

SSERC *Bulletin*



Ideas and inspiration supporting science and technology for all Local Authorities

No. 253 - Winter 2015

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50 years of SSERC

Whilst I can claim to be one of the longest serving members of the current SSERC team and whilst it may look as though my memory stretches back to the beginning of SSERC it really doesn't. So in putting this article together I have to thank John Richardson, Director of SSERC and my predecessor, for the excellent articles he wrote for both our 21st and 40th birthday editions much of which I have - in John's words - recycled here.

John became Director in the early 1980s and held the post for over 20 years. We all owe him a great deal for the way he managed to lead the organisation through some difficult times.

Although SSERC, or more correctly SSSERC (the Scottish Schools Science Equipment Research Centre), came into being in 1965, the origin of the Centre was a technical sub-committee of the Advisory Committee on Physics set up in 1961 to advise the Secretary of State on all matters relating to the teaching of physics. There were problems recruiting and retaining science teachers, we had outdated syllabuses, old-fashioned suffocating exams.

This pre SSSERC sub-committee chiefly assessed apparatus for its suitability in use with the modernised 'alternative' physics syllabus. They also designed prototype kit to plug the gaps where no suitable apparatus existed. This work was done by teachers in their spare time, with the help of the late Professor W.H.J. Childs. They worked in their own schools and at what is now Heriot Watt University. Incidentally, the new, but alternative, physics syllabus took only a few months to write and agree on.

By then, in England and Wales, the original Nuffield Foundation Science Project had begun. Scotland was designated a "Region" and a team was set up under the leadership of W.R. Ritchie. More development work on equipment began in schools and in the Apprentices' School at Ferranti Ltd. Figures such as "Physics is Fun", Jim Jardine, the late John Emery of Glenalmond and the late Joe Stewart all worked with Bill Ritchie. They produced groundbreaking bits of teaching kit such as the linear air track, the Venner stopclock and magnetic pucks for frictionless motion. By the Summer of 1963, several members of this group were also heavily involved with the work of the Scottish Nuffield physics team.

New biology and chemistry syllabuses were set to join the alternative syllabus already developed for physics. With the backing of the Scottish Education Department, and the National Advisory Committee on Physics, the local authorities were asked to co-operate in the setting up of a national science centre. Within 18 months, a structure for the funding and governance of such a Centre had been agreed, premises identified and refurbished.



Figure 1 - The 1st issue of the Bulletin.

The original organisation from 1965, SSSERC was a partnership, one led jointly from the outset by Edinburgh and Glasgow, "Corporations". They, in turn, recruited one or two others from the City and County Councils (at that time they were the education authorities). These core partners laid the legal and administrative foundations for what was to be a national advisory centre. Only when the initial stages were complete and premises found, was membership of the scheme offered to all of the Scottish City and County Councils as education authorities. In the present, councils are continually being urged to consider setting up shared services in the drive for efficiency. In this respect, SSERC was decades ahead of its time!

From the outset, and for a long time afterwards, the Centre's team remained small (5 to 7 staff). Many of the ideas for development and testing programmes were still coming from teachers and technicians based in schools. Even now, 50 years on and with the staff team swollen by secondees, semi-retirees working part-time and other folk on short-term contracts, we remain no more than a small to medium sized enterprise - although not in output.

With the advent of the Health and Safety at Work Act in the seventies, SSERC undertook the task of interpreting the multitude of documents, designed to cover workplaces as diverse as single person enterprises through to massive corporations, and identifying which part of the legislation was relevant to schools. Ensuring that employers are able to meet their legal obligations with regard to health and safety in science and technology classes will always remain a vital component of our work.

SSERC in 2015 has a profile that has expanded radically from the early days. One area in which this change is most noticeable is in our role in supporting teachers and technicians through our involvement in the delivery of professional development programmes. With significant support from, amongst others, the Scottish Government, the National Science Learning Centre, the Wellcome Trust and the Primary Science Teaching Trust, we have over the past 10 years worked with staff from virtually every secondary school in Scotland. Our support for science and technology in the Primary sector continues to grow; through our Primary Cluster programme we will, by March 2018, have worked with all Local Authorities in Scotland to put in place experiential professional development opportunities for their

primary practitioners. Alongside our professional development work we produce new resources to support school educators in Scotland with the implementation of *CfE* and new qualifications. We strive to ensure that science and technology teaching in Scotland remains firmly practical and experiential.

It is a real achievement for any organisation to reach 50. I believe SSERC has managed this by always ensuring that its core members (the 32 Scottish Local Authorities, teachers and technicians) receive a service that meets their needs - thanks to staff who are both passionate and completely committed. On top of this, we've also had wonderful support in

the governance of the Centre. In the 50-year lifetime of SSERC, we've only ever had six folk in the chair [The late Prof W.H.J. Childs and Councillor Joe McGinley; Councillor Ross Martin, Councillor David McGrouther, Councillor Kay Morrison and Councillor Walter McAdam] (sequentially not simultaneously). Councillor David McGrouther deserves special thanks for his unstinting efforts over many years, firstly as chair of the governors and then as chairman of the SSERC Board since incorporation.

Diamond Jubilee next!

*Fred Young,
Chief Executive, SSERC*

In memoriam Allen Cochrane

Staff at SSERC are saddened to hear of the sudden death of Allen Cochrane who had been with the organisation since 1976, retiring only 2 years ago due to ill health.

Allen, as a senior chemist at SSERC, was behind the Hazardous Chemicals Manual and many other resources considered invaluable by science teachers. His immense knowledge, creativity and thoroughness earned him the respect of both teachers and support staff.

We at SSERC were also in awe of Allen's professional qualities but we shall miss him for much more than that. Exemplifying the "gentle giant" cliché, Allen was a friendly, sociable and entertaining colleague.

Whilst he was particularly fond of the outdoors, he approached all aspects of life with an enthusiasm and generosity of spirit that was evident to all who met him. Those of us at SSERC who worked with him, learned from him, and laughed with him feel immensely privileged to have known him. We will be publishing a fuller appreciation of Allen on our website.

Small is beautiful

When we think of chemistry, we often tend to think of the big, spectacular reactions that are usually done as demonstrations where the whole object is to impress. Most chemistry work as carried out by pupils is done so at a smaller scale but it will still often use quite large amounts of reagents. There is, however, another way...

Figure 1 - Drop-scale reactions on a plastic sheet.

Microscale chemistry came on the scene in the 1980s but, in Europe and America at least, it remained a niche activity. Then, in the mid 2000s, green chemistry came on the scene in a big way and the green credentials of microscale gave it a new lease of life. (At this point, we would like to thank Bob Worley from CLEAPSS who has spent many years developing microscale chemistry activities for schools and has been generous enough to share them with us [1]).

It seems to us that while there will always be a place for large scale chemical work, microscale chemistry for schools in the UK is an idea whose time has come. Therefore, there is now a section of the Chemistry area of the website devoted to microscale chemistry with details of equipment and preparation as well as experiments [2].

Why microscale?

1) Safer procedures

Microscale procedures are usually safer than the original reactions because of their size.

2) Less waste

Dealing with waste is of great concern in all countries now. Using smaller amounts produces smaller amounts of waste. This in turn reduces time in preparation, clearing up and disposal.

3) Reduces cost

Microscale equipment is mostly plastic and inexpensive. Working on a microscale means using smaller quantities of sometimes

expensive chemicals. In addition, the reduction of waste as mentioned above can reduce disposal costs.

4) A laboratory is not always required

This is not always desirable but it can be very useful at times to be able to carry out some practical work when you do not have access to a dedicated laboratory.

5) Reduces practical times

If demonstrations and practical procedures take too long and have to be shelved to the next lesson, continuity is lost and the subject can become disconnected, not understood and potentially boring. Also, less time spent on the mechanics of the experiment allows for more discussion and questioning

6) Better classroom control

Much of the time wasted in lessons is caused by students moving around the room to find sinks and balances and collecting chemicals and equipment. This can lead to poor behaviour but microscale activities can be carried out in a small area of the room. Another revolution is that as the quantity of liquid used is at most 2 cm³, with practiced techniques, students can sit down to carry out the activity.

Despite the small scale and the generally inexpensive equipment, a lot of good, quantitative results can be achieved by these methods,

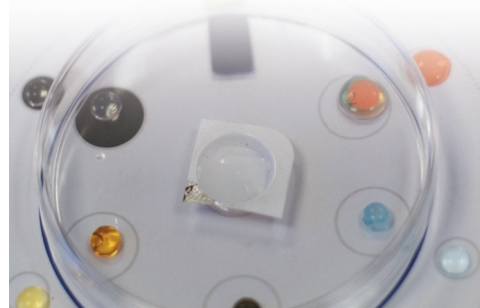


Figure 2 - Gas reactions contained in a Petri dish.

comparable in many cases with the full-scale approach.

Problems?

The fact that it is on a very small scale does mean that there are issues with using this technique for demonstrations. It is possible to get around this though. Images can be projected onto a white board using a webcam or video microscope.

Another problem is that using very small quantities can raise problems with dexterity for some pupils. Like any other skills, however, this is one that can be improved with practice.

Some microscale techniques

There are many experiments that can be done successfully on a microscale. There are more than 20 on the SSERC website with more to follow. Here, though, are a few general approaches to microscale chemistry.

1) Using drops on plastic sheets

- For many reactions normally carried out in test tubes, reducing the scale so that mere drops of solutions are used is an excellent approach (Figure 1).



Figure 3 - Burning a syringe of propene.

The instructions are printed on an A4 sheet which has spaces marked on it for the placement of drops of reagents. These can either be laminated or simply placed inside a plastic wallet. The great advantage here is that the instructions are immediately adjacent to the reaction so fewer mistakes are likely.

2) Using Petri dishes to contain gases

- using microscale quantities of reagents can allow hazardous gases such as ammonia, and hydrogen sulfide to be investigated in the open laboratory. Placing the reagents in a Petri dish (Figure 2) allows the gases to be largely contained which provides a relatively high concentration within the dish to facilitate reactions while maintaining a safe environment outside. (Figure 2 also shows the use of a section from a 'blister pack' for tablets being used as a micro reaction vessel - in this case to generate ammonia.)

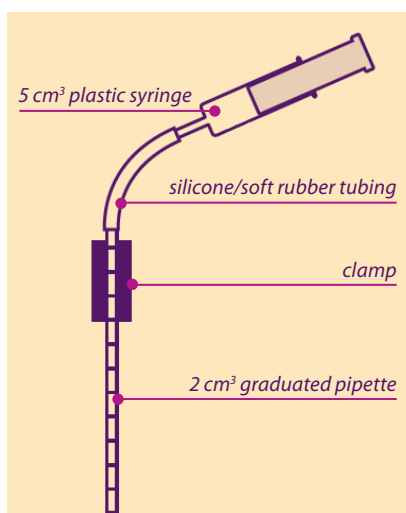


Figure 4 - Micro-titration using a glass pipette.

3) Using syringes to handle gases

- Luer lock syringes in particular are ideal for holding and dispensing small samples of gases (up to 50 cm³ or so). For instance, syringes of hydrogen can be used for a microscale reduction of metal oxides.

4) Microscale titrations

- These can be carried out in two ways:

- Using a glass pipette and a syringe (Figure 4). The titrant is drawn up into the pipette and then slowly pushed out, instead of using gravity, during the titration. The scale allows readings to 0.01 cm³.
- Using a pasteur pipette. This time the titrant is drawn up into the pasteur pipette and dispensed drop by drop. Counting the drops is a good proxy for volume (a quick experiment beforehand will tell you the volume per drop). A standard 1 cm³ Pasteur pipette will give you an accuracy of about 0.04 cm³, while a fine tip one will be accurate to 0.02 cm³. For more control, the bulb of the pipette can be placed in a clamp which is slowly tightened (Figure 5).

As an alternative in both methods, the titration can be carried out on a balance and the change in mass measured instead - for dilute solutions, it is quite acceptable to take the density as being 1 g/cm³ (the same as water).

5) Bottletop crucibles

Crucibles are a bit of a nuisance. Nickel ones are expensive and the porcelain ones break easily (being only intended as single use by the manufacturers!). In addition, they both have a tendency to fall off tripods too easily.



Figure 5 - Micro-titration using drops from a Pasteur pipette.

It is possible to get a microscale crucible quite easily from a muselet (the metal cap and wire from bottles of sparkling wine (Figure 6) and a few beers). The wire holder provides a handy grip for a pair of tongs or a clamp. For experiments like the burning of magnesium that requires a lid, it is possible to use crown corks (the tops from beer bottles and the like), two of which can be held together with a bit of nichrome wire (Figure 7).

We hope this article will open your eyes to the usefulness of the microscale approach to teaching chemistry and that, some of the time at least, small can be beautiful. ◀



Figure 6 - A mini crucible.



Figure 7 - Magnesium in a bottle-top crucible.

References

- <http://microchemuk.weebly.com/>.
- <http://www.sserc.org.uk/index.php/chemistry-resources/microscale-chemistry>.



Mulling over Müller-Lyer

In Unit 3 (*Neurobiology and Communication*) of *Higher Human Biology*, in the section that includes the study of perception, a suggested learning activity is to “Plan and design investigations using the *Müller-Lyer* illusion” [1]. At SSERC we have devised a possible approach to carrying out such an activity in the classroom. The associated resources are available on the SSERC website [2].



Figure 1

The *Müller-Lyer* illusion is one of a series of so called ‘distortion illusions’ [3] and it was first noticed by Franz Müller-Lyer in 1889. Since that time it has been the subject of much study and conjecture. The phenomenon can easily be introduced to learners by asking them to draw two straight lines of exactly equal length, one immediately above the other, and then to put ‘arrows’ on one line and ‘fins’ on the other. The addition of arrows and fins in this way makes lines which are exactly the same length appear to most people to be different; the line with fins being *apparently* longer than the line with arrows (Figure 1).

The cause of the illusion is not entirely understood although various explanations have been put forward. Richard Gregory, for example, cited the misapplication of depth cues as the cause of our misperception of the length of the lines [4]. Since we live in a world of straight lines and angles, he would argue that we readily perceive the adorned lines as being distant, or closer versions of corners, by applying 3-D depth cues to this 2-D image (Figure 2).

Having misapplied depth cues the brain then misapplies ‘size constancy’. Size constancy happens when the brain overrides information provided by the relative size of images on the retina, for example when we look at a scene containing distant and near objects (Figure 3).

In this scene of teachers on a SSERC course, the image created on the retina by looking at the most distant person in the scene is smaller than the image created on the retina by looking at the closest person in the scene, but we do not perceive the closest person as being bigger; this is size constancy [5].

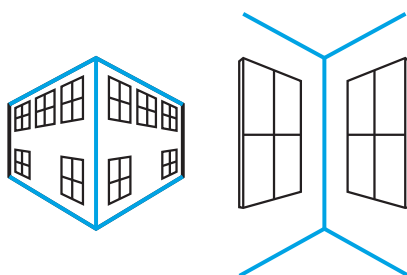


Figure 2 - (<https://www.rit.edu/cla/gssp400/muller/muller.html>).



Figure 3



Figure 4

Gregory would argue that in the case of the *Müller-Lyer* illusion the brain having misapplied depth cues then mistakenly adjusts for size constancy. Because the brain has assumed that the line with fins is further away it ignores the retinal information about size and assumes that the line with fins must be longer.

Gregory's mistaken depth cues explanation of the *Müller-Lyer* illusion relies on the addition of shapes that make 'corners'. However, even if the depth cues referred to by Gregory are removed and replaced with an alternative to the angles of corners as in Figure 4, the illusion is still apparent.

For this reason Hans Eysenck believed that the phenomenon was caused by the brain applying more complex interactions of cues including its ability to infer the existence of three dimensions from two-dimensional images. Several other possible explanations exist and further investigation of these might interest some learners.

Having said all this it is not necessary to understand the causes of the *Müller-Lyer* illusion in order to investigate its extent under different conditions. Although the *Müller-Lyer* illusion provides a nice context for the study of depth perception and size constancy, the main purpose of the activity described here is to allow learners to engage in the process of designing an investigation which will generate quantitative data. And for learners at *Advanced Higher* level, the data generated from the investigation might be used for further statistical analysis [6].



Figure 5

At SSERC we have created what we call our '*Müller-Lyer* device'. On the device the two lines in question are adjacent to each other and the arrow on the end of one doubles as the fin on the end of the other as in Figure 5.

The device can be adjusted by sliding the two sections towards, or away from, each other until the two lines **appear** to be of equal length and the scale on the back provides a means of 'measuring' the extent of illusion (Figure 6). (Of course, as an aspect of their experimental design, learners may well come up with their own method of measuring the extent of the illusion).

In the suggested experiment, the subject would adjust the device and the tester would read and record the extent of the illusion indicated on the scale on the reverse side. Here we suggest taking measurements under two conditions: 1) when the illusion is presented horizontally and 2) when the illusion is presented vertically (Figure 7). The independent variable is therefore 'orientation' and the dependent variable is the extent of the illusion.

Learners could be asked to suggest hypotheses and at *Advanced Higher* level it would be appropriate to include a 'null hypothesis'. In this case that orientation will have no effect on the apparent extent of the illusion. Issue 18 of the Wellcome Trust publication, *The Big Picture*, entitled 'Number Crunching' has a helpful explanation for learners of the null hypothesis [7].

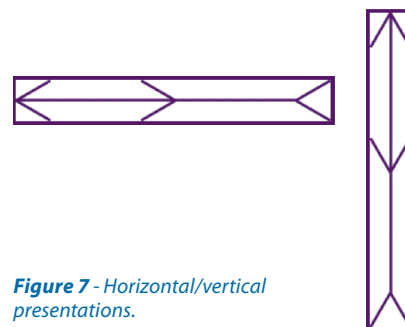


Figure 7 - Horizontal/vertical presentations.

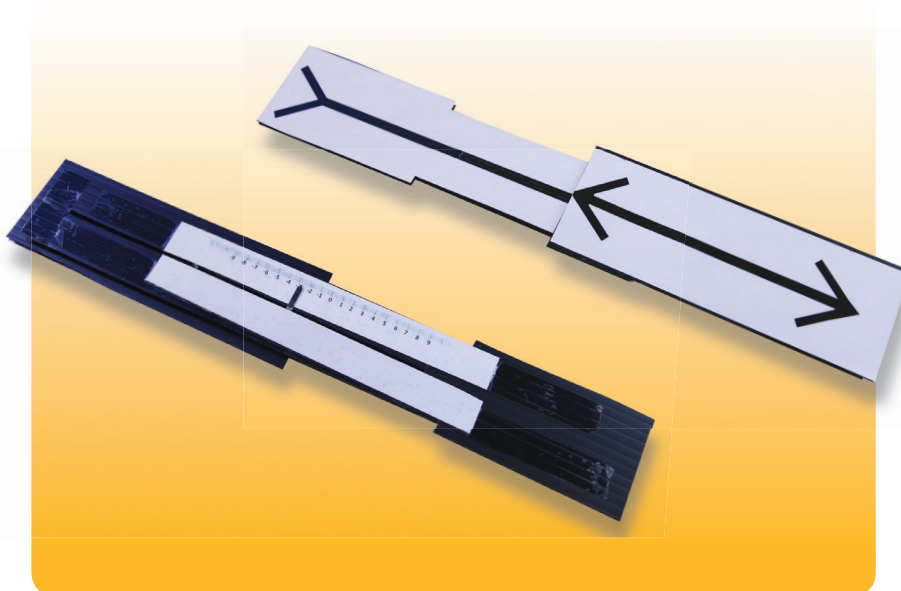


Figure 6 - Adjustable device with scale on reverse side.

Other aspects of the design of the investigation will need to be considered. For example, will all subjects be tested under both conditions (a within subjects design), or will different groups be tested for one of each of the conditions (a between subjects design). With a between subjects design, consideration would need to be given to random allocation of subjects to the two groups. In our student protocol we suggest a between subjects design [8]. Other considerations would be number of subjects, number of readings under each of the two conditions and how long the subject is given to adjust the device.

If the design includes a null hypothesis, the results can be analysed using a *t*-test to ascertain statistical significance of the difference between the two sets of results and, therefore, whether the null hypothesis can be accepted, or rejected. The *t*-test can be applied to the generated data most simply using a *Microsoft Office Excel* spreadsheet, or other freely downloadable statistical software packages [9]. In this case, since we are only setting out to accept, or reject the null hypothesis, the *Excel t*-test is adequate.

Using the *Excel t*-test

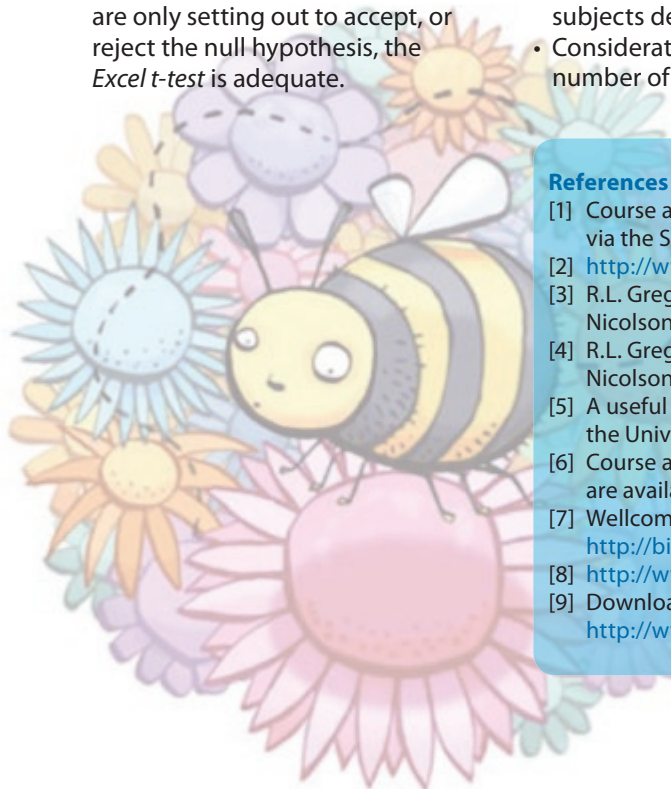
- Open up an *Excel* spreadsheet.
- Enter the data for horizontal and vertical presentations in two separate columns, A and B.
- Go to '**more functions**', then to '**statistical**' then to '**TTEST**'.
- Because we can't predict the direction of the results i.e. we have no reason to expect that the apparent extent of the illusion will be greater for the horizontal, or for the vertical presentation, the test required is '**two-tailed**'.
- Because our design is a between-subjects design, the appropriate test is the '**unrelated t-test**'.
- In this case it is appropriate to use, '**two-sample unequal variance**'.
- The *Excel t*-test gives a probability value (*p* value). If the *p* value is less than 0.05 the difference between the two data sets is statistically significant and the null hypothesis can be rejected. If the result is not statistically significant the null hypothesis cannot be rejected.

By using the *Müller-Lyer* illusion to plan and design an investigation in this way, learners can explore:

- An approach to achieving quantitative rather than qualitative results.
- A null hypothesis.
- Within subjects or between subjects design.
- Consideration of sample size and number of replicates.
- Data quality as measured by range and central tendency.
- The use of a *t*-test for significant differences.
- The ethical use of human subjects in research.

References

- [1] Course and Unit Support Notes for the NQ *Higher Human Biology* are available via the SQA website www.sqa.org.uk/ (accessed July 21st 2015).
- [2] <http://www.sserc.org.uk/>.
- [3] R.L. Gregory, *Eye and Brain: The Psychology of Seeing*, Weidenfield and Nicolson, 1979, p. 138.
- [4] R.L. Gregory, *Eye and Brain: The Psychology of Seeing*, Weidenfield and Nicolson, 1979, p. 151.
- [5] A useful graphic illustrating size constancy can be found on the website of the University of Calgary at <http://ucalgary.ca/pip369/mod5/constancy/size>.
- [6] Course and Unit Support Notes for the NQ *Advanced Higher Biology* are available via the SQA website www.sqa.org.uk/ (accessed July 21st 2015).
- [7] Wellcome Trust *Big Picture*, 'Number Crunching' available at <http://bigpictureeducation.com/number-crunching>.
- [8] <http://www.sserc.org.uk/>.
- [9] Downloadable statistics package called *R* available for free download at <http://www.r-project.org/>.



Experimental data

Background

In the Skills of scientific experimentation, investigation and enquiry section of the new Highers in Biology and Human Biology (see Course Support Notes for Higher Biology Course and the Course Support Notes for Higher Human Biology Course) learners are expected, inter alia, to:

- work with quantitative and qualitative data, discrete and continuous data and sampled data;
- deal with experimental data presented in tables, pie and bar charts, line graphs, lines of best fit, graphs with semi-logarithmic scales, graphs with error bars and information presented as box plots;
- analyse and interpret typically two interconnected tables, charts, keys, graphs or diagrams or a single source of graphical information with two to three patterns, trends, conditions, variables or sets of results.

The Biology Team in SSERC has on a number of occasions been approached to see if we might make a range of data sets available which could then be used by learners by way of practice. In this article we present a number of data sets which might be used together with some explanation of how the data have been generated. The raw data sets are available on the SSERC

website through the resources section for Higher Biology or Higher Human Biology.

Photosynthesis/respiration

We have published a number of reports on the use of carbon dioxide probes to measure respiration and photosynthesis rates in plants [1-4] and the basic protocol which we use for experiments to measure such rates is available via the website [5]. The basic experimental set-up is shown in Figure 1.

The data shown in Figure 2 have been collected over a total of some 9000 seconds and during that time the lamp has been switched on and off on a number of occasions. ▶



Figure 1 - Experimental set-up for measuring respiration and photosynthesis rates in plants. Basil leaves (ca. 5 g) are placed into a 'reaction chamber' together with a CO₂ gas sensor (Product code VR105512) from Instruments Direct Services Ltd. The sensor is linked to a computer via a Vernier Go!Link interface. Data were collected at 4 second intervals for some 9000 s with the lamp being switched on during the periods 360-1300 s, 2040-2912 s, 3860-4680 s, 5740-6760 s, and 7928-8796 s. At other times the apparatus was in darkness. Plots of data are shown in Figures 2 and 3.

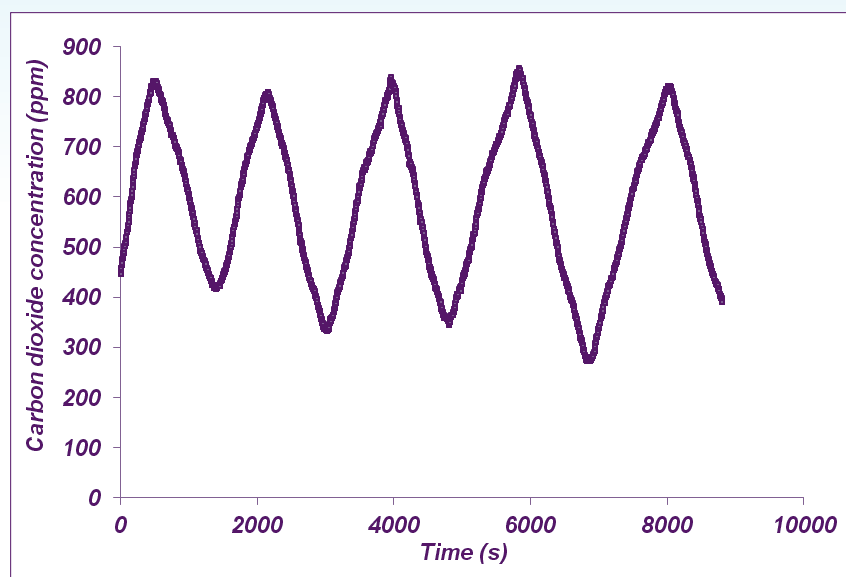


Figure 2 - The rate of change of carbon dioxide concentration in basil leaves. Data were obtained using a Vernier VR105512 probe.



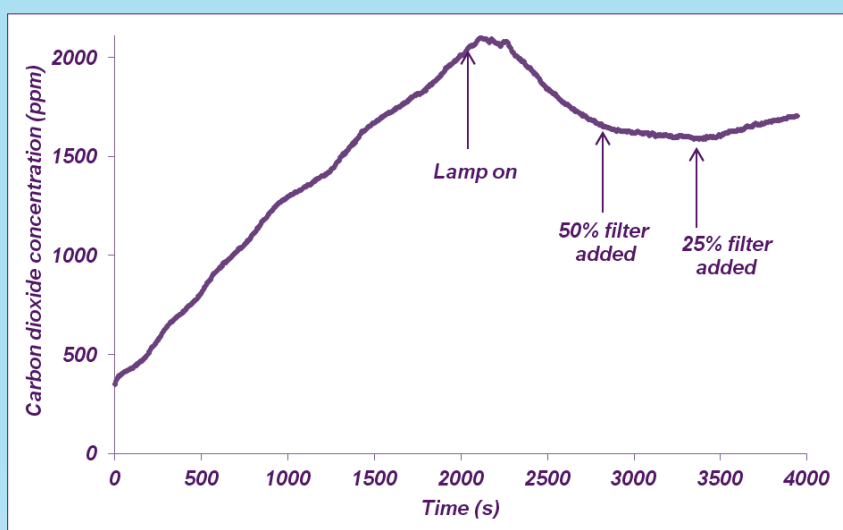


Figure 3 - Carbon dioxide concentration in a container containing basil leaves (ca. 5 g). Data were collected at 4 second intervals for some 4000 s. Between 0-2010 s the leaves were in darkness. At 2000 s the lamp was switched on. A 50% neutral density filter was added at 2720 s and this was replaced by a 25% neutral density filter at 3320 s.

Learners could be asked one or more of the following:

- 1) In the absence of light why is there a rise in $[CO_2]$?
- 2) The $[CO_2]$ starts to fall when the lamp is switched on - why should that be? (Interestingly the fall in $[CO_2]$ starts to become noticeable some 200 s after the lamp is switched on - why might there be this 'lag phase'?)
- 3) Are the rates of rise and fall in $[CO_2]$ the same in each segment of the plot? What does this tell us about how robust the protocol is?

Amongst the topics covered in the *Sustainability and Interdependence* in Higher Biology is the suggestion that learners might 'Carry out experimental investigations on limiting factors in photosynthesis'. Using carbon dioxide probes to monitor the rate of change of $[CO_2]$ as a function of light intensity is a relatively straightforward procedure and we have produced data sets for learners to analyse. The procedure involves the insertion of one or more neutral density filters between the lamp and the reaction chamber shown in Figure 1. Neutral density filters reduce light intensity across the visible range by a relatively constant amount (see [4] for further details).

In Figure 3 above we show the change in $[CO_2]$ under a variety of conditions of light intensity.

Learners could be asked one or more of the following:

- 1) What is the rate of change of $[CO_2]$ under conditions of 100 light, 50% light, 25% light and 0% light?
- 2) What is the explanation for the rise in $[CO_2]$ when light intensity is low (0% and 25%)?

Enzyme kinetics

β -glucosidase

In the most recent issue of the SSERC Bulletin [6] we provided a

protocol for using β -glucosidase in enzyme assays. In the same article we also gave some data sets which might be suitable for analysis by learners in support of their Assignment. We have placed the protocol on the SSERC website and separated out the associated data sets.

Dopa Oxidase

We have previously published [7] protocols and preliminary data for the enzyme dopa oxidase. We present here further data sets for this enzyme when extracted from both banana and germinating mung beans. Briefly, in our standard protocol enzyme extract (in this case from banana) and distilled water are placed in a cuvette and this solution is used to zero the colorimeter at the observation wavelength (in the data that are presented here we have used a Mystrica colorimeter and used the blue diode (ca. 450 nm)). In a new cuvette, substrate (L-dopa), distilled water and enzyme extract are mixed and the absorbance data recorded every 5 s (see Figure 4).

The effect of enzyme concentration can be readily shown by varying the amount of enzyme extract added and this is illustrated in Figure 5.

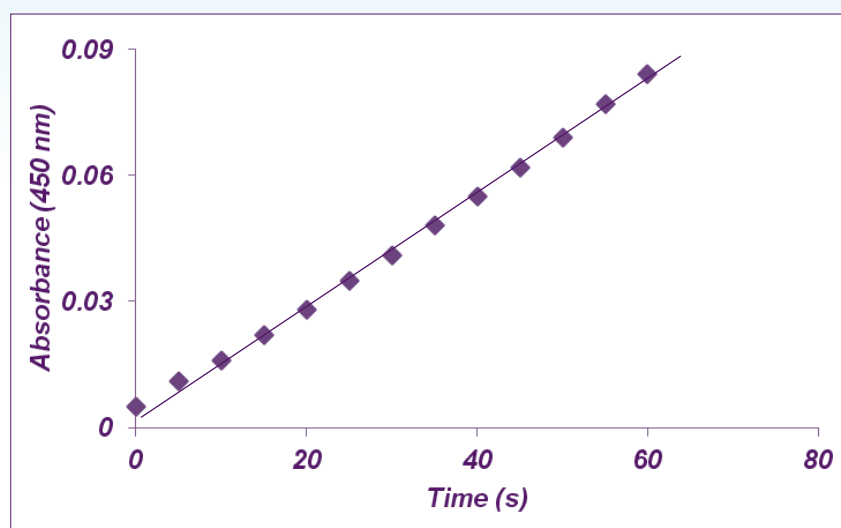


Figure 4 - Absorbance changes measured in a 1 cm cuvette containing dopa oxidase extract (10 μ l) from banana, distilled water (0.99 cm^3) and L-dopa (2 cm^3 , $1.25 \times 10^{-2} mol dm^{-3}$). Initial rate of reaction can be calculated from the slope of the solid line shown.

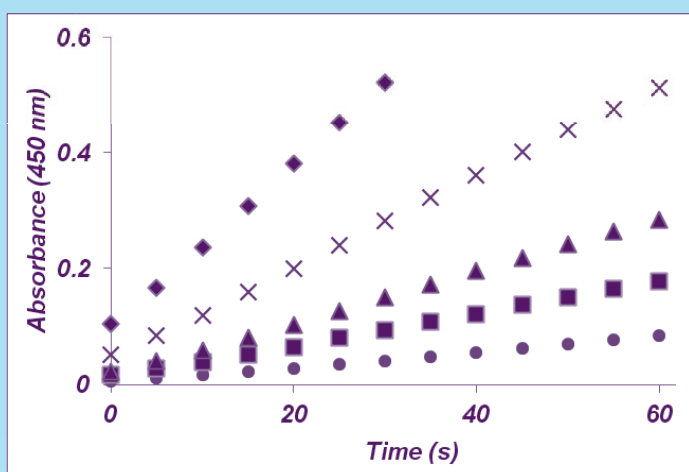


Figure 5 - Absorbance changes measured in a 1 cm cuvette containing dopa oxidase extract (● 10 µl; ■ 25µl; ▲ 50µl; × 100µl; ◆ 200µl) from banana, distilled water and L-dopa ($1.25 \times 10^{-2} \text{ mol dm}^{-3}$). Initial rate of reaction can be calculated from the slopes of the plots.

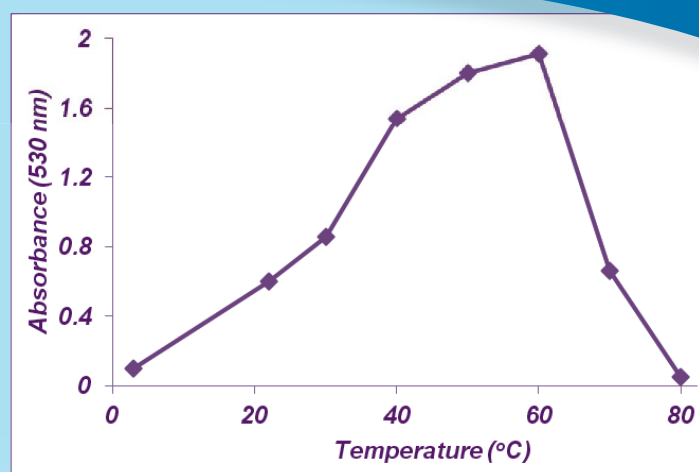


Figure 6 - The effect of temperature on the absorbance changes measured 10 minutes after mixing phosphatase extract with phenolphthalein phosphate. The reaction was stopped prior to absorbance measurement by the addition of sodium carbonate solution to a final concentration 0.5 mol dm^{-3} .

The data referred to in Figures 4 and 5 are for dopa oxidase extracts from banana. The website datasets also include data on enzyme extracted from mung beans.

Learners could be asked one or more of the following:

- 1) Why does the rate of change of absorbance increase with increasing enzyme concentration?
- 2) What is the relationship between enzyme concentration and rate of change (i.e. what do plots of rate of change as a function of enzyme concentration look like?)

Phosphatase

In a previous publication [8] we described a protocol for the extraction and assay of phosphates from mung beans. An interesting observation [9] is that the temperature profile of phosphatase is such that a maximum is observed at around 55°C. We have re-examined these earlier observations and the data from our experiments are shown in Figure 6. More detailed protocols on how these experiments were undertaken are available on the SSERC website. Briefly, the amount of phenolphthalein produced by the enzyme after a period of 10 minutes is measured and recorded.

The effect of temperature on the absorbance changes were measured 10 minutes after mixing phosphatase extract with phenolphthalein phosphate. The reaction was stopped prior to absorbance measurement by the addition of sodium carbonate solution to a final concentration 0.5 mol dm^{-3} .

Conclusions

We hope that the various data sets shown, together with additional examples on the SSERC website, will be useful sources of information for students in support of their studies. Excel files with all the raw data are available on the SSERC website. ◀

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- [3] Limiting factors in photosynthesis - carbon dioxide. SSERC Bulletin (2012), **248**, 2-3.
- [4] Measurement of limiting factors in photosynthesis. K. Andrews, P C Beaumont and K. Crawford (2015), School Science Review, **96**, 31-35.
- [5] Photosynthesis and respiration - protocol available at www.sserc.org.uk/index.php/biology-2/biology-resources/higher-biology-revised/metabolism-a-survival/3425-maintaining-metabolism.
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- [8] Fun with phosphatase. SSERC Bulletin (2015), **251**, 6-8.
- [9] Phosphatase enzymes from plants: a versatile resource for post-16 students. B. Meatyard, J Biol. Ed. (1999), **33**, 109-112.

Acknowledgements

The data for the activities described here were all generated by Emma Bissett who is a 3rd year PhD student at the University of Dundee. Emma is currently working with SSERC on a 3-month Professional Fellowship funded through the East of Scotland Bioscience Doctoral Training Partnership.



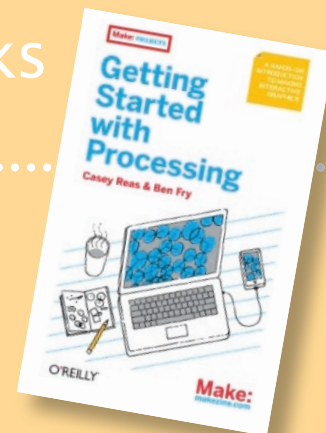
The introduction and uptake of Engineering Science in Scottish schools has sent Technical Education teachers scrambling back to their bookshelves for information and refreshers on electronics, processing and platforms.

With the reasonable prices of open source platform kits, more and more departments are better able to equip their classes with various components and connectors. What is perhaps missing is the teacher confidence in successfully using them. Here we consider two popular titles that may help.

Technology books

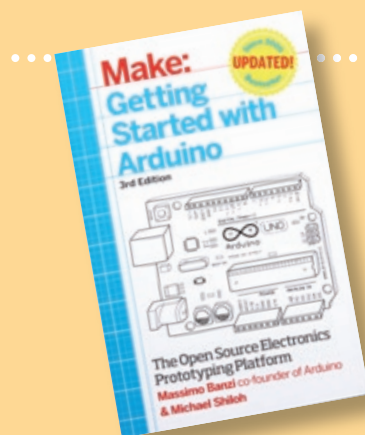
Getting Started with Processing, Casey Reas & Ben Fry

"This book is written for people who want a casual and concise introduction to computer programming, who want to create images and simple interactive programs." So while it is clear who this 200 page book is aimed at, once the initial tutorials are completed those of you who remember TurboCAD or early AutoCAD will be aware of the similarities of the good old days when you got a sense of achievement when typing in X, Y co-ordinates led to 2-D shapes that could be as complex as you wanted to make! The software required is basic and free to download (but feel free to make a donation to reward what were probably



months of hard work by the creators!) and there is a real feeling of accomplishment when numerical choices link together and create visual shapes, which are moveable around the screen when you get it right. Towards the end of the book it moves to the transferring of processing sketches to Arduino boards, opening up a whole host of further links and lessons in developing skills.

O'Reilly 2010 - £12.99



Getting Started with Arduino (3rd Edition), Massimo Banzi & Michael Shiloh

Having a book co-authored by the co-founder of Arduino, you'd be forgiven for expecting page after page of a sales manual for the company's products. However this 3rd edition of the original best seller really does concentrate on getting

the basic facts of making your kit work across to the reader with simple and concise language. Even if you feel you are being 'forced' to do Arduino with classes rather than 'wanting' to, the plain instruction, sketched images and extremely helpful Quick References at the end of the book probably mean that it won't be long before your book is full of highlighter panned paragraphs and pencil notes next to examples of circuits you can learn and teach your classes. Be warned however, you really need the Arduino hardware in front of you for lots of trial and error before you can expect to confidently lead 20 pupils through blinking lights, button sensors, debugging techniques and much more!

MakerMedia 2015 - £13.99

Countdown to physics safety

Here we look at what we believe are the top three issues in school physics health and safety.



Figure 1 - Shrouded leads.

3 High Tension power supplies

We don't do scare-mongering at SSERC so when we say that one of these, used incorrectly, could kill you, we're choosing our words carefully. In school physics, HT supplies are used for Teltron tubes and, occasionally, neon bulb experiments. Biologists may use electrophoresis power supplies that are HT and older microwave kits had Klystron power supplies that fell into this category. The HT supplies you come across will tend to be of the order of a few hundred volts. However, anything over 70 V smooth d.c. or 33 V a.c. or unsmoothed d.c. requires the same control measures. If used in wet areas, the limits drop to 35 V and 16 V respectively. Anything above these limits can create a "hazardous live". The exception is the school extra high tension (EHT) supply. Though the output may go up to 5000 V, these devices are current-limited. They cannot produce a large enough current to harm you. See Bulletin 208 for further details [1].

Control measures for HT supplies

- HT supplies and circuits are not to be used by pupils. The exception is that an S6 student, in a class where there were no pupils under 16, could use one under supervision, following instruction.
- The power supply should be labelled "not for pupil use" or similar. A warning notice should be placed beside any HT circuit.
- Shrouded leads (Figure 1) **must** be used. The conducting parts are covered unless it is plugged in to a suitable socket.

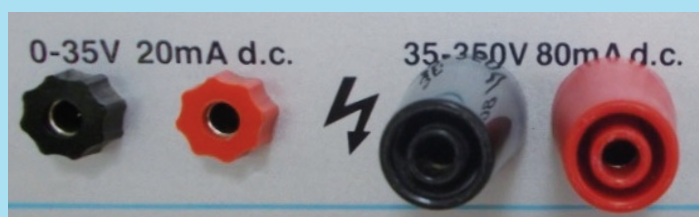


Figure 2 - Shrouded sockets.

- Shrouded sockets should be used on power supplies and apparatus. These can be retrofitted, as has been done to the HT supply in Figure 2. The shrouded sockets fit over the existing ones. An Allen key then fixes them in position. In the picture, the 0-35 V sockets are not shrouded (and don't have to be) but the 35-350 V sockets are. You can tell by the deep groove.
- Any hazardous live parts should be enclosed within the apparatus.
- Only specialist meters and leads should be used to take measurements. Contact SSERC if more information is required.

It is still possible to plug a standard 4 mm lead into a socket designed for a shrouded lead. In the case of an HT supply, this must not be done. Some newer EHT supplies also have sockets for shrouded leads. If you have shrouded leads, there is no reason not to use them, but from a safety point of view, it is not essential.

Some HT supplies are beyond redemption. The Klystron power supply in Figure 3 could be fitted with shrouded sockets but there are other features of the design that make it no longer suitable for school use.

2 Laser pointers

All our laser advice is based around the following principles:

- The lasers must produce only visible light so that the human aversion response is triggered.
- The laser power must be great enough for it to be useful but not so great that damage can occur in the time between the beam entering the eye and the aversion response - closing the eye or turning away - to happen. The aversion response takes on average about 0.25 seconds.



Figure 3 - Potentially dangerous power supply.

This means that only Class 2 (and not Class 2M or 2A or even 1M) lasers are suitable. They produce only visible light and are restricted to 1 mW or less. It is reasonable to ask, then, why we do not sanction the use of Class 2 laser pointers for experiments. There are two reasons. Firstly, laser pointers are too easily picked up and waved around by pupils. Secondly, the labelling of laser pointers is shockingly unreliable. Have a look on eBay. You will find “powerful Class 2” lasers. By definition, a Class 2 laser is not powerful. A contact at what was then the Health Protection Agency described battery-powered laser pointers as a “nightmare”, having found some that were nine times more powerful than their alleged classification. If this is not bad enough, consider the following. An organisation recently bought a batch of laser pointers to give away to delegates at an event. The pointers came from what looked like a reputable UK website that gave credible safety advice. One attendee felt that the pointers looked more powerful than expected and had theirs tested. It was 35 mW. Think how much less time you have before damage is done should this beam enter your eye, compared with one from a true Class 2 laser. The pointers were recalled. The company sent a sample of replacements but they too proved to be more powerful than they should have been. We have written, most recently in Bulletin 250 [2] about Class 2 laser diode modules from reputable suppliers. If you use these rather than laser pointers for experiments, you are adhering to SSERC, and by extension your employer’s guidance. Regarding laser pointers as presentation aids, we recommend sticking with red laser pointers of the sort built in to remote control handsets.

1 Radioluminescent dials

Around eight years ago, a programme was in place in schools to get rid of radioactive sources that either should never have been in schools or which were no longer considered suitable. The initiative made it easy for schools to dispose of material at no cost. It was highly successful but, occasionally, something turns up in a school that should not be there. Usually this is because it was overlooked when stock was audited during the disposal programme. Perhaps it was not kept in the main radioactive source store. Sadly, there have been a very small number of cases where schools have obviously retained stock that they claimed to have got rid of. In both cases, it is almost invariably a new member of staff who is left to pick up the pieces. These artefacts are often discovered after someone comes on a SSERC radiation protection course and subsequently decides to carry out their own audit. In the past year, two radioluminescent dials have been discovered (Figure 5). A few decades ago, it was common practice to paint the figures on watch or aircraft instrument dials with a mixture of radium and a luminous material. The mixture glowed, making numerals and indicator needles visible in the dark. Normally, we’d applaud anything that illustrates a physical principle in an interesting historical context, but here we have to say “no”. Current thinking is that an aircraft dial or watch containing radioactive material fulfils the definition of a sealed source provided its face is intact. If its activity is below 370 kBq it can be legally kept without expensive permits. If its activity is below 200 kBq, forthcoming legislative changes should make it easy to dispose of to dustbin. If the face is cracked, lower limits kick in. It is not a sealed source. Unfortunately, there is no easy way to tell the activity of a dial just by looking at it or researching on the internet. Here is the bottom line:

- Don’t bring radioluminescent articles into school.
- If someone offers you a radioluminescent article, politely decline.
- If you find a radioluminescent dial, please contact SSERC after double-bagging it and placing it in your radioactivity store, if you have one.



Figure 4 - Not suitable for work.



Figure 5 - "Glow in the dark" aeroplane instrument.

We have a method of estimating dial activity and will come to you, wherever you are, to carry out this procedure. So far, every dial we have tested has been in good condition and below both the legal limit for possessing it and the disposal limit based on forthcoming legislation. We will be recommending disposal because dropping the objects could transform them from sealed to unsealed sources. The estimated activities of the ones we tested would suggest that unsealed dials would need to be disposed of by

commercial contractors which could prove to be expensive. Note that not everything that glows in the dark is radioactive. We tested a number of alarm clocks at a museum. They did indeed glow in the dark but the glow faded with time suggesting they were merely luminous, absorbing light energy when it was bright and re-emitting it later. We could detect no ionising radiation coming from them with our instruments. Don't panic if you find a glow-in-the-dark object, but don't ignore it either.

This is not, of course, an exclusive list of safety topics in physics. Please have a look at the Physics section of the Health and Safety area of our website. You will need a log in to access it. Contact SSERC if you cannot get on. ◀

References

- [1] http://www.sserc.org.uk/images/Bulletins/208/4-6_Working_with_HT_supplies.pdf.
- [2] http://www.sserc.org.uk/images/Bulletins/250/SSERC_250p2-3.pdf.

Health & Safety

Face masks - update

We recently received an enquiry from a school asking whether there have been any changes to the specifications for face masks and this led us to review the recommendations for the face masks for the SAPS ELISA kit used for the detection of Botrytis infection in raspberries [1]. A previous Bulletin article [2] focussed on the best disposable masks for asthmatic students wishing to carry out this experiment or other activities involving spores.

We recommend that disposable masks/respirators should conform to **BS EN 149:2001**. The Health and Safety Executive [3] also advise that all respirators for use at work should be CE marked. Additional markings indicate the protection level achieved providing the respirator is a good fit and used correctly; these markings are, in order of increasing protection, **FFP1**, **FFP2** and **FFP3**. The amount of dust breathed is reduced by a factor of 4, 10 or 20 respectively. In some catalogues, these protection factors may be quoted as well (or instead), as **AP** (or **APF**) **4**, **10** or **20**.

An **FFP3 (APF 20)** respirator is advisable if you are exposed to high levels of grain dust or mould spores. It is important to remember though that these face masks will only provide proper protection if they are a good fit. It is not reasonable to expect one mask to fit different people; each person who might need one should have their own.

An updated table of appropriate facemasks/respirators and their suppliers is available from SSERC. ◀

References

- [1] Science and Plants for Schools - <http://www.saps.org.uk/secondary/teaching-resources/120-the-saps-elisa-kit-for-botrytis>.
- [2] Face Masks (2007), SSERC Bulletin, **221**, 2.
- [3] Health & Safety Executive - <http://www.hse.gov.uk/agriculture/dustmasks.htm>.

Ionising radiation web page

We have recently revamped the Ionising Radiation section [1] of the physics health and safety area of our website (Figure 1). There follows a brief explanation of what you will find on clicking each link.

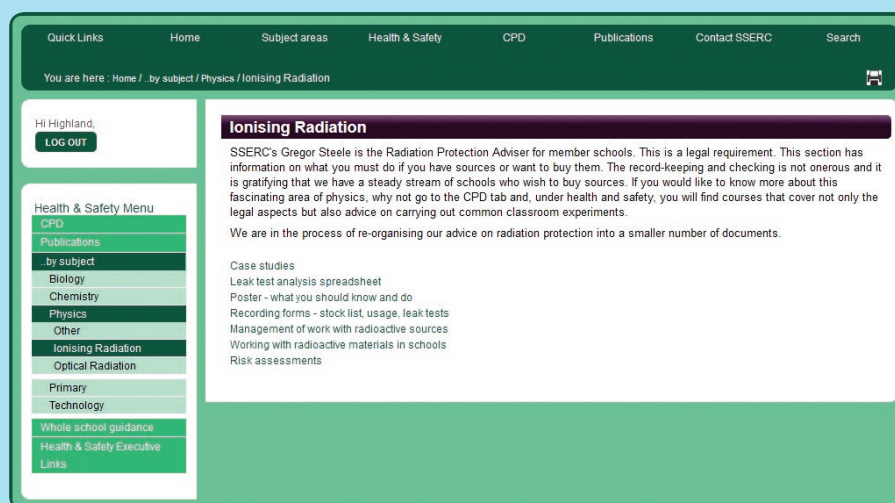


Figure 1 - The ionising radiation section of our physics safety information.

Section	Contents	Comments
Case studies	A collection of reports on incidents involving radioactive materials in schools.	Studying these incidents helped us to draw up sample contingency plans.
Leak test analysis spreadsheet	This spreadsheet allows you to enter the results of a leak test and find out whether or not your source passed.	The method of leak testing is described in the <i>Working with...</i> document.
Poster - what you should know and do	Poster with information that you need to have to hand - for example, safety rules.	This should be displayed somewhere in your department if you have radioactive materials in school.
Recording forms	Editable forms to record stock, usage and leak test results.	All of these are compulsory if you have sealed sources.
Management of work with radioactive sources	A guide for faculty heads and other managers as to what should be happening in a department that owns sources.	Think of this document as a detailed "what should be happening" and the one that follows as "how it should be done".
Working with radioactive materials in schools	A document for those working with sources, with detailed guidance on buying and using, contingency planning, leak testing, expectant mothers, storage and more.	Contingency plans can be edited for local use.
Risk assessments	Our risk assessments on the materials schools can work with.	This information can be used to create your own customised risk assessments for the activities you carry out with the sources.

Reference

[1] <http://tinyurl.com/SSERCradpro>.