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# Limiting factors in photosynthesis

The Biology team in SSERC has recently been reviewing and updating the range of resources offered through our website [1] to support the new Higher programmes in Biology and Human Biology.

The *CfE* Higher in Biology [2], which will be first taught in the 2014-2015 academic session, has three mandatory units:

- 1) DNA and the Genome;
- 2) Metabolism and Survival;
- 3) Sustainability and Interdependence.

Photosynthesis is covered in the 3<sup>rd</sup> of the above units and amongst the possible learning activities (in 'The science of food production' section) is the suggestion that learners might 'Carry out experimental investigations on limiting factors in photosynthesis'. There are a range of practical activities which one might use to cover this statement and the purpose of this article is to explore some of these in more detail.

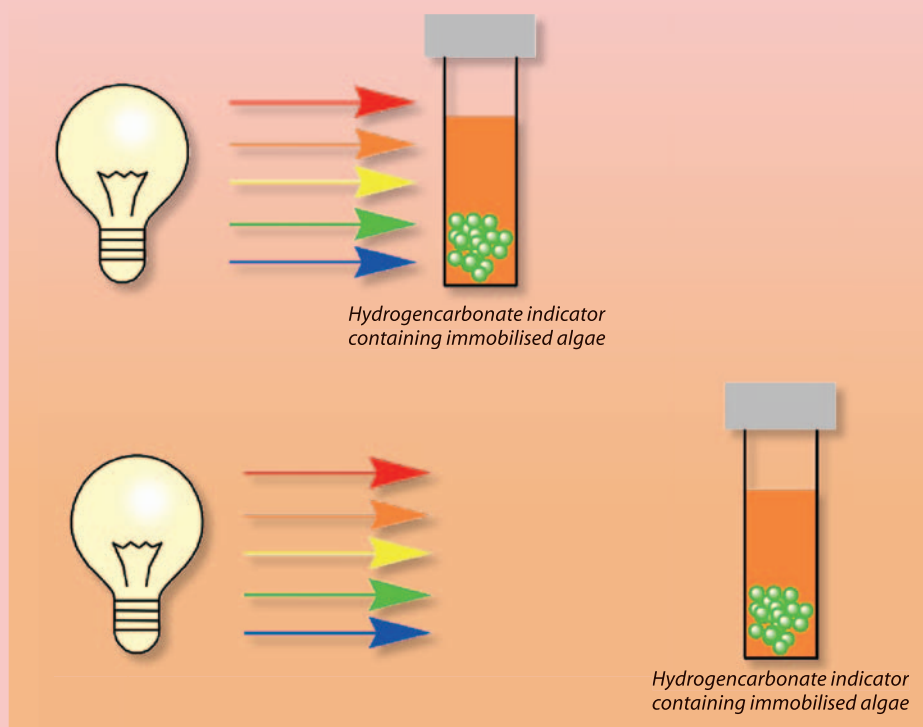


Figure 2 - Reducing the light intensity in photosynthesis experiments.

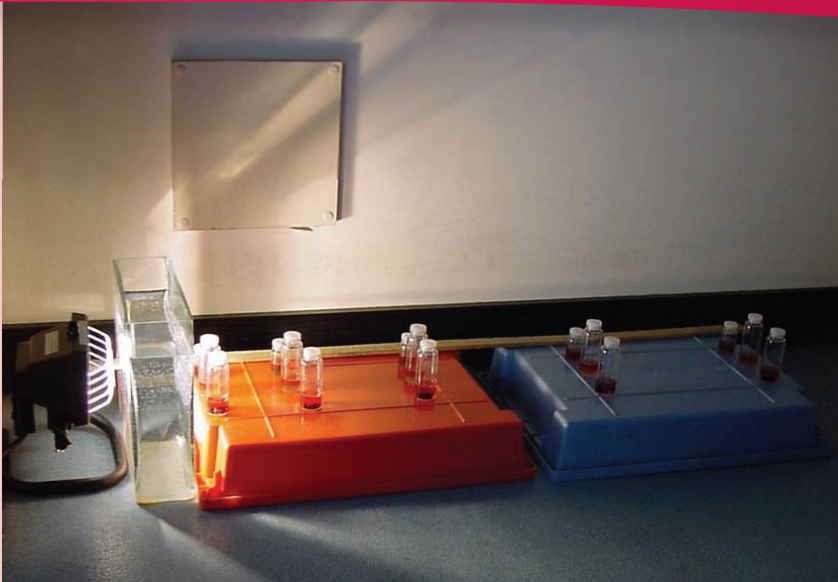


Figure 1 - Photosynthesis in action.

## Immobilisation of algae

For ease of convenience, many schools opt to use the well-established technique involving immobilisation of algae for which a kit and supporting documentation is available from the National Centre for Biotechnology Education (NCBE, [3]). Within SSERC we have made a number of investigations using immobilised algae and further details can be found in past issues of this Bulletin [4, 5]. In terms of investigating limiting factors, the most common experiment which is undertaken is the measurement of the effect of light intensity on the rate of photosynthesis. Using immobilised algae this

is a relatively straightforward experiment to set up. Briefly, you place immobilised algae (a detailed protocol for their production is available [1]) in a suitable vessel containing hydrogencarbonate indicator and place the samples in front of a suitable light source. As carbon dioxide is removed from solution (and the solution becomes less acidic) the indicator will change colour and the rate of colour change can be conveniently measured using a colorimeter. Reducing the light intensity (as shown schematically in Figure 2) can be readily achieved simply by moving samples away from the light source.



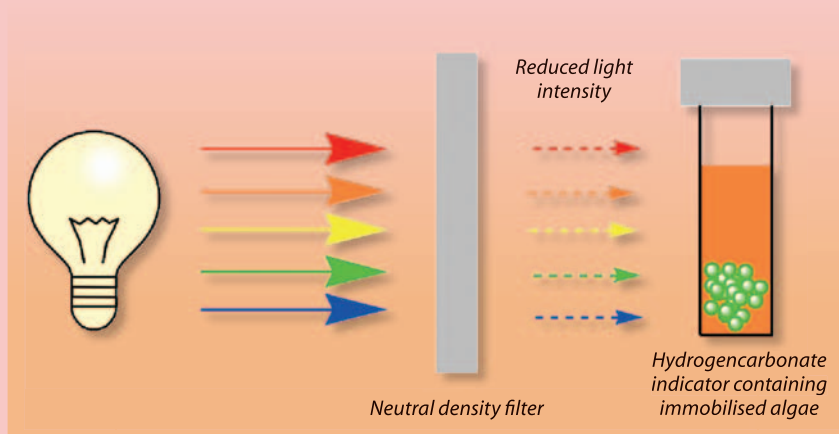
**Figure 3** - An experimental set-up for measuring the effects of light intensity on the rate of photosynthesis.

There are some drawbacks with this method which are worth highlighting here:

- Light intensity does not reduce linearly as you move your samples away from the lamp. The inverse square law applies and this can be a challenging concept for learners to take into account when planning experiments.
- It is important to minimise the effects of stray room light on your sample especially those samples which are distant from the lamp source.
- Inadvertent shading of samples can occur unless samples are placed correctly.
- Since temperature can also affect the rate of photosynthesis any heating effects from the light source must be minimised.

The set-up shown in Figure 3 demonstrates some of the pit-falls described above. For example the tubes containing the algae are spaced at regular intervals from the lamp and when plots are made the data points, because of the inverse square law, will tend to be bunched at one end of the axis. Additionally the tubes at the front are shading the tubes further away from the lamp. That said, heat effects from the lamp and the extraneous effect of room lighting appear to have been minimised by the insertion of a 'heat sink' and the switching off of room lights.

An alternative way of varying light intensity is to use so-called neutral density filters (shown schematically in Figure 4). These grey filters are available from a number of

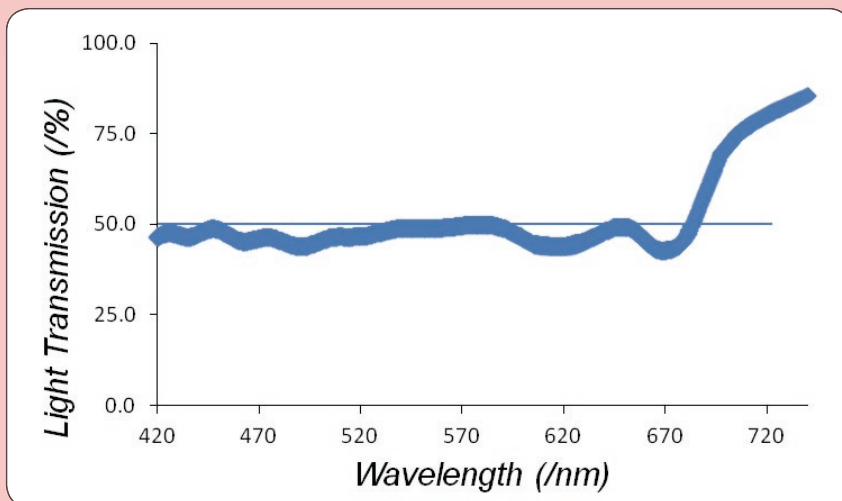


**Figure 4** - Using a neutral density filter to reduce light intensity in photosynthesis experiments.

suppliers and in SSERC we usually source them via Lee Filters (<http://www.leefilters.com/>) who have a number of distributors throughout the UK. It is possible that your colleagues in the Drama department will have a range of suitable filters since the neutral density filters are marketed as photographic stop filters and often used in lighting rigs for stage productions. Essentially a neutral density filter is designed to reduce light intensity by a given amount across all wavelengths. Lee Filters sell a number of neutral density filters. The product numbers (for which there does not appear to be a logical sequence) and the percentage of light which they transmit is given in the Table below. At the time of writing (August 2013) sheets (measuring 1.2 m x 0.25 m) of each filter were available from Black Light in Edinburgh ([www.blacklight.com](http://www.blacklight.com)) for a cost of £2.50 each (+postage).

Filter number	% transmission
298	71
209	50
210	25
211	12.5
299	6.25

We have made measurements of the transmission properties of the full range of neutral density filters and these are all available as Excel files on the SSERC website [1]. The data for Lee Filter 209 (notionally 50% transmission) is shown in Figure 5. The measured transmission for the neutral density filter is close to the manufacturer's data (the horizontal line is at 50% transmission) but it should be noted that the filter starts to transmit increased light levels towards the far red end of the spectrum - for most purposes this will not be problematic. ▶



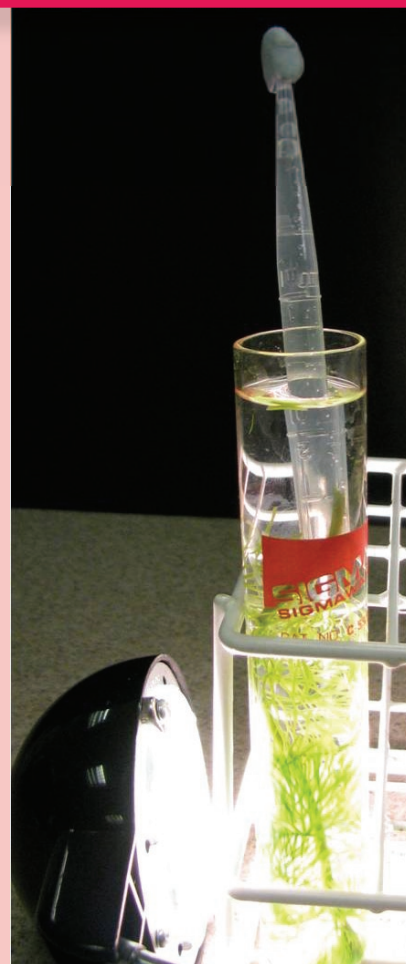
**Figure 5** - Light transmission of a Neutral Density 209 filter from Lee Filters. Data is displayed as percentage of light transmitted as a function of wavelength at 1 nm intervals. The horizontal line represents 'pure' 50% transmission.

There is no need to buy a complete set of filters. A single layer of filter 298 will notionally allow 71% of light to pass through. A single layer of filter 298 combined with a single layer of filter 210 would allow  $(0.71 \times 25\%) = 17.8\%$  of the light to pass through. Two layers of filter 209 is equivalent to 1 layer of 210 etc. The experimental set-up shown in Figure 6 shows how the effects of light intensity might be measured and the advantages using of neutral density filters are apparent. All samples are equidistant from the lamp, any heating effects from the lamp will affect all samples equally, room lighting complications are reduced, and the effects of shading are removed.

Judicious use of filters allows estimates of the compensation point to be determined and this has been the subject of a previous article in this Bulletin [5] and so these will not be discussed further here.

### **Cabomba**

Within the Biology Team at SSERC we have what can only be described as a long-term love affair with the aquatic plant *Cabomba* and we have previously published on its usefulness [6-8] in a number of experiments. The ability to measure rates of oxygen production [6] and the increasing availability from a number of commercial sources makes *Cabomba* 'our pond weed of choice'.



**Figure 7** - Illumination of *Cabomba*.

Qualitative and quantitative measurements of the effect of light intensity on the rate of oxygen production using *Cabomba* are relatively straightforward. The basic experimental set-up is shown in Figure 7. A 'sprig' of *Cabomba* is placed in a boiling tube containing 1% sodium hydrogencarbonate and a fresh cut applied to the stem of the *Cabomba*. Bubbles of



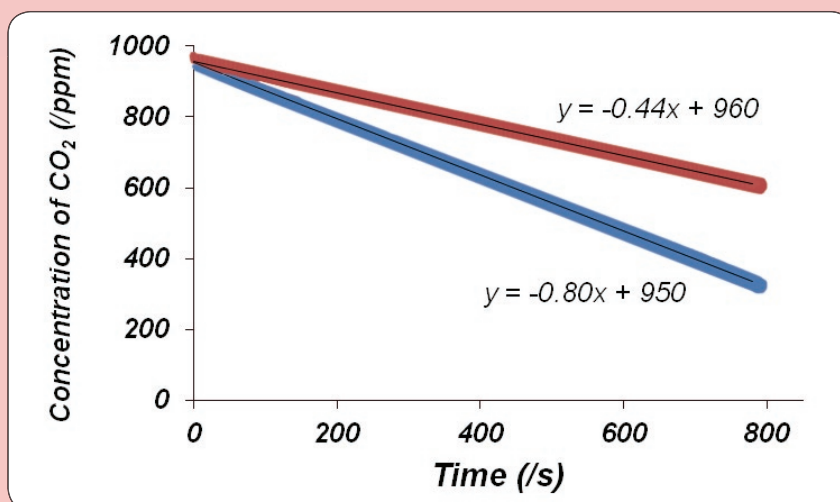
**Figure 6** - An experimental set-up allowing for measurement of the effects of light intensity on the rate of photosynthesis. Bijou bottles containing immobilised algae are exposed to light from a fluorescent tube; light intensity is altered by the addition of a suitable filter.



gas which emerge from the stem can be counted or arranged to displace a known volume of sodium hydrogencarbonate from a disposable pipette which has been placed over the stem. The rate of gas production can be varied by wrapping the boiling tube with neutral density filters.

### Carbon dioxide probes

There are a number of advantages in using carbon dioxide probes to measure rates of photosynthesis and we have reviewed those previously [9]. Results from a typical experiment are shown in Figure 8. In this case leaves from a basil plant (approximately 2.5 g of material [ca. 12 leaves]) were placed in a sealed vessel and exposed to the light from a small desk lamp. The lower data set shows the leaves received the full beam and the upper data set was produced when the intensity of the beam was reduced by 50% using a 209 neutral density filter. Data was collected at 4 second intervals for about 13 minutes in both cases. The best line fits to the data yields slopes with a ratio of 1.8 - close to the value of 2.0 that one might expect. In common with the immobilised algae experiments, issues around changing distance from the light source are overcome.



**Figure 8** - The rate of photosynthesis in basil leaves as a function of light intensity. Data were obtained using a Vernier VR105512 probe. A 50% neutral density filter was either present (●) or absent (●).

Carbon dioxide probes offer additional advantages over the immobilised algae system including:

- a wide range of different plant materials can be investigated
- photosynthesis rates can be investigated in 'real situations' e.g. in the field;
- the readings of carbon dioxide concentration are direct and available in 'real time'.

In principle it would, using carbon dioxide probes, be possible to measure rates of photosynthesis at fixed light intensities with varying carbon dioxide concentrations present. We will endeavour to undertake such experiments and report on our success, or otherwise, in a future issue of the Bulletin. ◀

### References

- [1] The SSERC website is available at [www.sserc.org.uk](http://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.
- [2] SQA (2012) Higher Biology Course Support Notes - can be downloaded at [http://www.sqa.org.uk/files\\_ccc/CfE\\_CourseUnitSupportNotes\\_Higher\\_Sciences\\_Biology.pdf](http://www.sqa.org.uk/files_ccc/CfE_CourseUnitSupportNotes_Higher_Sciences_Biology.pdf) (accessed August 6<sup>th</sup> 2013).
- [3] NCBE (2013), NCBE-SAPS Photosynthesis kit. Available at <http://www.ncbe.reading.ac.uk/NCBE/MATERIALS/METABOLISM/photosynthesis.html> (accessed August 6<sup>th</sup> 2013).
- [4] Crawford, K. (2006) SAPS Photosynthesis Kit: the use of algal balls to investigate photosynthesis. SSERC Bulletin **219**, 2-5.
- [5] McAndrew, R. (2008) Investigating the compensation point of algae. SSERC Bulletin **225**, 6-7.
- [6] Crawford, K. (2005), *Cabomba* - a reliable alternative to Elodea? SSERC Bulletin **215**, 10-12.
- [7] Adams, A., Moore, G., Crawford, K. and Beaumont, P. C. (2011) *Cabomba* Tricolour. SSERC Bulletin **238**, 2-4.
- [8] Adams, A., Moore, G., Rutherford, A., Stewart, F., Crawford, K. and Beaumont, P. C. (2012) *Cabomba* - an exocharmic plant! School Science Review **93**, 9-12.
- [9] Beaumont, P. C. (2012) Measuring gaseous carbon dioxide. SSERC Bulletin **238**, 5-7.

# Disc-o fever

Has your school invested in a set of iPads? If so, what are they used for in science? Web browsing? Document viewing? Simulations? If you go to the *Physics* subject area of [www.sserc.org.uk](http://www.sserc.org.uk) and select the *Miscellaneous* category, you will find a list of iOS and Android apps that people attending the 2013 IoP/SSERC Summer School found useful.

As we have mentioned in previous articles, some datalogger manufacturers are now building in tablet and smartphone compatibility into their products. The latest that we have come across is the Labdisc (Figure 1).

Around the size of a smoke detector, the Globisens Labdisc has a series of onboard sensors and ports, most of them located around the perimeter of the device (Figure 2).

You can buy a basic Labdisc for £349 ex VAT at the time of writing. This has seven onboard sensors and you can add external probes at a later date. We opted for the "General Science Set". This costs £403 for one, with bulk discounts available. For that we received a datalogger with Voltage, Current, Light, Air Pressure, Temperature, Ambient Temperature, pH (Figure 3), Distance (Figure 4), Relative Humidity, Microphone, Sound Level and GPS sensors, plus a "Universal input" for adding third party probeware.



Figure 1 - Labdisc datalogger.

The sampling rate depends on the sensor. It can be as high as 24 kHz. Sampling resolution is given as "12 bit". This means that, whatever the sensor range, if you divide this by 2 to the power 12, i.e. 4096,

you will get the resolution of the individual sensor. For example, the voltage sensor is stated to have a range from -10 V to +10 V. This is a range of 20 V. The voltage resolution is therefore 20 divided by 4096, giving about 5 mV.



Figure 2 - Some of the Labdisc ports.

So, for the price of a Pasco Spark or Vernier Labquest 2, you get a datalogger and a set of sensors that have been well-chosen to support a fair number of school experiments. Unlike the Spark or LQ2, you don't get a sophisticated touch screen. We can see where Globisens is coming from on this one - why spend money on a touch screen when pupils will probably have access to a better one on their desk if not in their



Figure 3 - PH sensor.

schoolbag or pocket? At this point, we should note that Pasco, Vernier and DataHarvest all have systems linking other computers or tablets to their sensors.

The Labdisc uses Bluetooth for connectivity. Only one device can hook up to a Labdisc (a limitation not encountered with the Vernier LQ2). The systems supported are Windows, Mac and iOS. We're told that Android and Linux are on the

way. In the case of the iPad, users first download the free GlobiLab app from App Store. Next, they enter **Settings**, select **Bluetooth** and tap on the Labdisc, which will be visible in the list of broadcasting devices (Figure 5).

Next, Globilab is launched on the iPad and the relevant sensor, sampling rate and number of samples to be taken are chosen (Figure 6).

An icon is tapped to begin logging. All the usual iOS pinch-to-zoom features are implemented. Figure 7 shows a typical data plot.

Data can be displayed in a variety of formats, including analogue and digital instrument displays and can be mailed either as a graph image or a spreadsheet file. Note the Map button on the screenshot shown in Figure 7. The Labdisc has GPS. The user can take it for a walk and record, for example, light level at

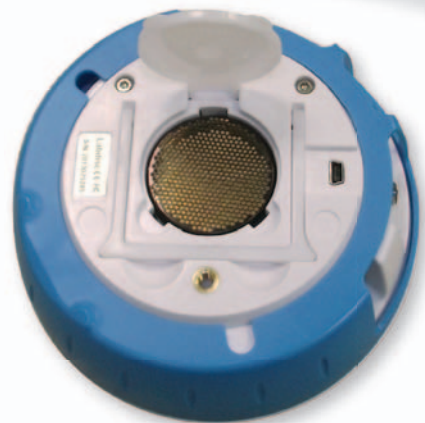


Figure 4 - Ultrasonic distance sensor.

various points on the journey. The app then integrates with Google maps, to display the light level throughout the walk.

Whether a Labdisc or other system is used, it would be good to see tablets, laptops and smartphones used as part of a datalogging setup. Science needs to be seen as an up-to-date, cutting edge subject utilising the latest technology rather than just foosty, tarnished wood and brass instruments.

The Labdisc is distributed in the UK by Tyn Can [1].

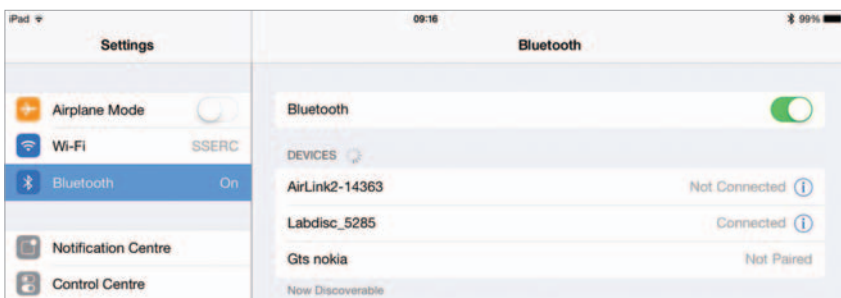


Figure 5 - Hooking the Labdisc up to an iPad.

**Reference**

[1] [www.tyncan.com](http://www.tyncan.com).



Figure 6 - Selecting the sensor and logging parameters on GlobiLab.

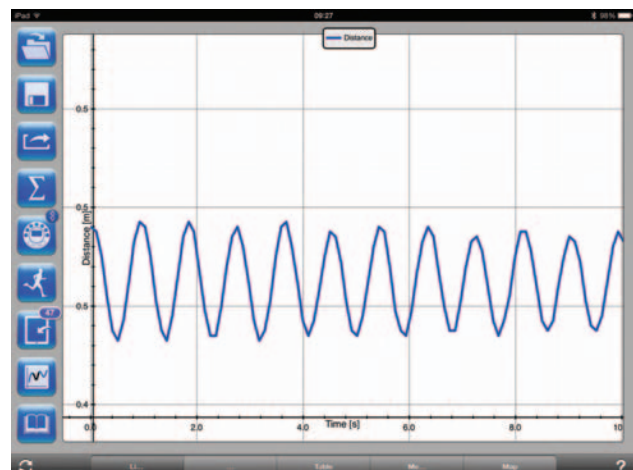


Figure 7 - Data plot on GlobiLab.



# Demonstration corner

## THE NORTHERN LIGHTS

The phrase 'The Northern Lights' probably conjures up an image similar to that shown in Figure 1. The phenomenon arises from the interaction/collision of charged particles with atoms or molecules in the upper reaches of the earth's atmosphere. A significant proportion of the energy released from such processes appears in the visible part of the electromagnetic spectrum.

We have come across another use of the term 'The Northern Lights' and it is this latter usage which forms the basis of this contribution from the Demonstration Corner Team.

The Northern Lights demonstration was first shown to us by Simon Quinnell of the National Science Learning Centre (NSLC) in York. Simon in turn had been shown the demonstration by Tracey Padgham when she was a participant on a course run at NSLC. Our searches in the literature have failed to locate other mentions of the demonstration.

### Materials

You will need the following items:

- 500 cm<sup>3</sup> or 1 dm<sup>3</sup> wide-necked conical flask;
- 20 cm<sup>3</sup> of concentrated HCl;
- 200 cm<sup>3</sup> distilled water;
- 5-6 g CuCl<sub>2</sub>·2H<sub>2</sub>O;
- Spatula;
- Heat proof mat;
- Aluminium foil (approximately 20 cm x 20 cm, screwed up into a loose ball shape);
- Safety screen;
- Matches;
- Splints.



**Figure 1** - Image attributed to Rafal Konieczny. Downloaded from [http://commons.wikimedia.org/wiki/File:Aurora\\_Borealis\\_NO.JPG](http://commons.wikimedia.org/wiki/File:Aurora_Borealis_NO.JPG) (accessed October 10<sup>th</sup> 2013).

### Method

- 1) Place the conical flask on a heat proof mat, surrounded by safety screens.
- 2) Add water and then HCl (must do it this way round).
- 3) Add CuCl<sub>2</sub>·2H<sub>2</sub>O.
- 4) Add aluminium foil.
- 5) Turn the room lights down (or if safe to do so turn them off).
- 6) Allow the reaction to continue for approximately 30 s then using a lit splint ignite the hydrogen gas



- 7) Step 6 can be repeated a few times.
- 8) Once the reaction mixture has cooled down the production of copper can be shown.

### Observation

On the basis of their positions in the reactivity series we can predict that copper will be displaced from its salts by aluminium. Because of the presence of an impermeable oxide layer on the aluminium foil the reaction would not normally proceed in aqueous solution. The presence of the acid has 2 effects. The acid removes the oxide layer thereby exposing 'pure' metal. The displacement of the copper then proceeds. A second reaction which takes place is the production of hydrogen gas as a result of the reaction between aluminium and the acid. After a time delay (30 s or so) sufficient hydrogen is produced to allow its ignition. The hydrogen which has been produced is of course moist and the moisture contains some copper ions because of their solubility. Upon ignition of the hydrogen the characteristic green flame test colour of copper is observed.



# Nitrogen and living things

In the two most recent SSERC bulletins [1, 2] we offered descriptions of practical and discussion activities on the broad theme of 'fertilisers and food security'. In Curriculum for Excellence (CfE) this theme is located in Line of Development 03 (Concept development in the Sciences [3]) and in the unit entitled Life on Earth in each of the National 4 and National 5 courses in Biology [4,5].

At National 4 and 5 the theme broadens to include knowledge of the nitrogen cycle and the role of nitrogen in ecosystems.

Here we offer some activities which support learning relating to the nitrogen cycle and micro-organisms involved in nitrogen fixation.

## Practical activity 1 Isolating nitrogen-fixing bacteria from the root nodules of leguminous plants

*Rhizobium* is an example of a nitrogen fixing microorganism found in the root nodules (Figure 1) of legumes such as peas, beans and clover. The root nodules of the common garden plants known as lupins (Figure 2) have conveniently large root nodules which contain *Rhizobium*. At SSERC we used lupins for this practical. The aims of the practical are to allow learners to:

- Identify root nodules on leguminous plants.



Figure 1 - Root nodules.

- Isolate and grow *Rhizobia* on an agar medium (Figure 3).
- Carry out microbiological 'sterile techniques'.

## Practical activity 2 Nitrogen-fixing bacteria in soil

*Azotobacter* is a nitrogen-fixing bacterium found free-living in soil. *Azotobacter* can be isolated by growing it in a nitrogen-free medium (Figure 3). The aims of this practical are to demonstrate that:

- There are microorganisms in soil which can be grown on nutrient agar.
- Some soil microorganisms can grow on a nitrogen-free medium.
- Those growing on a nitrogen-free medium must be fixing nitrogen gas from the air. ▶



Figure 2 - Lupin (*Lupinus polyphyllus*).



Figure 3 - *Rhizobium* growing on MYEA agar.



Figure 4 - Nitrogen and Living Things cards.

### Card based activity

#### Nitrogen and Living Things

This activity (Figure 4) can be used in a variety of ways which allow learners to explore the role of nitrogen in living things and the role of microorganisms in the nitrogen cycle.

A detailed student protocol and a teacher/technical guide for each of the practical activities, and the *Nitrogen and Living Things* cards, can be found on the SSERC website [6]. ◀

### Curriculum links

#### Line of development 03

At second level - *SCN 2-03a*, learners can explore the role of fertilisers through practical activities involving, for example, house plant nutrient fertilisers. The effect of factors such as dilution of the fertiliser or use of different fertilisers can be investigated.

At third level - *SCN 3-03a*, learners grow plants using a variety of growth promoters and inhibitors to investigate ways in which plant growth can be altered. Learners could undertake research into the use of these and of alternatives, including the growth of genetically-modified (GM) plants. They can explore the role of pesticides, herbicides and fungicides. They could consider organic farming methods and compare these with the use of artificial chemicals and GM crops, enabling learners to develop informed views on the use of each.

At fourth level - *SCN 4-03a*, learners design an artificial fertiliser taking account of the major nutrients that are required by a plant for healthy growth i.e. nitrogen, phosphorus and potassium in appropriate proportions. They can consider the solubility of salts containing the major nutrients, and potential problems associated with their overuse. There are useful opportunities to develop numeracy skills, for example in the calculation of percentage compositions of simple fertilisers.

#### National 4 - Life On Earth

Investigate/research the nitrogen cycle including the role of microorganisms.

#### National 5 - Life On Earth

Animal and plant proteins are produced from nitrates. The roles of nitrifying, denitrifying, root nodule and free-fixing soil bacteria.

### References

- [1] SSERC (2013), Fertilisers and food security, SSERC Bulletin **244**, 4-7.
- [2] SSERC (2013), Eutrophication - investigating the effects of fertilisers on the growth of an algal population, SSERC Bulletin **245**, 4-7.
- [3] Learning and Teaching Scotland, *Sciences: Concept development in the sciences*. Available at [http://www.educationscotland.gov.uk/Images/Conceptdevelopmentinthesciences2\\_tcm4-550290.pdf](http://www.educationscotland.gov.uk/Images/Conceptdevelopmentinthesciences2_tcm4-550290.pdf) (Accessed 19<sup>th</sup> December 2013).
- [4] SQA (2012). Course Unit Support Notes for new National Qualifications are available on the SQA website at <http://www.sqa.org.uk/sqa/45724.html>.
- [5] SQA (2012). Course Unit Support Notes for new National Qualifications are available on the SQA website at <http://www.sqa.org.uk/sqa/45725.html>.
- [6] Available at <http://www.sserc.org.uk/index.php/biology-2/biology-resources/biology-national-4/n5-life-on-earth/3418-energy-in-ecosystems>. The SSERC website is available at [www.sserc.org.uk](http://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.



## Suitable sources of eyes for dissection

From time to time SSERC receives enquires about suitable sources of eyes for dissection. The SSERC Code of Practice *Materials of Living Origin - Educational Uses* [1] states in paragraph 4.5 that *Only materials fit for human consumption obtained from abattoirs, butchers or fishmongers may be used for the purposes of dissection or experimentation.* The measure that controls risk is using materials fit for human consumption rather than where the material is obtained from. It is the regulations for food production that reduce any potential hazard from using animal material for dissection or experimentation.

This has led to considering other sources of materials fit for human consumption that can be used for dissection and experimentation. For example deer eyes obtained from gamekeepers can be used for dissection as long as they come from animals fit for human consumption [2]. Legislation [3] allows gamekeepers to make the decision that animals are fit for human consumption. Recently we have also had enquiries about obtaining eyes from knackers that prepare pet food. Animal by products

that are used for pet food manufacture are controlled by the Animal By-Products (Scotland) Regulations 2011 and so are fit for human consumption although that is not their intended use. Thus eyes or other materials obtained from such a source may be used for dissection or experimentation.

Whatever their source, eyes that are obtained from cattle, sheep or goats that are more than 12 months old at slaughter are controlled by the *Specified Risk Materials (SRM) Regulations* and the guidance on their disposal in appendix 7 of *Materials of Living Origin - Educational Uses* must be followed. ◀

### References

- [1] *Materials of Living Origin* (2012), [www.sserc.org.uk](http://www.sserc.org.uk).
- [2] *Eye dissection - Using deer eyes* (2013) SSERC Bulletin **242**, 11.
- [3] *The Wild Game Guide* (2011) Food Standards Agency.

## Skeletons in the cupboard

On occasion, we have had enquiries from schools about what to do when old human skeletal remains have been found, often lurking forgotten deep in a cupboard and a legacy from previous times. The guidance provided in the SSERC publication *'Materials of Living Origin - Educational Uses; A Code of Practice for Scottish Schools'* [1] states that states that Skeletal material (bones, teeth etc.) may be used for demonstration and for investigative work. The use of such material in school can be of considerable educational value and so long as all involved understand the educational objectives of using the material, there is no reason why the old human bones should not be kept for appropriate study.

It may be, however, that the department does not want to keep the bones and the question then arises of how best to dispose of them. In such an instance, the Centre for Anatomy and Human Identification at the University of Dundee would happily take the skeletal remains for teaching purposes. If there are old human bones that you would like to discard, please contact Gillian Malone at the University of Dundee [G.Malone@dundee.ac.uk](mailto:G.Malone@dundee.ac.uk). ◀



### Reference

- [1] The Code of Practice can be accessed via the Biology Health & Safety pages on the SSERC website <http://www.sserc.org.uk/index.php/health-safety/health-a-safety-home140>. 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.

## How to get sued - an idiot's guide

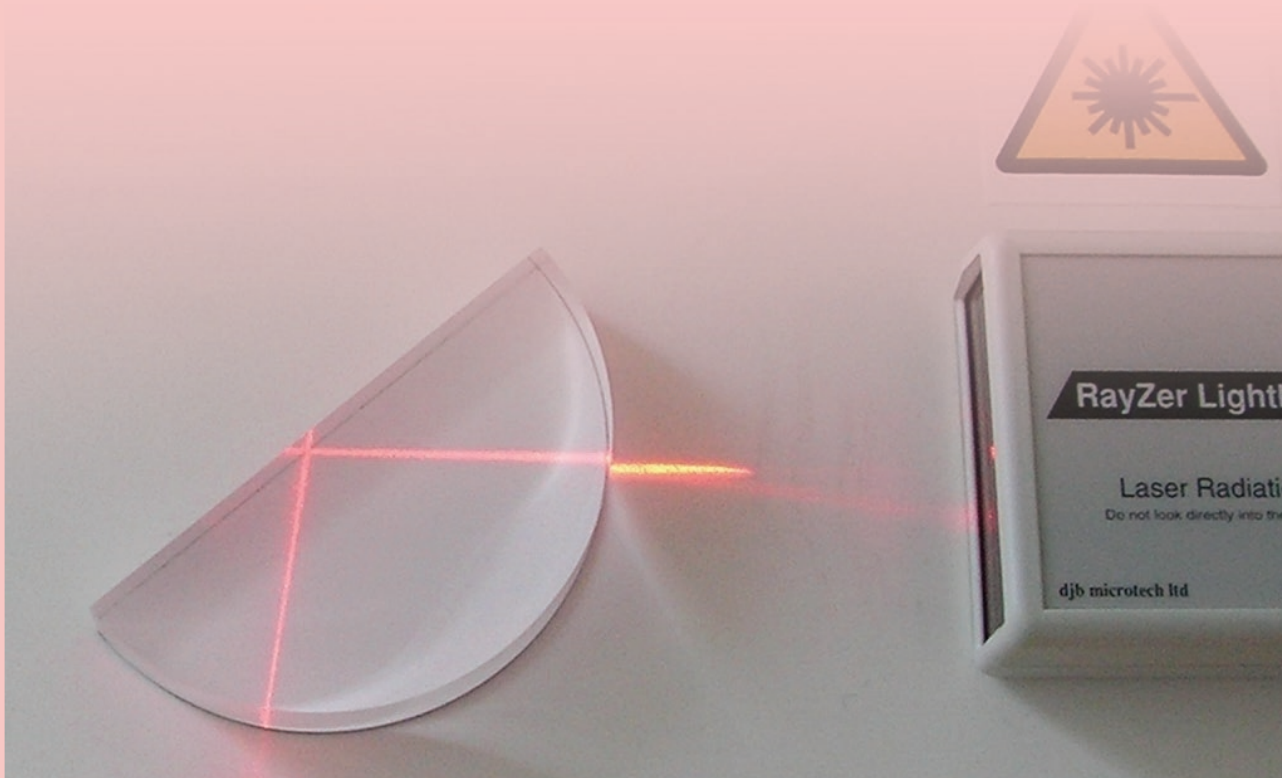


Figure 1 - Safe, effective school laser raybox.

Very few teachers and technicians find themselves in court due to health and safety breaches, but if you really want to get in trouble, it can be done. All you need to do is disregard your employer's health and safety guidance. Suppose you are carrying out a demonstration with an alkali metal. This has been risk assessed and you have been instructed to use a safety screen, eye protection and a lump of material about 3 mm by 3 mm by 3 mm. (Note: this is not the full list of control measures for this experiment. Please consult the Hazardous Chemicals section of our website.) You perform the demo, it goes well and your pupils are impressed. Then the trouble starts. "Gonnae use a bigger bit?" says one of the children. Egged on, you repeat the experiment until a golf ball-sized piece causes a reaction that no safety screen can protect against. Had a freak accident occurred with the small piece, you would have the law on your side. You followed your employer's guidance. In using a golf ball-sized chunk, you stepped outside of this legal protection.

We came across a more subtle case recently. Figure 1 shows an effective, safe laser raybox. Lasers like this are entirely suitable for pupil use. They are Class 2: they give out only visible light and their power is such that should the light enter your eye, your natural aversion reflex - blinking or turning away - will kick in before any damage has been done. Supposing an equipment supplier sells a laser product that is more powerful than the Class 2 specification (we know of some on sale). What are the consequences of using such a laser? Your employer looks to SSERC for advice on such matters and SSERC says no. Advice on lasers is contained in our guide to Optical Radiation [1]. Do have a look at the section on school sources and, in particular what we have to say about safe laser use and laser pointers. If you buy and use a device that is deemed unsuitable and a pupil is harmed, or claims to have been harmed you could be in trouble. This is not to scare you - more to highlight the ways in which sensible teachers and technicians stay out of trouble. ◀

### Reference

[1] <http://tinyurl.com/SSERC-OPTIC>.