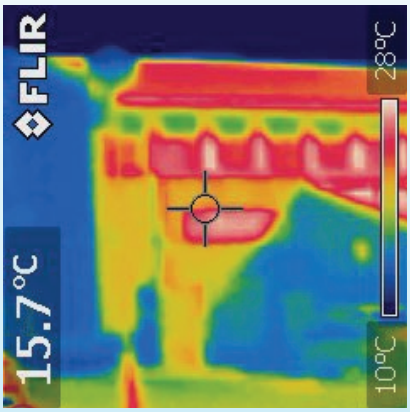


Figure 3 *- Which parts of our new building are not well-insulated?*

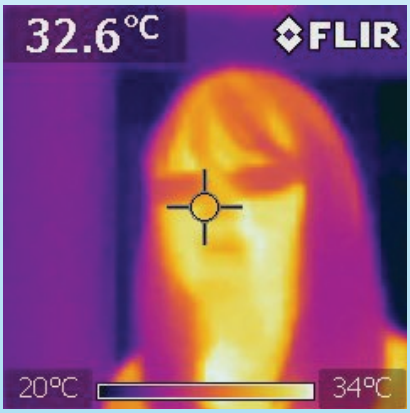


Figure 4 *- Is this the coolest person working at SSERC?*

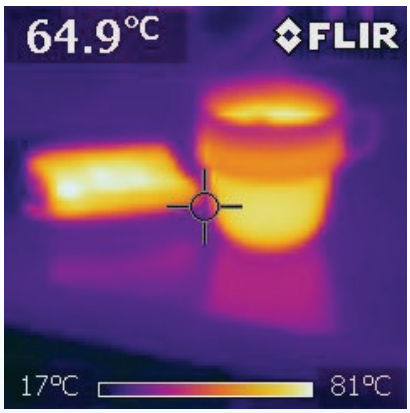


Figure 5 *- Tea and toast.*

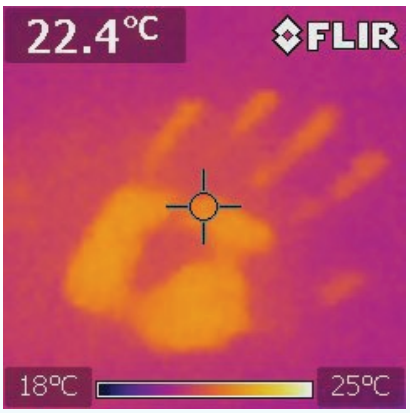


Figure 6 *- Hand print.*

Figure 5 shows some tea and toast. Children could design insulating containers for food or investigate the insulating properties of different materials by wrapping them around bottles of warm water.

Figure 6 is a hand print left by briefly touching a surface. Figure 7 shows friction heating caused by scuffing a foot on a carpet.

Figure 8 shows a car that has just stopped after a fair-sized drive. Note the warm tyres and hot brake discs. Note also that figures 3 and 8 use a different colour palette to that in figures 4, 5, 6 and 7.

And now to a matter of some delicacy and a series of tests, the story of which, like Sherlock Holmes' tale of the Giant Rat of Sumatra, the world is not yet prepared. Boys of school age, when given a thermal imaging camera, are going to sooner or later point it where they shouldn't. Our trials revealed nothing embarrassing. Whilst they were not extensive, you will understand our reluctance to use the phrase "small sample size." Our FLIR i3 came from Data Harvest [1]. We are considering lending it out to schools if they work with us to ensure its safe uplift and return.

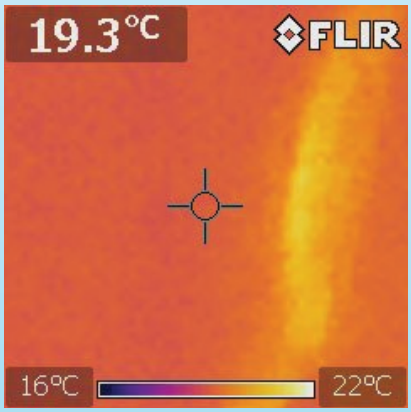


Figure 7 *- Friction heating of a carpet.*

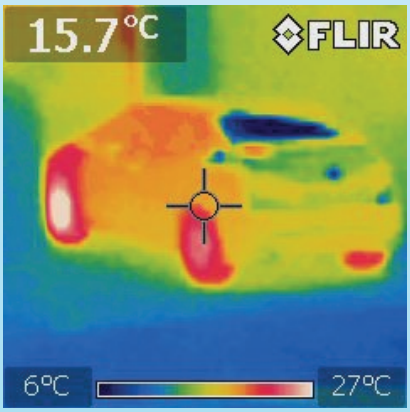


Figure 8 *- Warm tyres and hot discs.*

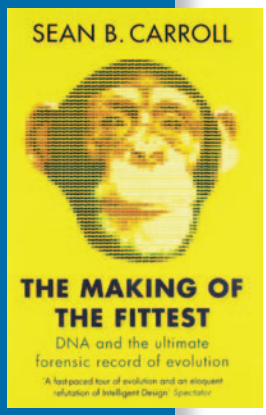
Reference

[1] www.dataharvest.co.uk

Book review

This is the first of what is planned to be an occasional series of reviews of 'popular science' books in biology. As a result of the new areas of biology that have been introduced to the revised and *CfE* Higher Biology, Higher Human Biology and Advanced Higher Biology courses these books can provide teachers with useful background to the new science they will encounter in these courses. Pupils can also be introduced to these books to extend their personal learning.

The Making of the Fittest - DNA and the ultimate forensic record of evolution by Sean B Carroll, Quercus, London, 2009.



This book is based on genomics and as such it relates well to the *DNA and the Genome* Unit of Higher Biology and the *Human Cells* unit of Higher Human Biology. It is also relevant to the *Organisms* and *Evolution* Unit of Advanced Higher Biology. The chapters in the book follow a theme and written in an essay type style making them suitable for reading in isolation or for using as excerpts to support lessons. Good use is made of interesting examples that illustrate the theory and could be used as mini case studies for pupils. Overall the text is accessible enough in style for students.

A fuller and more detailed review is available on the SSERC website (www.sserc.org.uk).

Digitising an image

A (possibly sad...) member of the SSERC Biology Team recently wanted to obtain the absorption spectrum of chlorophyll b in digital form. There are a number of ways by which this data set could be generated.

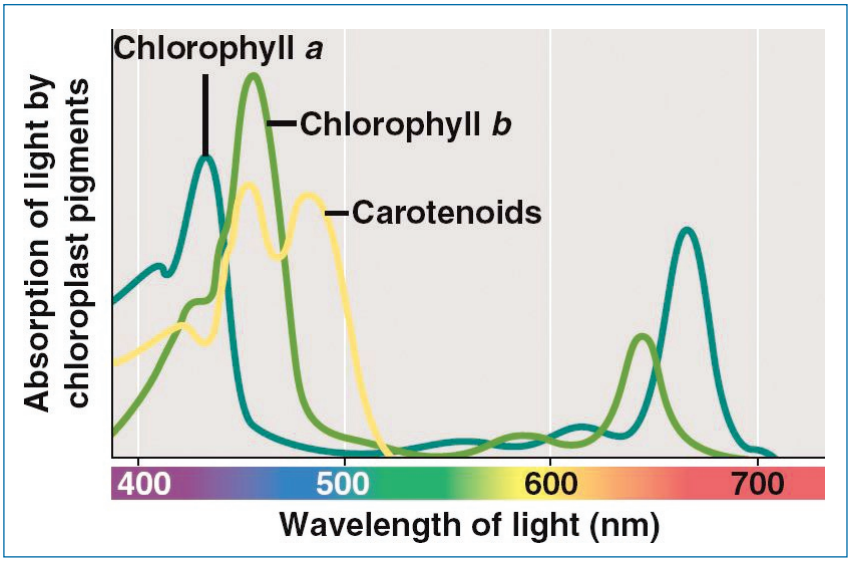


Figure 1 *- The absorption spectra of chlorophyll a, chlorophyll b and 'carotenoids' (adapted from http://www.glogster.com/austinprice2012/light-absorption-in-chloroplast/g-6ksfuqsdki8i206c2tmc1a0 - accessed August 28th 2013).*

Colorimeters, generally, are not suitable for the task since they do not offer sufficient observation wavelengths to allow good resolution. Additionally the standard cuvettes used in colorimeters and spectrophotometers are not very resilient to the 'normal' solvents (hexane, propan-2-one etc.) for chlorophyll.

The search, as is often the case, then moved to the web as a possible source of data. Entering the phrase 'chlorophyll absorption spectrum' into Google Images produces a plethora of wonderful images which can be downloaded. A typical image is shown in Figure 1.

The challenge now is how do you generate a set of data points which characterise each of the various curves shown in Figure 1?

Alternatively is it possible to generate a set of (x,y) coordinates for the curves? One option open to us is to use a graph paper/ruler combination. It is, of course, possible to download the image, increase its physical size and print it out and then with judicious use of a ruler (possibly a set-square?) generate a set of data points. Suppose you want data approximately every 2 - 4 nm this becomes a laborious process but clearly it can be done. An alternative approach suggested (somewhat wistfully it has to be said) by one of the more 'experienced' members of the team was to see if we still had an epidiascope that would project the image on to a wall or screen onto which a grid had been painted. The fact that many of the available walls in SSERC have recently been painted made this option a non-starter although we might still have an epidiascope.

The question which we then asked was 'Is there a piece of readily available, simple, cheap (free would be even better!) and reliable software that would do the job for us?' The obvious place to look for an answer is the web and the search term 'digitize plot' (with some reluctance we avoided the spelling 'digitise') yielded a number of possibilities. For a variety of reasons we were attracted to a piece of software called 'Plot Digitizer' which is available as a free download (http://www.southalabama.edu/physics/software/plotdigitizer.htm) from the Physics Department at the University

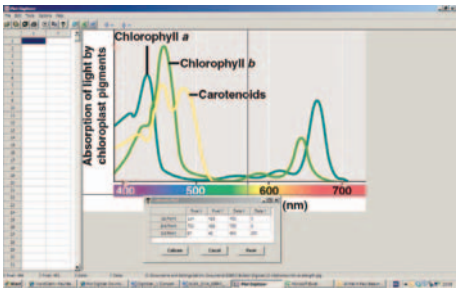


Figure 2 *- Calibration screen for the jpeg image from Figure 1. Software used was 'Plot Digitizer' (available at: http://www.southalabama.edu/physics/software/plotdigitizer.htm).*

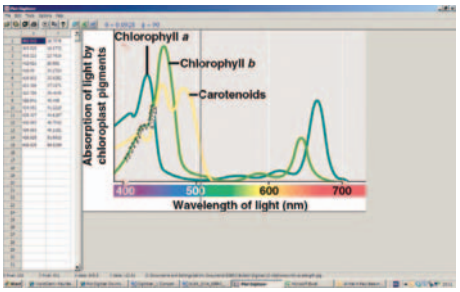


Figure 3 *- Partial digitisation of the jpeg image from Figure 1. Software used was 'Plot Digitizer' (available at: http://www.southalabama.edu/physics/software/plotdigitizer.htm).*

of South Alabama. The software is described as *'a useful program for extracting data from a linear, semi-log, or log-log plot'*. Apparently all you need to do is *'Using an optical scanner, create a Bitmap or JPEG image of the plot and open the image file in Plot Digitizer. Then, after calibration, you can extract the data values by merely clicking on the data points'*.

This sounded as if it would fit the bill. At first glance it is readily available, cheap and simple. The remaining question centres on reliability. The steps involved in digitisation are:

- Import an image file (we used a jpeg version of figure 1).
- Calibrate the screen - i.e. you need to 'tell' the software the (x,y) coordinates of 3 points on the plot which you wish to digitise (see Figure 2). The points chosen were (400, 0), (700, 0) and (400, 100) - the latter being an arbitrary value given that the plot in figure 1 does not display values on the y-axis.
- Using a mouse (or keypad), trace the curve and at relatively frequent intervals click the mouse and the coordinates of the point will be recorded in the data columns (Figure 3).
- Once all data points have been collected the file can be exported in a variety of formats the most useful of which we found to be as a Microsoft Excel file.

Having digitised the curve for the chlorophyll b absorption spectrum using the software and generated an Excel file of the data, we are now in a position to address the remaining question *'How reliable is the software?'* Figure 4 shows a plot of absorption vs wavelength for the chlorophyll b curve from Figure 1.

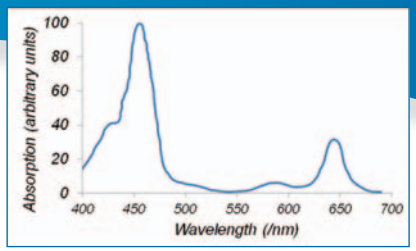


Figure 4 *- Absorption spectum for chlorphyll b generated by digitisation of the curve in Figure 1. The curve shows data from 120 points generated using 'Plot Digitizer' (available at: http://www.southalabama.edu/physics/software/plotdigitizer.htm).*

In an ideal world the plot in Figure 4 would be identical to the chlorophyll b curve in Figure 1 and it looks pretty good to us. Our conclusion is that Plot Digitizer 'does what it says on the tin'.

Health & Safety

Breaking bad bottles

We have had a few reports recently concerning the structural failure of plastic bottles. While this can often be a mere annoyance, the bottles in question have been ones containing concentrated acids.

In one case a bottle of concentrated sulfuric acid was picked up by the moulded handle which promptly broke off. In another, a bottle of nitric acid was picked up by the neck and it broke there. There have been similar reports from our colleagues in England as well.

As far as we can ascertain, these are the original bottles the chemicals came in from the suppliers. They are also usually a few years old, 4 to 6 or so. We should add here that the reports concern bottles from a variety of suppliers.

Having looked into the subject, it seems that plastics of various sorts are prone to embrittlement, albeit at a slow rate, usually as a result of the plasticiser leaching out into whichever solution is being kept in them. This process can be accelerated by various factors, depending on the particular plastic involved. These include heat, uv light and oxidising agents.

Figure 1 *- A nitric acid bottle showing severe cracking.*

This is still an uncommon problem but we would recommend that if you are handling a plastic bottle of concentrated acid you inspect it beforehand and handle it carefully. In the longer term, if you find you have bottles of, for instance, concentrated nitric acid, that tend to sit around for several years, it might be an idea to see if it is possible to purchase in smaller quantities (1 litre rather than 2.5 litres for example) to make sure that the bottles are not sitting in your chemical store for too many years.

Phenolphthalein

As the CLP/GHS system takes hold, a few changes in classification are coming to light. Most of these are minor alterations, usually due to shifting boundaries between, say, irritant and corrosive. A few, however, are more radical. Phenolphthalein is one such case.

The process of classification by The European Chemical Hazards Association (ECHA) proceeds as follows:

- All the companies who are manufacturing or importing the chemical into the EU must assess its hazards and pass on that information to ECHA.
- ECHA then assesses these submissions, looks at the evidence and then comes to an agreed, 'Harmonised' classification which is the one to be used in future across the EU.

Over recent years, concern has been growing about the long term health effects of phenolphthalein. Last year, ECHA produced a new classification and as a result a substance which had previously been classed as being of little hazard is now a carcinogen (category 1B), a mutagen (category 2) and a reproductive toxin (category 2). This seems a little alarming but there is no need to jettison all your phenolphthalein.

The classification applies to the solid and to solutions of 1% and more. As the prime use of phenolphthalein is as an indicator, it is already used in low concentrations and in small amounts. We would recommend that phenolphthalein solutions be made up to concentrations of less than 1%; 0.5% is a good working strength for most purposes. At this concentration no hazard labels are required. That is not to say that there is no hazard, but it does mean that the dangers are slight enough to be deemed not significant.

Technicians who prepare the solutions should take precautions to avoid contact with the solid: wear gloves and goggles (BS EN 166 3) and avoid raising dust. Fortunately, phenolphthalein is not volatile so unless it is handled carelessly there is little chance of any exposure.

If you buy in solutions from a chemical supplier, try to order 1% or below. If they supply a more concentrated product then dilute it with the solvent in which their product is supplied.

And finally... remember that just because the 0.5% phenolphthalein is not considered a hazard in your indicator, don't forget the hazards due to 99.5% of methanol, propan-1-ol or whichever other solvent you are using.

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