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Impulse experiments using Electrolycra

This is an inexpensive, simple method of getting a force/time graph and comparing impulse with change in momentum.

The Higher course requires: *use of Newton's third law to explain the motion of objects involved in interactions. Interpretation of force/time graphs involving interacting objects. Knowledge that the impulse of a force is equal to the area under a force/time graph and is equal to the change in momentum of an object involved in the interaction.* Calculations on data obtained from the force/time graph are also required and this experiment works through them too.

Requirements

A 2 cm width, 11 cm length of Electrolycra™, 2 bulldog clips, 2 weights of 10 N, a piece of thick cardboard 13 cm by 10 cm, a voltage sensor, a variable 50 Ω potentiometer, two 22 Ω resistors, two 1.5 V batteries, a ball or bead of mass ~0.5 g and suitable interface for data logging, see Figure 1.

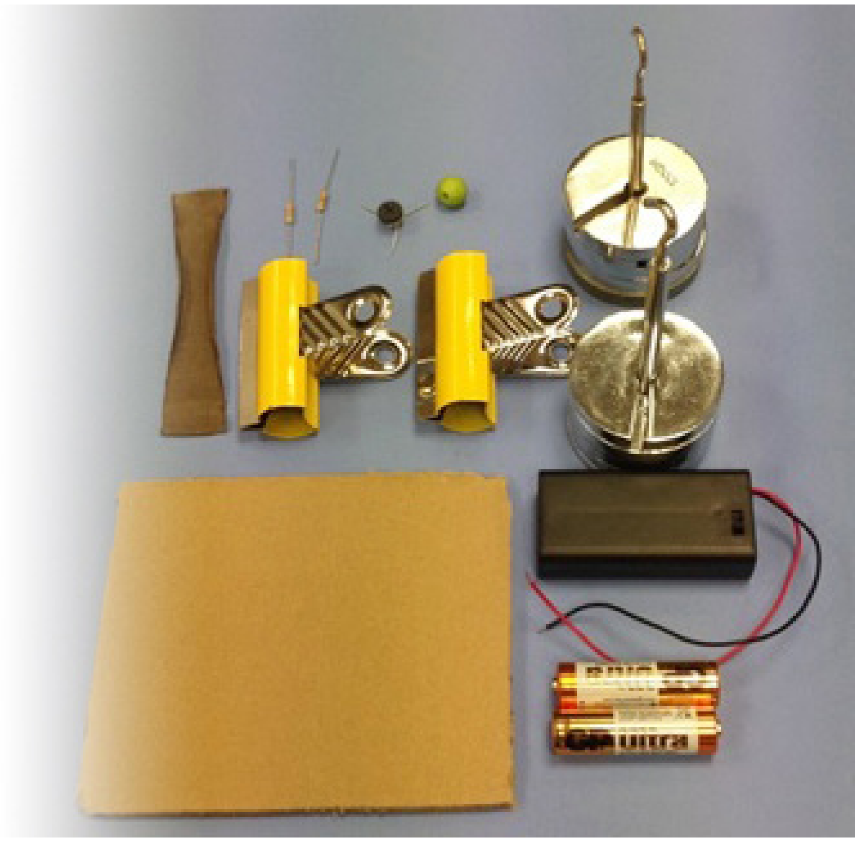

Figure 1 - Equipment required.

Constructing the voltage sensor

Cut a 10 cm by 13 cm rectangle from a piece of 5 mm thick cardboard. At the centre of the card use a pair of compasses to draw a circle with a radius of 5 cm. Cut out the circle, see Figure 2. Cut two, 2 cm long slots, 7 cm apart in one of the 13 cm long sides, see Figure 2. Extend the slots through only half the thickness of the card by a further 3 cm, see Figure 2. These slots keep the crocodile clips that connect the Electrolycra to the voltage sensor in place. Lay the Electrolycra across the centre of the circle so its longitudinal axis lies along the diameter of the circle. Stretch the Electrolycra by 1 cm and hold it firmly in place using the bulldog clips, see Figure 3. The Electrolycra must be stretch just enough so it displays a voltage that is proportional to its extension. >>

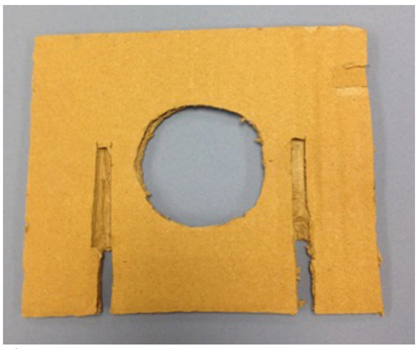

Figure 2

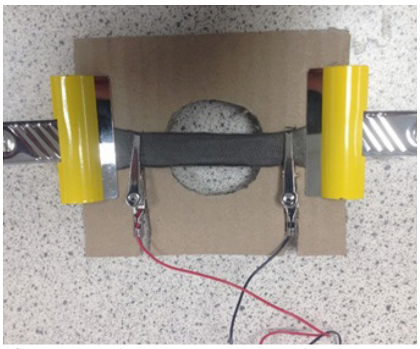

Figure 3 - Voltage sensor construction.

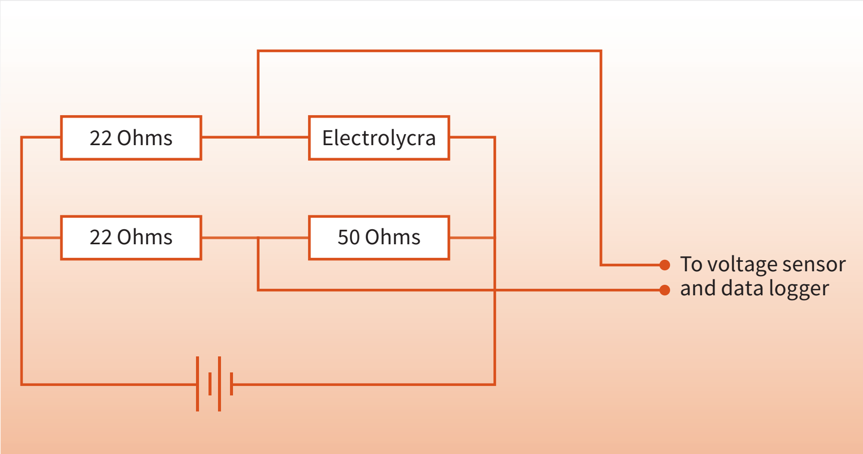

Figure 4

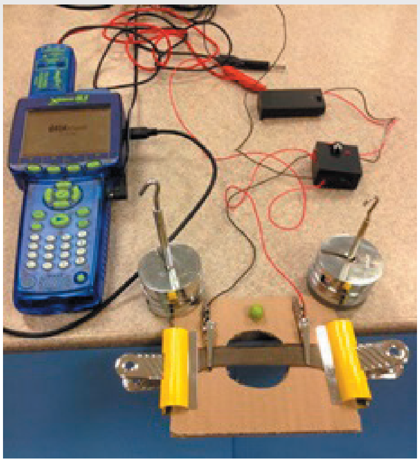

Figure 5

Construct a Wheatstone bridge as shown in Figure 4. Connect the Electrolycra into one arm of a Wheatstone bridge using the crocodile clips and connect the voltage sensor across the Wheatstone bridge so the off-balance voltage can be recorded, Figure 5. The off-balance voltage is recorded using a voltage sensor and a data logger. The voltage sensor needs to be calibrated so the voltage can be converted to a force.

Calibrating the voltage sensor
To calibrate the voltage sensor known masses are hung from the Electrolycra, see Figure 6. The easiest way to get the results is to record the off-balance voltage using the data logger. The reading tends to start high when the mass is first applied, then reduce. It is this initial high reading that should be used on the calibration graph. The masses must be placed with care, so that no extra force is applied by the mass dropping onto the carrier. The results are shown in Figure 7.

Calculations

The off-balance voltage against time graph for the bead dropped from a height of 2 cm is displayed on the computer, see Figure 8. The area under a force/time graph gives the impulse. The off-balance voltage can be converted to a force using the force/off-balance voltage graph, see Figure 7. A force time graph can then be plotted, see Figure 11.

The area under a force/time graph gives the impulse. Electrolycra exhibits hysteresis. It does not immediately return to its original state after being stretched by impact. The best estimate of the >>

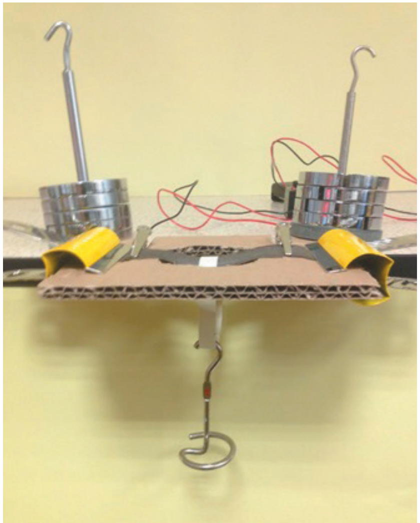

Figure 6

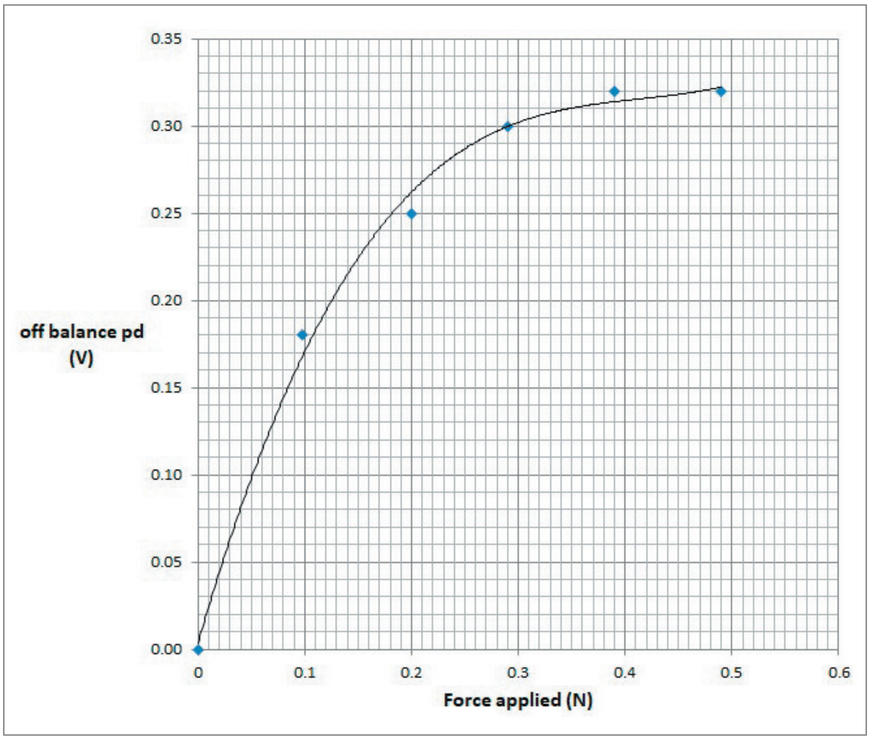

Figure 7 - The results.

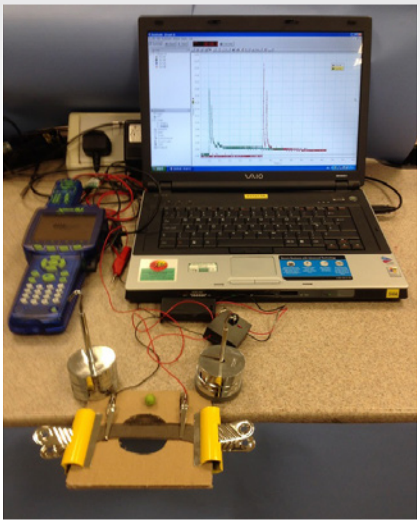

Figure 8 - The off-balance voltage against time graph for the bead dropped from a height of 2 cm is displayed on the computer.

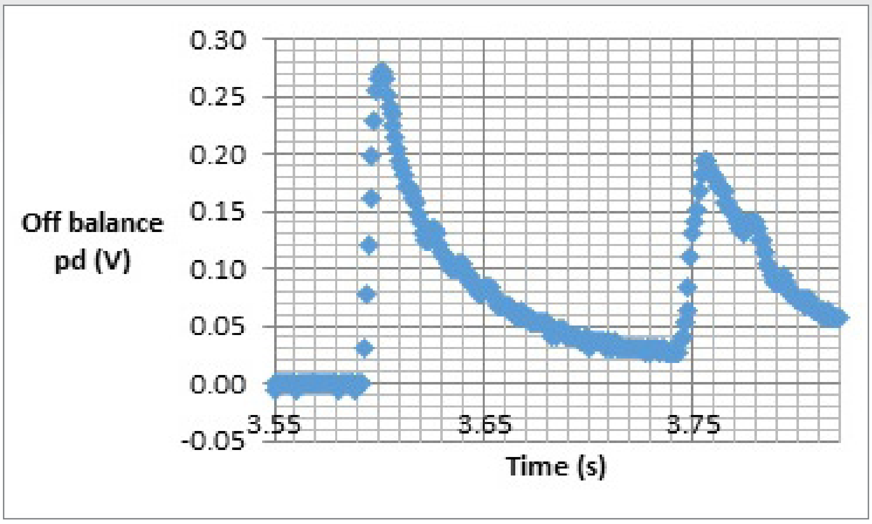

Figure 9 - Bead dropped from 2.0 cm.

area is found by doubling the area up to the peak of the graph in Figure 11 (the area bounded by the dashed lines).

Impulse = 2 x ½(0.009-0.001) x 0.21 Ns = 0.0017 Ns.

The mass of the bead was found, using a balance, to be 5.6 x 10^{-4} kg. Its change in momentum can be found if the height it is dropped from is know.

The bead was dropped from a height of 2.0 cm.

The loss of gravitational potential energy is assumed to be equal to the gain in kinetic energy.

$mgh = \frac{1}{2}mv^2$ giving, on rearrangement $v_1 = \sqrt{(2gh)} = \sqrt{(2 \times 9.81 \times 0.02)} = 0.6\ ms^{-1}$

The bead bounced on the Electrolycra and reached a height of 1.0 cm. This can be deduced as when the bead was dropped from a height of 1 cm the peak voltage was 0.2 V, see Figure 10.

$v_2 = \sqrt{(2 \times 9.81 \times 0.01)} = 0.4\ ms^{-1}$.

Taking the downward direction as positive, v_1 as the initial velocity and v_2 as the final velocity the change in momentum is given by:

$\Delta mv = m(-v_2 - v_1) = 5.6 \times 10^{-4} (-0.4 - 0.6)\ kg\ ms^{-1} = -6 \times 10^{-4}\ kg\ ms^{-1}$.

Summary

Comparing impulse with change in momentum, they are of the same order of magnitude rather than equal. Several assumptions have been made throughout the analysis and, as a further teaching point, these assumptions can be discussed with students.

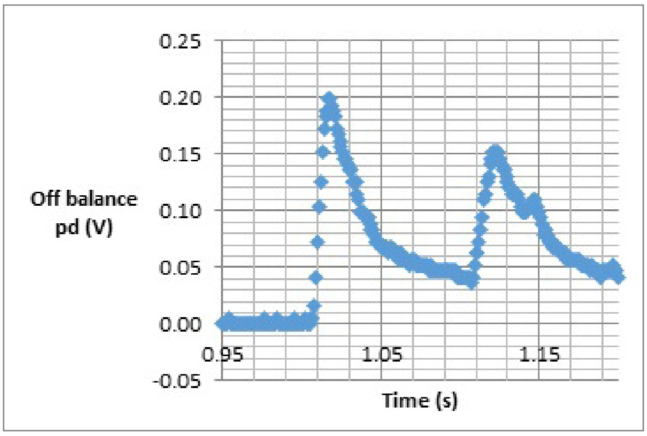

Figure 10 - Bead dropped from 1.0 cm.

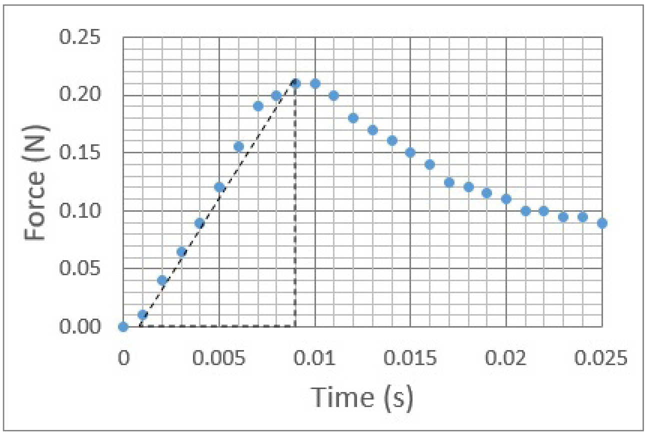

Figure 11

End-product inhibition of the enzyme phosphatase - revisited

The SQA Course Specifications for Higher Biology and Higher Human Biology each suggest, as a context for the study of metabolic pathways, a learning activity where students might, "Carry out experiments based on end-product inhibition using phosphatase and phenolphthalein phosphate" [1].

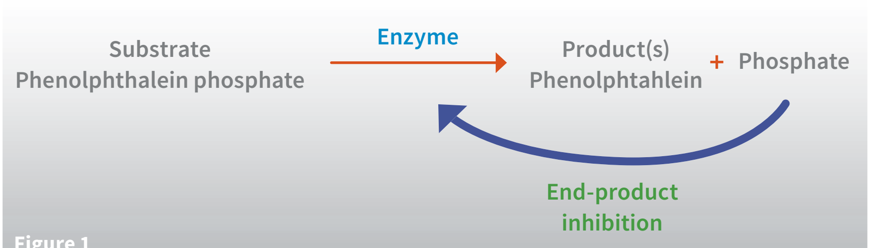

Figure 1

One form of the enzyme phosphatase is easily extracted from mung bean shoots (bean sprouts) and SSERC has produced several protocols based on investigating the activity of this enzyme [2].

The protocol suggested here is based on one produced by the Biotechnology Scotland Project, SAPS and the Higher Still Development Unit [3], which in turn is based on the work of Dr Barry Meatyard [4].

Background

Phosphatase enzymes are found in a wide range of plant and animal tissues. They are key enzymes in cell metabolism because they release the phosphate groups required for synthesis of, for example, ATP, phospholipids and nucleotides.

There are two main groups of phosphatase enzymes. These are acid, or alkaline depending on the pH at which they work optimally. In this protocol we will use an acid phosphatase (pH 5) which is simply and cheaply extracted from germinating mung beans (beansprouts).

For the enzyme assay proposed here, an artificial substrate phenolphthalein bisphosphate (PPP) is used. Phosphatase reacts with PPP to produce phenolphthalein (PP) and a free phosphate group. Increased levels of phosphate inhibit the enzyme (Figure 1).

This protocol uses a range of concentrations of sodium dihydrogen phosphate in a citric acid buffer solution to provide the enzyme-inhibiting phosphate group.
The higher the concentration of phosphate present, the greater the inhibition of the enzyme. However, in these acidic conditions, the products of the reaction are colourless, so after a suitable incubation time an alkaline solution (sodium carbonate) is added. This serves two functions: it causes any free phenolphthalein to turn pink and it stops the reaction by denaturing the phosphatase enzyme.

Two different salts of sodium and phosphate are used:
- Disodium hydrogenphosphate (Na_2HPO_4) is a component of the pH 5 citric acid background buffer.
- Sodium dihydrogenphosphate (NaH_2PO_4) is added in varying amounts to the background buffer to provide a range of concentrations of enzyme inhibitor (Table 1).

>>

Cuvette number	1	2	3	4	5
Concentration NaH_2PO_4 (M) in background buffer	0	0.05	0.10	0.20	0.30

Table 1

	20 minutes at 30°C				
Inhibitor concentration (M)	0	0.05	0.10	0.20	0.30
Absorbance	0.133	0.112	0.093	0.075	0.064

Table 2

Method

In outline, the basic method is as follows:

- Prepare solutions of inhibitor in buffer.
- Extract phosphatase from bean sprouts: grind using a mortar and pestle; filter; centrifuge.
- Set up reaction mixtures in each of 5 cuvettes: 1.5 cm^3 appropriate inhibitor + buffer solution; 0.3 cm^3 PPP; 0.3 cm^3 enzyme extract.
- Incubate for 20 minutes at 30°C.
- Stop the reaction: add 1.5 cm^3 sodium carbonate (makes PP turn pink).
- Measure absorbance using colorimeter (550 nm or green filter).

A detailed teacher/technical guide is available on the SSERC website [5].

Our experiments

Using the method and reaction mixtures described above we set out to measure the effect of varying inhibitor concentration on enzyme activity as indicated by the absorbance of phenolphthalein in the solutions.

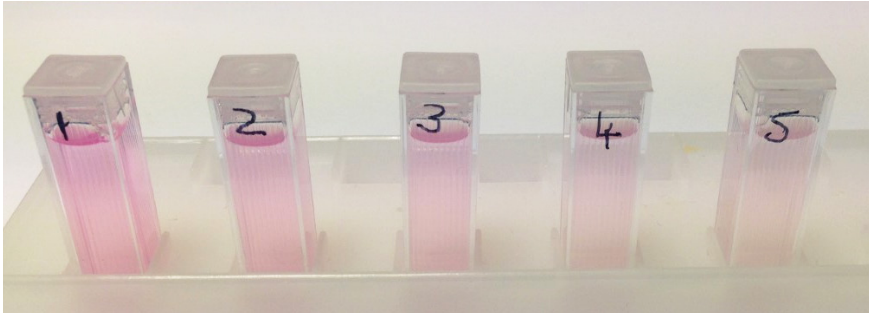

Figure 2 - Phenolphthalein phosphate, phosphatase and a range of concentrations of inhibitor (Table 1). After 20 minutes the addition of sodium carbonate alters the pH thus denaturing the enzyme and causing the phenolphthalein to become pink.

	10 minutes at 20°C				
Inhibitor concentration (M)	0	0.05	0.10	0.20	0.30
Absorbance	0.050	0.050	0.049	0.048	0.043

Table 3

	20 minutes at 20°C				
Inhibitor concentration (M)	0	0.05	0.10	0.20	0.30
Absorbance	0.083	0.065	0.055	0.053	0.040

Table 4

We used a Mystrica colorimeter [6] using the green diode. We used water as a blank. Initially the cuvettes were incubated by floating them in a water bath at 30°C for 20 minutes (Table 2 and Figure 2).

With school-based investigative work in mind, we were interested to see if this procedure could be repeated at room temperature within a typical teaching period, thereby negating the necessity for a water bath. Tables 3 and Figure 3, and Table 4 and Figure 4 contain results of reactions carried out at room temperature for 10 and 20 minutes respectively.

We concluded that it is possible to use the basic experimental protocol with the suggested reaction mixtures and get clearly visible and measurable results which illustrate end-product inhibition of phosphatase at room temperature ~20°C.

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Figure 3

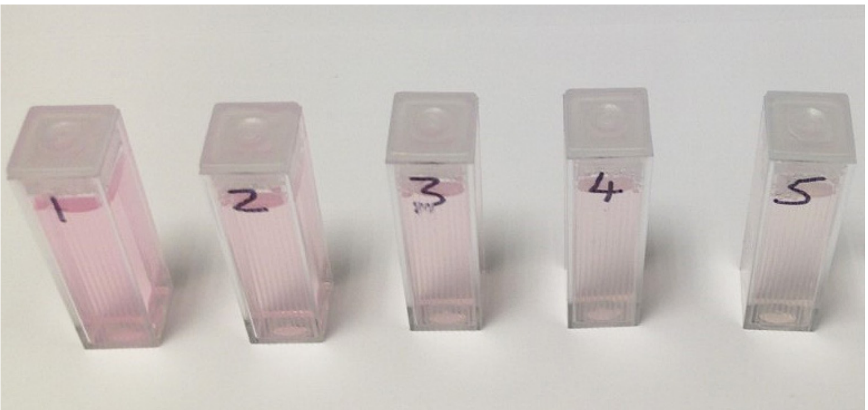


Figure 4

For visual comparison, Figure 5 shows cuvette number 1 from each of our experiments.

Investigation ideas

- Investigate enzyme properties by varying temperature – see also [2].
- Investigate enzyme properties by varying pH [2].
- Investigate the effect of varying substrate concentration.
- Investigate the rate of reaction by varying the times at which the reaction is stopped [2].
- Investigate the inhibiting effect of other phosphates, or of a general enzyme inhibitor.
- Compare phosphatase activity in different plant species. <<

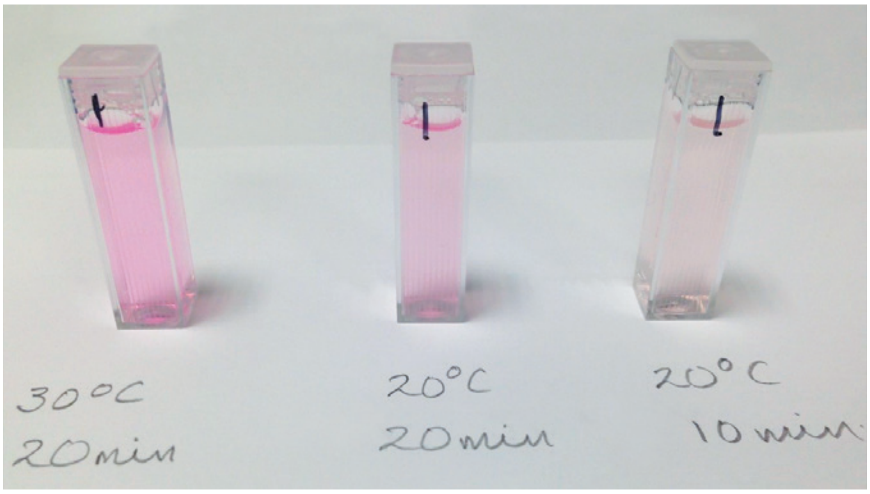


Figure 5

Further information

Further student support and information relating to this protocol, and to phosphatase enzymes can be found on the SAPS website:

- Phosphatase enzymes in plants https://www.saps.org.uk/secondary/teaching-resources/292-student-sheet-14-phosphatase-enzymes-in-plants.
- https://www.saps.org.uk/?category=0&text=phosphatase&option=com_qflarticlesfilter&view=articles&Itemid=0&qfl-search=1&modulename=Article+Filter+Right+Module.

References

[1] SQA (2018) Higher Biology Specification available at https://www.sqa.org.uk/files_ccc/HigherCourseSpecBiology.pdf (accessed November 2019).
SQA (2018) Higher Human Biology Specification available at https://www.sqa.org.uk/files_ccc/HigherCourseSpecHumanBiology.pdf (accessed November 2019).

[2] Fun with Phosphatase, *SSERC Bulletin*, **251**, 6-8, available at https://www.sserc.org.uk/wp-content/uploads/2015/05/SSERC251_p6-8.pdf and SSERC website, Higher Biology available at https://www.sserc.org.uk/subject-areas/biology/higher-biology/enzymes/.

[3] Advanced Higher Practical Activities (2000), Higher Still Development Unit.

[4] Meatyard, B (1999), Phosphatase enzymes from plants: a versatile resource for post-16 students. J Biol. Ed., 33, 109-112.

[5] Link to SSERC website teacher/ technical guide available at https://www.sserc.org.uk/subject-areas/biology/higher-biology/enzymes/ or https://www.sserc.org.uk/subject-areas/biology/higher-human-biology/cell-metabolism-4/.

[6] Mystrica website www.mystrica.com.

Free STEM teaching resources from the University of Edinburgh

The School of GeoSciences, in collaboration with the Open Educational Resources (OER) Service, at the University of Edinburgh have released a series of free STEM teaching resources for school teachers and educators. The resources, which can be downloaded free of charge from TES Resources, are accompanied by Curriculum for Excellence learning objectives and outcomes, and are designed to be easily re-used and adapted for different classroom scenarios and curriculum levels.

These innovative and engaging resources have been created by senior honours students as part of the University's GeoScience Outreach Course, which gives students the opportunity to develop their own science communication projects with schools, museums, outdoor centres and community groups, creating a wide range of reusable educational resources for science engagement and community outreach. The course enables students to gain experience of science outreach, public engagement, problem solving, teaching and learning, and knowledge transfer while developing valuable transferable skills that enhance their employability.

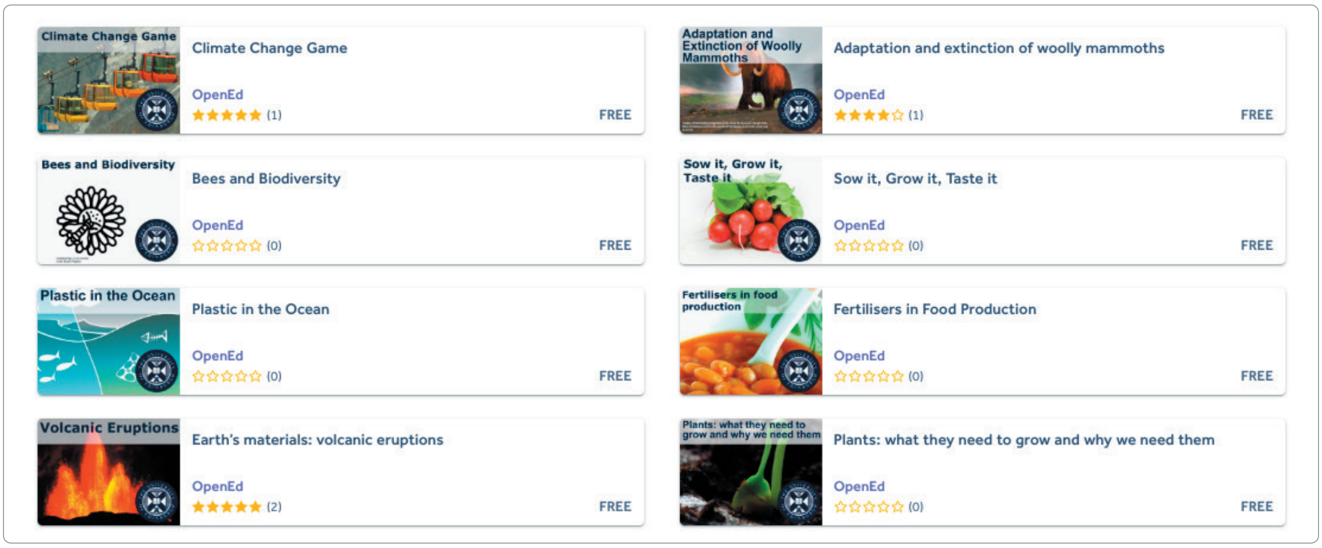
Students have responded positively to the GeoSciences Outreach course and the opportunities it provides, while school teachers' comments on the resources they have created are equally enthusiastic.

> *"It has been good to take my learning out into the community and give something back."*
> *Student testimony*

The resources cover a wide range of interdisciplinary STEM subjects in fun and creative ways. Topics include biodiversity, sustainability and conservation, climate change, food production, marine pollution, volcanoes, continents and oceans, graph theory, and statistics for environmental sciences.

Earth's Materials: Volcanic Eruptions

This resource, developed by student Isla Simmons, provides a series of four interdisciplinary lessons about volcanoes for SCQF Levels 2 and 3, covering several aspects of the curriculum, including SCN 2-17a, SCN 2-19a, SOC 2-07b, TCH 2-02a, LIT 2-02a and EXA 2-14a. In the first lesson, pupils conduct experiments to model the processes that occur within volcanoes during eruptions. In the second lesson, pupils study the 1973 eruption of Heimaey, Iceland, through role-play, as they plan what action to take as lava flows threaten their town. The third lesson asks >>



> *"Incredibly useful, especially the fact that you provided editable versions."*
>
> *Teacher feedback*

pupils to carry out their own research to investigate historic volcanic eruptions, and design a poster to present what they have learned to their classmates. And in the final lesson, pupils visit Arthur's Seat, an extinct volcano in Edinburgh, to learn geological field skills such field sketching and rock observation, allowing them to consolidate all they have learned about volcanoes and apply it to a real-life, local example.

This resource has a five-star review on TES Resources - "This is totally amazing!! A brilliantly inspiring resource." <<

Lava fountains of the fissure eruption in Holuhran on Iceland (CC-BY SA 4.0, Joschenbacher, on Wikimedia Commons).

Further information

- You can download these free resources from the University of Edinburgh on TES Resources: https://www.tes.com/teaching-resources/shop/OpenEd.
- Find out more about the GeoScience Outreach Course here: https://www.ed.ac.uk/geosciences/undergraduate/geoscience-outreach.
- Creating open educational resources is part of the University of Edinburgh's commitment to discover and share knowledge and make the world a better place. To find out about our vision for open education, and to access more free teaching and learning resources, visit Open.Ed https://open.ed.ac.uk/.

SSERC professional learning courses

Our professional development courses range from twilight events, day-courses through to residential meetings lasting up to 6 days in total. Our curriculum coverage spans both primary and secondary sectors and we offer events for teachers as part of their career long professional learning, newly qualified teachers and technicians. Many of our events receive funding from the ENTHUSE Bursary scheme or the Scottish Government.

Courses available for online booking include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Chemical Handling	No	18-19 February 2020	21 January 2020	Secondary Technicians
Fabrication Skills	Yes	18-19 February 2020	10 January 2020	Secondary Technology
Safe Use of Workshop Machinery	No	25-26 February	28 January 2020	Secondary Technicians
SSERC_Meet Teddy in the Park	No	26 February 2020	31 January 2020	Primary
Statistical analysis of data in R	No	7 March 2020	7 February 2020	Secondary
SSERC_Meet Science Inquiry: Observing, Exploring & Classifying	No	4 March 2020	7 February 2020	Primary
Electrical Safety and PAT	No	10-11 March	6 February 2020	Secondary Technicians
Safe Use of Workshop Machinery	No	18-19 March 2020	13 February 2020	Secondary Technicians
Maintenance of Fixed Workshop Machinery	No	25-27 March 2020	18 February 2020	Secondary Technicians
Welding Skills	Yes	6-7 May 2020	27 March 2020	Secondary Technology
Safety in Microbiology for Schools	Yes	13-15 May 2020	27 Mar 2020	Secondary Technicians
Safe Use of Workshop Machinery	No	13-14 May 2020	27 Mar 2020	Secondary Technicians
Welding Skills	Yes	21-22 May 2020	3 April 2020	Secondary Technology
Chemistry Summer School	Yes	26-28 May 2020	24 April 2020	Secondary Chemistry
Royal Society of Biology Annual Teachers' Meeting	No	28 May 2020	24 April 2020	Secondary Biology
Safe Use of Other Fixed Workshop Machinery	No	2-3 June 2020	1 May 2020	Secondary Technicians
Maintenance of Fixed Workshop Machinery	No	9-11 June 2020	8 May 2020	Secondary Technicians
Intermediate Physics	No	10-11 June 2020	8 May 2020	Secondary Technicians
Introductory Chemistry	No	17-18 June 2020	15 May 2020	Secondary Technicians
Biology Summer School	Yes	23-25 June 2020	29 May 2020	Secondary Biology

Please check our website pages at **https://www.sserc.org.uk/professional-learning/calendar/** for the most up-to-date details on our career long professional learning calendar.

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2020: year of the Young STEM Leader

“2020 will be the year of the young STEM Leader”
Alastair MacGregor, Chief Executive of SSERC

The pilot of the Young STEM Leader Programme continues in Scotland with over 70 centres taking part. With many Young STEM Leaders in action across the country, we have taken the opportunity to visit and document their amazing journey. Not only can you see fantastic content on our Twitter page, you can also read some in-depth case studies from a small selection of our pilot centres. Visit our website [1] to access our Twitter feed and click the case studies tab too!

Become a delivering centre

We are preparing for our full national launch of the programme where centres such as schools, community and youth groups in Scotland can register to deliver the programme.

The next step for those interested is to attend either online or face-to-face Information Sessions, available across Scotland. As with all things YSL, you can find out more or sign up on our website.

SCQF milestone

The YSL Project Team at SSERC is pleased to announce that “YSL 6” is now on the Scottish Credit and Qualifications Framework. The qualification was credit-rated by SQA at SCQF level 6 with 3 credit points. This means that young people will not only develop leadership, employability, social and communication skills, they will gain a formal award in the process! Delivering centres who work with Insight can also claim the tariff points available for offering the award to their young people.

A YSL of All Saints Secondary in Glasgow leading STEM workshops with pupils of St Philomena's Primary.

Young STEM Leaders of Dalmarnock Primary exploring the vast STEM content in photography.

A message from the Project Manager

The YSL Programme is open and accessible to all of Scotland’s young people. It does not have any entry requirements or conditions, there are no tests or exams, just a simple YSL Log to document their leadership journey.

Many people in Scotland don’t consider STEM as a possible pathway for them because they are not being shown its full meaning, the limitless contexts and opportunities it holds. By widening the context of STEM and challenging stereotypes, misconceptions, outdated views and elitism, the YSL programme aims to change all of this!

YSLs can complete this programme in a STEM context that suits and interests them – no matter how unusual their content may be. This programme is the perfect way for any young person in Scotland, irrespective of experience or background, to get involved in STEM.

Reference
[1] www.yslpilot.scot.

Virtual Reality in the School of Education at University of Glasgow

When we wrote in Bulletin 260 [1] on the control measures for using virtual reality in the classroom, we admitted that we did not have much experience of the technology ourselves and wondered if our safety advice was draconian. Since then, we have worked with Gabriella Rodolico of Glasgow University who used our guidance and found it to be entirely appropriate. We thought that Gabriella's findings on the pedagogical aspects of VR would be of interest to many teachers of STEM subjects. She has kindly agreed to share her findings in the following article.

Figure 1 - Gabriella Rodolico - Lecturer in Science Education (Biology) at University of Glasgow.

Evidence proves that learning technologies have a huge impact on education at whatever level. A recent study compared the impact that traditional learning, based on books and videos, and Virtual Reality taught lessons had on students in Higher Education. It was demonstrated that VR-supported lessons were able to enhance positive emotions while reducing negative emotions before and after the learning phase [2]

While on the one hand some studies shows that 83% of teachers think that virtual reality might lead to better understanding of learning concepts, greater collaboration (71%) and motivation in the classroom (84%) [3], on the other hand there are barriers to the effective implementation of this technology in the classroom, such as lack of confidence and time [4].

Very recently, I started to look into the possibility of studying the impact of Virtual Reality in Education, with the aim to analyse the impact that this type of technology has, not only on the understanding of difficult concepts in science education, but also on the learning experience that teachers and students share every day in the classroom and the enjoyment that comes from this mutual exchange.

In the last few months, I have started a collaboration with Avantis, a leading company in the sector of Virtual Reality applied to Education. The company has supported my initial proposal by agreeing to a short-term loan of their ClassVR headsets and access to their educational portal.

As a first step I visited the Erskine Stewart's Melville School in Edinburgh, where the brilliant work of Mr Simon Luxford-Moore, eLearning Co-ordinator, has effectively implemented VR technology in the lesson planning of several subjects in the school.

I was able to observe a P6 classroom and I was blown away by the learning and teaching that was going on there. I interviewed the classroom teacher and I realised that, if on the one hand technology is a fantastic teaching tool, on the other hand it is only successful if carefully blended with several other effective pedagogy techniques.

This also highlighted that the only really essential factor that makes learning enjoyable and effective in the classroom is the teachers' passion and commitment to their job with the students at the centre of their planning.

With this in mind, I have planned, in collaboration with my colleagues, some lessons for the PGDE primary student teachers, with a balanced blending of traditional as well as innovative effective pedagogy techniques. >>

A pit-stop tour of active learning methods in preparation for an on-campus teaching session was organised for our PGDE primary student teachers who, in a meta-level approach, had the chance to test several teaching tools. Students moved from traditional peak flow meters and body organ aprons, to innovative augmented reality t-shirts showing the internal organs, and virtual reality ClassVR headsets with an immersive virtual tour around the body.

The following week PGDE primary student teachers had to plan a lesson on Body systems, in a micro-teaching cooperative style, for the P6 students from Corpus Christi Primary School, who were invited to visit the School of Education. They had the chance not only to choose between all the resources shown the previous week, but also to create new resources and implement them in their teaching.

The results were amazing [5], and the high quality of resources produced as well as the positive feedback offered by the P6 pupils, showed that, when it comes to teaching passion and confidence, they can be positively supported by technology, but they are also innate qualities to cherish and further develop with a commitment to lifelong learning. "Docendo Discimus" Seneca- only by teaching we learn!

Further planning is ongoing to evaluate how to increase teachers' confidence in applying innovative technology such as VR, by organising more seminars within teacher training courses, which will give more chances to student teachers to integrate the VR technology in their effective pedagogy. <<

References

[1] https://www.sserc.org.uk/wp-content/uploads/Publications/Bulletins/260/SSERC260p12.pdf.

[2] Devon Allcoat* and Adrian von Mühlenen: Learning in virtual reality: Effects on performance, emotion and engagement. Research in Learning Technology Vol. 26, 2018.

[3] https://www.businesswire.com/news/home/20160627005621/en/Survey-Finds-Teachers-Virtual-Reality-Reality-Classroom.

[4] Peter Reed. Staff experience and attitudes towards technology-enhanced learning initiatives in one Faculty of Health and Life Sciences. Research in Learning Technology Vol. 22, 2014.

SSERC Annual Conference keynote speakers

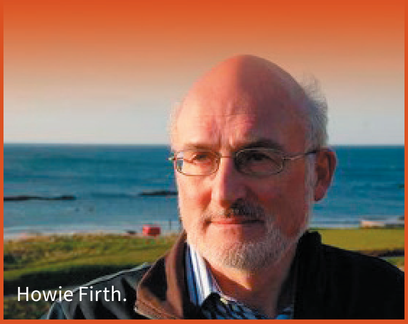
For the SSERC Annual Conference in December 2019 we were very fortunate in having two keynote speakers – Graeme McAlister and Howie Firth. Short biographical notes for both speakers follow:

Graeme McAlister is the Chief Executive at the Scottish Childminding Association. Graeme has over 17 years' senior experience in the voluntary and health sectors in Scotland, specialising in communications, public affairs, stakeholder engagement and membership. During this time, he has influenced legislation, policy, practice and thinking in a number of areas and contributed to the strategic repositioning of organisations for which he has worked.

The title of Graeme's presentation was '*The Importance of Childminders in Supporting Learners*'.

Howie Firth is a scientist, writer and broadcaster who was director of the first Edinburgh Science Festival in 1989, providing the city's concept of a science festival with a format that has subsequently spread

Graeme McAllister.



Howie Firth.

to many other countries. Howie continues to advise and assist with the organisation of science festivals across the UK and internationally.

The title of Howie's presentation was '*Science Festivals: Making science accessible to wider audiences in Scotland*'.

Both speakers generously allowed us to film their presentations and these can be viewed via our SSERC TV channel [1, 2]. <<

References

[1] Graeme Mc Allister's presentation is available at https://www.youtube.com/watch?v=YOJPldGoFR0.

[2] Howie Firth's presentation is available at https://www.youtube.com/watch?v=Q3feYoff5O0.

Safety in Microbiology
Level 3 training

Safety in Microbiology – A Code of Practice for Scottish Schools and Colleges (SSERC 2018) [1], the most recent edition of which was issued to schools in December 2018, contains guidance on the safe handling of micro-organisms for local authority and SSERC member schools and colleges. In most cases, local authority, or independent school/college, employers have adopted the Code of Practice to meet the requirements of the COSHH Regulations and of other related health and safety legislation.

Where the Code of Practice has been adopted by an employer, various training requirements are necessary for microbiological work to be undertaken according to the Code of Practice guidance.

The following extracts from the Code of Practice refer to training requirements:

1.8 The level of work with micro-organisms that a teacher or technician may undertake will be limited by the training that the teacher or technician has undergone.

Training required for work at level 1

2.2 [At level 1] No specialist training is required.

Training required for work at level 2

3.1 For class laboratory work with learners at level 2 a science teacher does not require specialist (level 3) training. However, teachers may prefer and feel more confident in managing level 2 laboratory class work if they are trained to level 3.

3.2 Support for science teachers with limited experience of microbiology could be provided in a short in-school training session from a more experienced technician or teacher colleague. Such support could be based on the SSERC Microbiological Techniques [2] resource materials.

3.3 Teachers of level 2 classes must be trained in dealing with spillages.

3.4 In order for level 2 class laboratory work to be safely carried out, personnel trained at level 3 must be available to carry out the preparation, maintenance and disposal level 3 tasks necessary to support level 2 work.

Training required for work at level 3

4.1 For level 3 work technicians and teachers are required to be trained to level 3. They must have undertaken and achieved the competence standards of the SSERC Safety in Microbiology for Schools course. Senior phase students may be trained to carry out a range of level 3 tasks for specific experiments or project work. Such students must be supervised by a teacher or technician trained to level 3.

4.2 The following level 3 tasks are normally required to be carried out in an establishment in support of level 2 work:

a) order, receipt, labelling and storage of cultures;
b) preparation of sterile media and sterile equipment;
c) preparation of cultures for class use;
d) maintenance of stock sub-cultures;
e) sampling from bioreactors;
f) sterilisation and disposal of cultures;
g) sterilisation of used equipment;
h) management of incidents of spillage;
i) staining of incubated plates (e.g. starch agar).

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Determination of competence to carry out level 3 tasks

To operate within the Code of Practice school technicians who are preparing and disposing of materials for level 2 work must be trained to level 3. There is no absolute requirement for teachers to be trained to level 3 (unless they are carrying out, or supervising level 3 tasks).

A teacher or technician is considered competent to carry out level 3 tasks if they have undertaken and achieved the competence standards of the SSERC course, Safety in Microbiology for Schools, which has been SCQF Credit and Levelled by SQA. However, employers may consider an individual competent if they have undertaken a degree, course or work-based training that allows them to meet the same competence standard within the last five years. SSERC sometimes receives enquiries from teachers or technicians outlining their qualifications and asking us to determine their competence to undertake level 3 work. SSERC can only explain the guidance, it is for the employer to make the decision.

Level 3 refresher training

From time to time SSERC also receives enquiries, from individual technician/teachers who have already passed the Safety in Microbiology for Schools course, regarding refresher training. If an employer has a policy on refresher training, individuals must adhere to their employer's requirements. Otherwise, there is no hard and fast rule about refresher training. If an individual regularly uses and has maintained the skill level they achieved in microbiological techniques via the Safety in Microbiology for Schools course (or equivalent), there may be no need for a refresher course. If, however, an individual has not had the opportunity to maintain these skills through regular practice, refresher or re-training is appropriate. <<

References

[1] Safety in Microbiology – A Code of Practice for Scottish Schools and Colleges (SSERC 2018) is available at https://www.sserc.org.uk/health-safety/biology-health-safety/codes-of-practice/.

[2] SSERC advice on microbiological techniques is available at https://www.sserc.org.uk/health-safety/biology-health-safety/microbiological-techniques/.

Protactinium generator update

In our last bulletin, we told you that protactinium generators eight years old or more would require to be disposed of. We ourselves own one and whilst we knew that disposal would not be cheap, we were taken aback at just how expensive it could be. Co-ordinating disposals from a number of schools could bring the cost down significantly. If you have not already informed us that you have a protactinium generator awaiting disposal, please do so immediately. <<

Capacitor safety

'What is the maximum capacitance allowable for a capacitor that will be used by students?' A query like this one was emailed to our helpline and, as is often the way of these questions, there turned out to be more to it than initially seemed to be the case.

Voltage

We can approach this from the 'hazardous live' perspective that we discussed in Bulletin 266 [1]. If the capacitor is fully charged by being connected to a potential difference of more than 30 V, this will exceed the safety limits set down by SSERC. However, the power supply doing the charging would also exceed these limits, so this is not something that is likely to happen in schools. Having said that, there are electronic circuits and methods of connecting charged capacitors together that can give voltages greater than that used for charging. These should not be used if they result in potential differences greater than 30 V.

Energy

A Van de Graaff generator, like a capacitor, has the ability to hold charge. We assess the risk of harm from these devices by considering the energy of the discharge rather than the voltage. Voltage, though initially well above 30 V, reduces to zero. There are some Advanced Higher experiments that involve charging a parallel plate capacitor using an EHT supply, but in these cases the capacitors have very low capacitances in the picofarad range. Using the capacitor energy formula $E = ½ CV2$, where C is the capacitance of the capacitor and V is the potential difference across it, the energy works out to be well below the 350 mJ limit for high voltage discharges. Note that only an EHT supply can be used for these experiments as it is current-limited. Although an HT supply has a lower output voltage, it is not current limited and must not be used for these activities.

Figure 1 - Electrolytic capacitors.

Supercapacitors

Is that the end of the story? Enter the supercapacitor. When there were only two channels on TV and Wagon Wheel biscuits were nearly as big as actual wagon wheels, the idea of a small 20 F capacitor would have been laughable. Now such supercapacitors are easy to obtain. Typically, they have an operating voltage of 2 or 3 V, though we have seen some that can be charged until the potential difference across them is 12 V. Such a capacitor has the potential to store a few hundred Joules. Were you to accidentally short-circuit such a charged capacitor with a piece of jewellery such as a ring, there could be a sudden, large amount of localised heating. Care is needed.

Other considerations

Some capacitors such as electrolytic capacitors are polarity sensitive. Connecting these the wrong way round can cause them to explode. The negative side of the capacitor is usually marked with a minus sign, and the leg on that side is shorter. Do not use such capacitors with ac. Very old paper-based capacitors may still be in use in schools. The ageing paper can break down at voltages below that for which the capacitors would have been rated as being safe when new. By this we mean that current can flow through the material that is supposed to act as an insulator between the plates. This can create a fire hazard.

You can find the summary in Table 1 below.

Control measure	Rationale
The potential difference across a capacitor or an assembly of capacitors must not exceed 30 V.	This is to avoid anyone coming into contact with a 'hazardous live'. See below for the special case of parallel plate assemblies.
Parallel plate capacitors must not be charged using HT supplies.	Unlike EHT supplies, HT supplies are not current-limited.
Take care not to short-circuit a charged supercapacitor with jewellery.	The energy in a supercapacitor, if transferred to a piece of jewellery during a short, could cause damaging localised heating.
Do not charge any capacitor to a value above its voltage rating. For an older paper-based capacitor, keep well below the maximum rated voltage.	Too large a voltage can cause a capacitor to break down, presenting a fire hazard.
Ensure that electrolytic capacitors are used only with dc and are always connected the correct way round.	Wrongly-polarised electrolytic capacitors can explode.

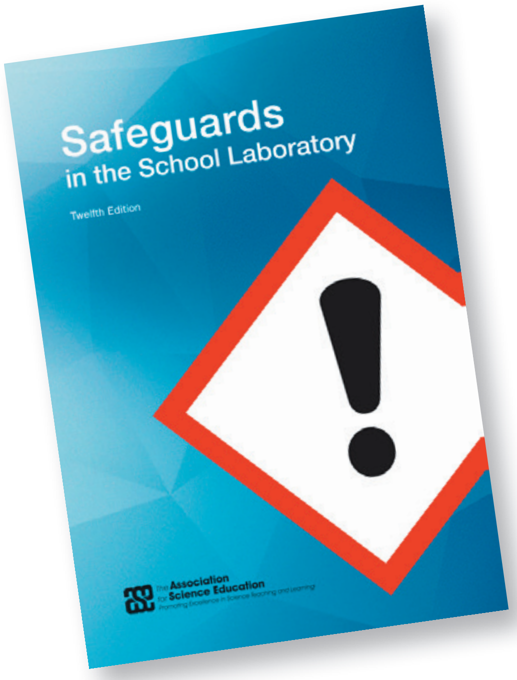
Table 1 - Summary.

Reference

[1] https://www.sserc.org.uk/wp-content/uploads/Publications/Bulletins/266/SSERC-bulletin-266p11_18.pdf.

A new edition of Safeguards in the School Laboratory

At its Annual Conference in Reading, ASE launched the 12th edition of *Safeguards in the School Laboratory*. This familiar title was written by members of the ASE's Health & Safety Group and is intended for all those involved in 11-19 science education. It will be particularly useful for newly-qualified and trainee teachers, new technicians and for those seeking promotion to, or newly-appointed as, heads of department, senior technicians, etc. Having said that, one experienced former head of department, who joined the Group shortly before the revision started, was astonished at how much he hadn't known!



Safeguards in the School Laboratory seeks to provide an overview of health & safety issues in science education; it flags up areas where there are significant misconceptions, where problems commonly arise and draws attention to situations which, although rare, may have serious consequences.

Although the underlying advice in the 11th edition (2006) is still sound, it has been updated where legislation has altered, e.g. on chemical hazards and radioactivity, or where school practice has changed. Most sections have been reworded to improve clarity; the chapters and sections dealing with chemicals have been completely reorganised and rewritten.

Strictly speaking, this is really the 13th edition. *Safeguards in the Laboratory* was first published by the Association of Women Science Teachers in 1933 '*… to help inexperienced teachers to avoid some of the commoner laboratory mishaps and to guide non-scientific headmistresses in laboratory administration from the point of view of safety.*' In 1947, the Science Masters' Association and the Association of Women Science Teachers published what was described as the 1st edition of Safeguards in the Laboratory, followed by the 2nd edition in 1950 and the 3rd in 1957. The 4th edition (by now, *Safeguards in the School Laboratory*) came in 1961. By the 5th edition in 1965, the ASE was the publisher and rest is history - 6th edition in 1972, 7th 1976, 8th 1981, 9th 1988, 10th 1996 and 11th 2006.

It does not replace detailed health & safety advice or risk assessments provided by SSERC on behalf of employers (or CLEAPSS in the rest of the UK); it does, however, alert readers to those occasions when they need to be careful and check those details. Ideally it should be read from cover to cover, even if some parts are skipped over at a first reading. Physicists do use some chemicals, biologists do use electrical equipment and technicians need to understand the issues facing teachers - and vice versa. This approach is perhaps most valuable for heads of faculty to make them aware of potential problems outwith their own subject specialism.

This, coupled with Topics in Safety, the latest chapters of which are available on the ASE website, provides an invaluable resource for managing health and safety in school science departments. «

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