SAPS SCIENCE & PLANTS FOR SCHOOLS

OSMOSIS

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Support for plant sciences – the role of the Gatsby Charitable Foundation

The Gatsby Charitable Foundation's interest in plant science dates back to the 1980s and its commitment to this area continues to grow. The overarching aim of Gatsby's plant science programmes is:

to develop basic research in fundamental processes of plant growth and development and molecular plant pathology, to encourage young researchers in this field in the UK, and to support improved introduction to the world of plants within school science teaching.

Despite the critical role that plant science will need to play if we are to find solutions to arguably the greatest problems facing the planet in the 21st Century (climate change, food security, energy production, etc.), study in the UK of plant sciences and plant science research attracts relatively few people compared to other branches of the biosciences. Anecdotal evidence suggests that there is a growing problem, in the UK and beyond, in recruiting sufficient high calibre scientists into plant science. Gatsby has recently commissioned research to investigate this issue further and seek hard data.

Artist's impression of the new Sainsbury Laboratory - Cambridge

In the last 10 years alone, Gatsby Trustees have approved grants totalling more than £56 million for work in plant science. In addition to this impressive sum the Foundation has recently committed a further £89 million to the construction, within the grounds of the Cambridge University Botanic Garden, of a new state-of-the-art centre - the *Sainsbury Laboratory, Cambridge*. This laboratory, due to open in 2010, will be a global centre of excellence for plant science research, employing over 100 of the world's best plant scientists.

SAPS – what lies ahead?

SAPS is set to undergo major changes over the coming weeks and months and this final issue of *Osmosis* allows us to bring you up to date with proposed developments.

Since 1990, SAPS has received the bulk of its funding from the Gatsby Charitable Foundation. SAPS has worked with teachers, scientists and educationalists to promote plant science and molecular biology as key curriculum areas and to support teachers and lecturers in the delivery of plant science education in schools and colleges. SAPS is now recognised nationally and internationally for its dynamic programmes and commitment to devising lively, reliable resources and encouraging their use in the classroom.

Science and Plants for Schools, Cambridge University Botanic Garden, 1, Brookside, Cambridge CB2 1JE. Tel: 01223 748455
SAPS Biotechnology Scotland Project. Tel: 01383 626077, email: saps@sserc.org.uk

The Gatsby Trustees believe that the key focus of SAPS should now be to concentrate on the 16-19 sector (or at least a 14-19 education continuum) and in particular seek to work with the Awarding Bodies, QCA and others to help define the plant science content of post-16 curricula. To move this agenda forward the SAPS Trustees and the Gatsby Trustees have decided that the time is right for a new structure and focus for the work of SAPS. In August 2008, SAPS moved from Homerton College, Cambridge into accommodation at the Cambridge University Botanic Garden. Later in the year SAPS will no longer function as a charity but become a project of the University of Cambridge.

There will be some changes to the work of SAPS as the new organisation comes into existence. The most noticeable changes will be (i) removal of support for activities in the primary and early secondary stages of the curriculum, (ii) a reduction in the number of workshops especially in primary and early secondary stages of the curriculum, and (iii) the formation of a new team of personnel to deliver the emerging agenda.

Gatsby support for the work of SAPS Scotland will continue until December 2009.

Paul Beaumont, current Director of SAPS, writes:

I was appointed to the post of Director in July 2001 and since that time have watched SAPS grow from strength to strength. I have been very fortunate to work with a team of gifted and committed individuals who, through their efforts, have developed a raft of new teaching resources to support the curriculum as well as offering CPD opportunities for teachers, trainee teachers and technical staff. We have done some excellent things over the years and I am proud to have worked with, and been part of, such a wonderful group of people.

There is much left to do. It is my sincere hope that the new Director, together with his/her team, will continue to receive the support of the wider educational community in their important endeavours.

Contact Details for SAPS:

From 1st September 2008, the new address will be:
SAPS, Cambridge University Botanic Garden,
1, Brookside, Cambridge CB2 1JE. Tel: 01233 748455
Website www.saps.org.uk

Our existing e-mail address (saps@homerton.cam.ac.uk) will continue for the foreseeable future.

Photosynthesis kits

Changes to the structure of SAPS will have an impact on the availability of the SAPS Photosynthesis Kit. Those of you yet to use the kit might be interested to see some of the available information on the SAPS website (see, for example, http://www-saps.plantsci.cam.ac.uk/articles/fotosyn/photosyn.htm).

The kit will still continue to be available through the National Centre for Biotechnology Education at the University of Reading (http://www.ncbe.reading.ac.uk/). SAPS and NCBE have worked together over many years and we are delighted that they have agreed to produce the kit and ensure 'business as usual'.

For news on an exciting new free photosynthesis resource see page 7.

Investigating the compensation point of algae: a new use for old balls!

Pupils often have difficulty with the concept of plants being at their compensation point – where photosynthesis and respiration are in balance. The difficulty probably arises from the much neglected fact that plants respire! Teaching and learning about plants often focuses on photosynthesis with respiration either being an annoying complication that we could do without or ignored altogether! Rodger McAndrew and Kath Crawford from *SSERC* have developed a practical protocol that provides a method for exploring the light conditions under which either respiration or photosynthesis dominates.

Most materials required for this experiment are available in the SAPS photosynthesis kit (see http://www-saps.plantsci.cam.ac.uk/articles/fotosyn/photosyn.pdf for a review of the kit and its possible uses).

The algae, *Scenedesmus quadricauda,* is firstly immobilised using sodium alginate/calcium chloride mixtures to produce algal balls (see http://www-saps.plantsci.cam.ac.uk/worksheets/ssheets/SS23.pdf for detailed instructions on preparation of algal balls).

Hydrogencarbonate indicator can be used to estimate the concentration of dissolved CO_2. The range of colours displayed by hydrogencarbonate indicator is shown in the image below (ranging from pH = 7.6 (yellow) to pH = 9.2 (purple) in increments of 0.2).

(Image taken from Eldridge, D. (2004), A novel approach to photosynthesis practicals. School Science Review, 85 (312), 37-45)

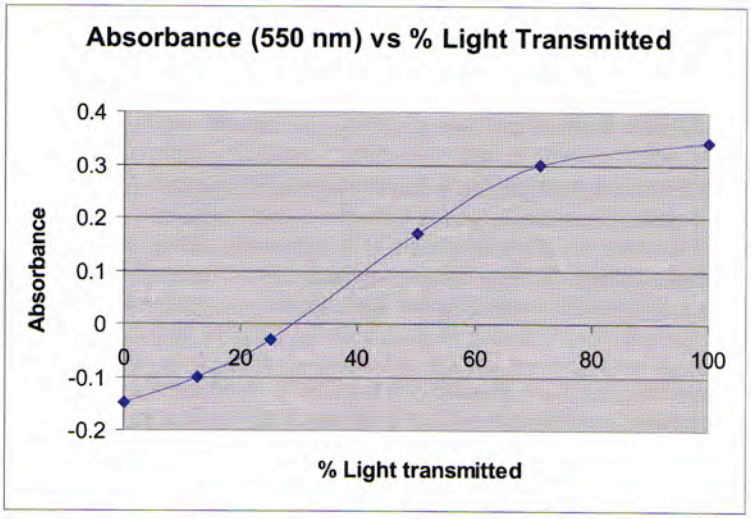
Six Bijou bottles were set up each containing 30 algal balls and 4 cm^3 of hydrogencarbonate indicator (pH 7.6). A further Bijou bottle, containing only hydrogencarbonate indicator with a pH of 7.6, was prepared and this bottle was designated as the blank. Changes in CO_2 concentration can be readily followed. Under conditions where the rate of photosynthesis was greater than the rate of respiration, the hydrogencarbonate indicator turned 'darker' (i.e. there is a net loss of CO_2 from solution and hence a rise in pH). The hydrogencarbonate indicator turned 'lighter' under conditions where respiration dominated (i.e. there is a net increase of CO_2 in solution and hence a fall in pH).

The light intensity was varied by wrapping one layer of a different neutral density (ND) filter (included in the SAPS Photosynthesis Kit) around four of the bottles - these neutral density filters allow defined proportions of light to pass through. The fifth bottle was left without a filter so as to allow the maximum amount of incident light. The final bottle was covered in aluminium foil to exclude all light. All bottles were then placed close to, and at the same distance from, a fluorescent tube. The heat given off by the fluorescent tube was negligible. After 50 min irradiation the absorbance of the 6 solutions was measured in a colorimeter (Biochrom Ltd, model CO7500) using a 550 nm filter and results are shown in the table below. The solution used to zero the colorimeter was the blank described above.

% light transmitted through the ND filter	100	71	50	25	12.5	0.0
Absorbance at 550 nm of sample after 50 minutes irradiation	0.34	0.30	0.17	-0.03	-0.10	-0.15

It can be seen that for 3 of the solutions the change in absorbance after 50 min irradiation was negative. This means that in these 3 solutions there had been a drop in pH – under these conditions of light intensity there is a net increase in CO_2 concentration indicative that respiration is the dominant process. In the remaining 3 solutions the positive change in absorbance indicates that photosynthesis is the dominant process. The point at which there is no net change in the concentration of dissolved CO_2 is defined as the compensation point and can be estimated from plots such as that shown on page 4. From the graph the compensation point can be estimated as 29% of the maximum light intensity. At that light intensity the hydrogencarbonate indicator would not change colour as the processes of photosynthesis and respiration would be 'compensating' for one another i.e. the uptake of CO_2 by the plant through photosynthesis is exactly matched by its release through plant respiration. So, at the compensation point there is no change in the concentration of dissolved CO_2, no change in pH and therefore no change in indicator colour.

Further experimental details are available from sts@sserc.org.uk.



Rodger McAndrew (SSERC) and Kath Crawford (SAPS Biotechnology Scotland and SSERC)

Let's Talk!

In recent years, school science curricula have been updated to include requirements for teachers to raise awareness of scientific issues with their pupils. It is difficult sometimes for teachers to locate suitable resources which allow them to raise such issues within their classrooms thereby making the science which they teach more relevant to the everyday lives of their pupils.

Let's Talk!, developed by Marjorie Smith at Dollar Academy, is a new resource which provides discursive activities for both primary and secondary pupils, helping them to explore scientific issues. The resource has been developed and trialled with support from the Wellcome Trust, the AstraZeneca ScienceTeaching Trust (*AZSTT*), and Learning and Teaching Scotland.

The topics covered by the resource include:

- **Plants matter** – habitat destruction; importance of plants for food and medicine.
- **Environmental issues** – pollution, habitat destruction, global warming, world health and poverty.
- **Human reproduction** – test-tube babies; designer babies.

The activities have recently been trialled in 125 schools in Scotland and have been well received by both teachers and pupils. An independent evaluation of the package has been carried out:

> *...All of the materials have been carefully thought-out and produced in a very attractive and, more importantly, a stimulating manner*
>
> *...The packages have achieved their principal aim, stimulating effective discussion on topical scientific issues. It is clear from a variety of sources that pupils who normally contribute little in class have been motivated by these packages*
>
> *...Pupils clearly felt that the exercises gave them a forum for discussion where their views could be safely expressed – there were not necessarily any right or wrong answers*

Further information

Aspects of the Plants Matter resource are available on the *AZSTT* website at:
http://www.azteachscience.co.uk/code/development/lets_talk/background_information.htm

For further information and details of how to obtain the materials, contact **Marjorie Smith** at: Lets.talk@btinternet.com

Biology Behind Barbed Wire

This worksheet is designed for use in secondary biology lessons and covers reducing and non-reducing sugars. It is based on the account of the same name published in the magazine 'Discovery', 1946.

During the Second World War many prisoners in the Far East suffered from vitamin deficiency diseases due to malnutrition. For example, although vitamin B_1 is found in most foods and vitamin B_2 is found in meat, dairy products and vegetables, neither are present in white rice. Deficiency in vitamin B_1 leads to pain, swollen arms and legs due to poor circulation, paralysis, coma and death. Deficiency in vitamin B_2 leads to the skin cracking, becoming inflamed and failing to heal. It can also lead to progressive blindness.

In response to these deficiency diseases a number of the POWs imprisoned in Eastern Indonesia (who in their peacetime lives were biologists, botanists and doctors) developed a way to culture yeast to provide a vitamin supplement. This remarkable story has been documented by L. J. Audus, who later became Professor of Botany at Bedford College, University of London, and has been used as the basis for the experiment described below.

Reducing Sugars to Maximise Yeast Growth

Yeast requires compounds containing nitrogen and sugars in order to grow. A liquid medium made from maize contained both of these components but the scientists found that the yeast grew better when they added more sugar to the culture. The type of sugar added was important because yeast requires sugars to be in their simplest form – monosaccharides which can be distinguished from disaccharides and polysaccharides using Benedict's reagent. (In the camp the POWs used Fehling's reagent. The chemistry is similar but the use of Benedict's reagent is simpler and safer).

Method

Benedict's Test

Add 5 cm^3 of the sample solution to 5 cm^3 of Benedict's reagent in a test tube. Put the test-tube in a boiling water bath for 5 min.

A precipitate indicates that monosaccharides (reducing sugars) are present and the colour of the precipitate indicates the quantity of sugar. Green precipitate indicates trace amounts, with yellow, orange and red precipitates indicating progressively more sugar in the sample. If there is no precipitate and the solution remains blue then no monosaccharides are present.

Within the camp the POWs had access to (a) water that had been used to wash rice, (b) cane sugar, (c) cane sugar boiled for 15 min with very dilute hydrochloric acid and (d) banana extract (made by boiling overripe and bruised bananas in water for 15 min and keeping the liquid part).

For each of these potential sources of monosaccharides conduct the Benedict's test. Which of the 4 extracts above would be the best to use for growing yeast?

Using your knowledge of carbohydrates can you explain why is this the case?

Teachers' Supplementary

The experiment described above has been designed to complement the national curriculum for GCSE biology.

Benedict's Reagent

100 cm^3 of Benedict's solution contains 17.3 g sodium citrate ($Na_2C_6H_5O_7.2H_2O$), 10.0 g sodium carbonate (Na_2CO_3), and 1.73 g copper (II) sulfate ($CuSO_4.5H_2O$).

Producing the samples for the students:

(a) Rice washings: approximately 100 g of white rice washed in 50 cm^3 of water. Mix and allow to settle. Use the liquid portion.
(b) Cane sugar. Dissolve 1 g of cane sugar in 100 cm^3 of hot water.
(c) Cane sugar boiled with HCl. To 50 cm^3 of the cane sugar solution produced as for (b), add 1 cm^3 of 0.1M HCl. Boil for 15 min (add extra water if it looks in danger of boiling dry).
(d) Banana extract. Mash 1 overripe/bruised banana into water (for a 75 g banana approximately 300 cm^3 of water is needed). Boil for 15 min, adding extra water if required to avoid the extract boiling dry. Sieve to remove the banana pulp and use the liquid portion.

Explanation of results

Rice, and its washings, contain the polysaccharide starch and as such will give a negative result with Benedict's test. Cane sugar is mainly the disaccharide sucrose so again will give a negative result with Benedict's. However, boiling cane sugar with dilute hydrochloric acids breaks the bonds between the component monosaccharides (glucose and fructose). This solution should react strongly with the Benedict's reagent (dark red precipitate). Bananas contain some fructose (which is a reducing sugar) so the banana extract should also react positively (orange precipitate).

In the prison camps both of solutions (c) and (d) were used as part of the yeast manufacturing process.

References and acknowledgements

A scientific paper, intended for non-specialists, describing the whole process was written by the botanist L. J. Audus, on his return to the UK and can be obtained as a *pdf* from the SAPS website (use the search facility at www.saps.org.uk and enter the term *Biology Behind Barbed Wire).* The original journal "Discovery" is no longer published. Professor Audus has also written a book on his experiences as a prisoner of war called "Spice Island Slaves; A History of Japanese prisoner of war camps in Eastern Indonesia May 1943-August 1945, 1996, Alma Publishers, UK, ISBN 09517497 2 2". These notes were produced using information from both of these sources and with the much appreciated cooperation of Professor Audus himself.

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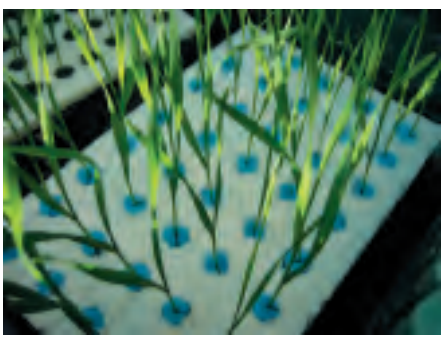
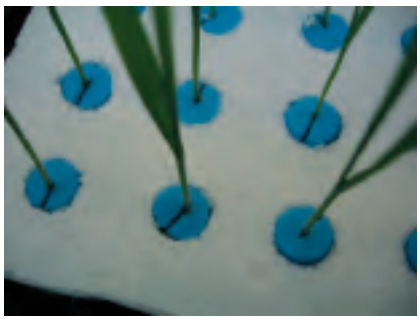
A simple hydroponics system for growing barley

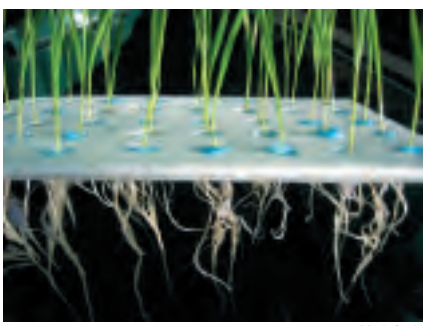
Harvesting and measuring large batches of plants for generating class data, especially when data on root growth would be useful, is fiddly and messy when they have been grown in compost. Even if they are grown on some sort of inert medium such as absorbent paper, the roots become tangled and grow through the paper, making separation without breaking virtually impossible. Growing the plants in a liquid medium allows easy provision of large batches of plants with clean intact root systems and can be done with a simple system using a plastic storage box and an air pump. Using this method, batches of barley can be produced at various ages or grown with different nutrients allowing classes to measure height, biomass, root length, count lateral roots, leaf mass or area etc.

Large plastic storage boxes can readily be obtained from a variety of sources. It is best to go for opaque plastic rather than clear or translucent since this reduces growth of algae. Plants can be supported by floating rafts made from sections of polystyrene tiles. Rows of holes can be drilled in the rafts using a sharp cork borer. If the holes in the polystyrene tile are drilled closely together, the seedlings will support each other as they grow taller.

Barley seeds are first sown on absorbent paper in shallow trays and when the shoots are about 1.5 cm tall, they are individually removed from the absorbent paper, inserted into the holes and gripped gently by a flexible split plug made from expanded foam. A sleeping mat from an outdoor shop provides ideal material for this and the plugs should be cut with the same diameter cork borer. A small cut in the plug accommodates the plant stem.

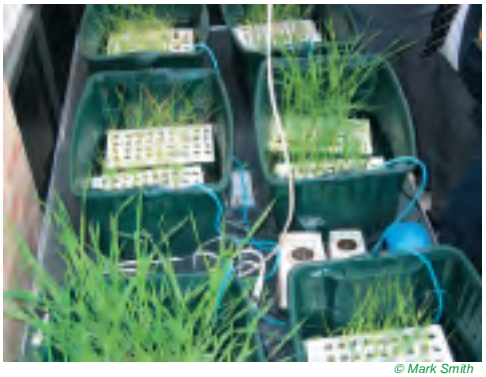






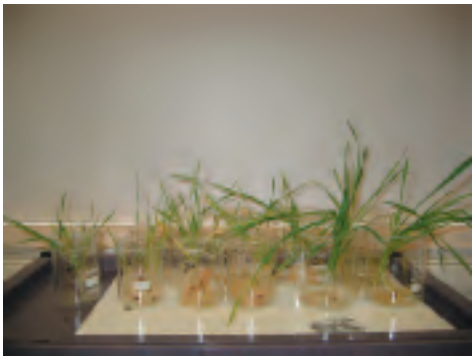
A small aquarium air pump is necessary to oxygenate and mix the water. This can be attached to a long airstone via a short length of plastic airline and a valve to control the airflow. If possible, extra illumination will speed up the growth rate.

Several rafts can be grown together in one box which allows easy sharing of the plants between groups of pupils. Four to five weeks in a warm environment allows them to reach maximum size and a series of rafts can be set off at weekly intervals.



© Mark Smith

Once the plants have grown, they can easily be removed into beakers for pupils to measure. The picture to the right shows a series of barley seedlings at different ages, which was used to produce a growth curve.



© Mark Smith

Alternatively, the composition of the liquid growth medium can be altered so that pupils can investigate the effect of different nutrient ions. The basic medium is made up by mixing a series of solutions in 10 litres of water, which is an appropriate volume for one container. To prepare the basic medium the following various solutions are required:

Solution	*Added salt*	*Concentration (g dm^{-3})*
A	Potassium nitrate	202
B	Calcium nitrate	472
C	Sodium dihydrogen orthophosphate	103
D	Magnesium sulfate	184.5
E	Potassium chloride	148
F	Calcium chloride, anhydrous	222

Better growth and healthier plants will result if the following solution is also used:

Solution	*Added salt*	*Concentration (g dm^{-3})*
G	Manganese sulfate	2.2
	Copper sulfate	0.24
	Zinc sulfate	0.28
	Boric acid	3.1
	Sodium molybdate	0.96
	Sodium chloride	5.8
	Fe EDTA Na	36.7

Liquid growth media are made up by adding the following to 10 litres of water in one container:

Volume of solution added (cm^3 / 10 dm^3)	A	B	C	D	E	F	G
Complete	20	20	20	20	0	0	10
N-deficient	0	0	20	20	20	20	10

This system has been successfully used for the last three years to grow batches of barley for measurement by classes in an entire year group of 140 pupils.

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FREE Photosynthesis resource

We are delighted to announce the production of a new resource, designed and developed by Debbie Eldridge, to support learning and teaching of photosynthesis. Aimed at keystage 3, the resource comes in 3 parts – *Teacher Guide, Technical Guide* and *Pupil Guide*. We have **750 free copies** of the resource available for distribution. Details of how to order your copy will shortly be available on the What's New section of the SAPS website (http://www-saps.plantsci.cam.ac.uk/whatsnew.htm).

Electrophoresis of plant pigments – a forensic scenario

A large number of dyestuffs used in clothing are derived from plants or are made synthetically, based on plant products. In the developed world, there is such a demand for dyes that large scale synthetic manufacture is necessary. However among ethnic groups in developing countries, many people still use traditional means of dyeing clothes.

© Leighton Dann

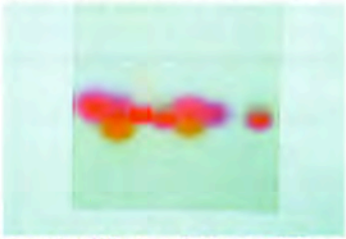
This is a street market in North Vietnam, where Hmong people buy slabs of indigo to dye their clothes their traditional blue colour.

If subjected to electrophoresis in an agarose gel, these pigments will move at different speeds because of their molecular structure and charge. This could form the basis of a forensic examination as part of a police enquiry, looking at the colour in some clothing found at a crime scene.

Virtually any water soluble dye or ink can be used. Many schools will have an assortment of stains lurking at the back of their chemical store. All the ones I have used have been made up as a 0.1% solution (dissolve 0.1 g of the stain in about 10 cm^3 ethanol and then dilute to 100 cm^3 with water). Alternatively, several food dyes are available from supermarkets, or a variety of inks (e.g. Windsor & Newton) from art shops.

The electrophoresis is carried out as follows: samples are prepared by mixing 3 cm^3 ink or dye with 100 μl TAE buffer (x 50 strength, pH 8.5, see reference), 200 μl 20% sucrose and 1.7 cm^3 water. Cast a 1% agarose gel (in normal strength TAE buffer). Load 15 μl samples into the wells.

Electrophoresis has been conducted with either the BioRad or Edvotek gel systems or with the minigels from NCBE. Running at 120 V (with a quarter strength TAE buffer in the electrode chambers), separation is complete within 15 minutes, and no staining is required. To run the NCBE mini gels at 120 V, they must be removed from the small gel tanks and placed in a BioRad or Edvotek tank. As the samples are relatively mobile, they diffuse throughout the gel once the electrophoresis is finished, so it is wise to make a digital image straight away. Placing the gel on a small light box, such as obtained from photographic suppliers, enhances the image.



This example is using Windsor & Newton inks and phenol red.

A suitable forensic scenario might be the following: a body was discovered in some woodland. There were signs of a struggle, and the victim had some torn clothing or fibres tightly held in one hand. This material was dyed red (or blue). In the forensic laboratory, an appropriate solvent is used to extract the dyestuff which is then concentrated and identified by running alongside other material dyes in an electrophoresis system. Alternatively, fibre samples might be found on the shoes of an abducted person, coming from the mats in the assailant's car, or some paint may have been found on the victim's clothing.

This type of evidence is called 'trace and contact evidence' and includes textile fibres (both the type and colour), glass, paint etc. often found in only trace quantities. The principle is that whenever anyone commits a crime, they always leave something behind, which was not there before. In the example described above, this would be the coloured cloth. Clearly, it would be most unlikely that anyone would be convicted on the basis of a piece of clothing. However, it would be part of a wider forensic examination, including DNA analysis, fingerprints and footprints etc.

References:

How to make TAE buffer http://biotech.about.com/od/buffersandmedia/ht/TAE.htm

Sarah Payne – fibres evidence convicts a child killer www.forensic.gov.uk/forensic_t/inside/list_casefiles.php?case=7

The Case of the Car Carpet www.abc.net.au/science/forensic/bigcases/case_sample_04.htm

Further details from the author.

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SAPS Biotechnology Scotland Project

For a number of years SAPS Scotland has been working with colleagues in the Scottish Schools Equipment Research Centre (SSERC) to provide CPD opportunities for teachers, trainee teachers and technical support staff.

Kath Crawford gives us an insight into what has been going on 'north of the border' in recent months.

© SSERC

From early October 2007 until the end of March 2008, the new SSERC premises in Dunfermline proved their worth and buzzed with even more life than normal. As part of the Scottish Government supported project 'Support for Scottish Science Education through CPD', new (albeit temporary) staff were busy helping develop resources and associated CPD, while science teachers and technicians took part in the CPD experience. Many of the courses offered took place in two parts ($4^1/_2$ days in all), with Part 2 taking place several weeks after Part 1. Typical programmes included hands-on practical work, exciting speakers and discussion activities – all contributing to the 'delegate buzz'. Most sessions were held in the SSERC labs and meeting rooms with residential accommodation and a few sessions in local Dunfermline hotels.

During Part 1, all course delegates were provided with a digital still or video camera, and equipment such as alternative energy kits (chemistry and science courses), electrophoresis kits (biology course) or smart materials kits (physics), plus a host of ideas for engaging, participative activities to use with their pupils back in the classroom. Delegates were encouraged to try out or adapt activities from Part 1 of the course (the so-called 'gap task') and to 'show and tell' at Part 2. As a result, all delegates left the course with a host of new ideas to take forward in the classroom.

A typical delegate comment is: '*My classroom practice has changed as a result of this excellent, inspiring course'*.

© SSERC

In March 2008, Fiona Hyslop, the Scottish Government's Cabinet Secretary for Education and Lifelong Learning, announced the award of some £2,000,000 over the next 3 years to take forward CPD across all the sciences. The success of the work of SAPS in Scotland was a key contributory factor in the Government's decision.

SAPS Workshops

The normal workshop programme offered by SAPS is 'on hold' until the new team is in post and decisions about the direction which SAPS will take have been made. Leighton Dann and Jenny Edrich, former members of the SAPS team, will be offering a range of CPD workshops which incorporate SAPS protocols and resources from their new home at the Science Learning Centre East of England based at the University of Hertfordshire in Bayfordbury. Full contact details for Leighton and Jenny are given in the flier enclosed with this issue of *Osmosis* (except in Scotland).

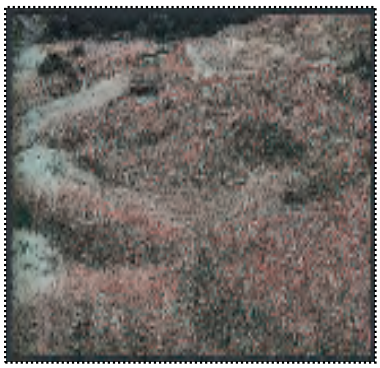
Workshops in Scotland will continue to be available and anyone interested should contact the SAPS Scotland team on 01383 626 077 or by e-mail at saps@sserc.org.uk.

Practical activities to support 'How Science Works'

The programme of study for the Key Stage 4 core science curriculum suggests that pupils should be encouraged to look at science in a different way – not focusing on a body of facts or understanding of concepts – but more as a process looking at the way science and scientists work within society. There is an emphasis on the development of science and technology in contemporary contexts. There is clearly importance in educating all pupils about the uncertainties in science so that they understand enough about the issues to help them make informed choices in life.

For some science teachers this change in emphasis is welcome but one of the common criticisms of teachers and students is that alongside these changes there has been a decline in the number and range of practical activities in the science curriculum. Here at SAPS we believe that practical activities help to enthuse pupils about science and form the process underpinning "How Science Works". We have been developing some simple activities and methods, which pupils can use to generate data.

We have developed a scheme of guided practical work which can help students undertake some genuine enquiry based investigatory work. We have written newspaper articles to stimulate students to ask questions which they can test themselves.



Copper pollution from medieval mine - potential health threat…

Slag heap from copper mine. Storm – washed onto land – reduction in yield – some plants dying.

Scientists say "The drainage waters are more acidic than vinegar, with pH values around 2, and carry large loads of metals, including copper, zinc, and iron".

Typical questions generated by the pupils include:

- *Does copper affect germination?*
- *Does copper affect growth?*
- *Are some plants more tolerant of copper than others?*
- *What minerals do plants need to be healthy?*
- *Do plants grow better with more minerals?*
- *How do some plants grow in poor soils?*

Simple methods for carrying out a range of practical activities allow students to investigate their problem (without knowing what the result is likely to be) and they can then use some scientific articles written by SAPS to help them interpret their data in a creative way.


OLD SCIENTIST

Copper not so harmful

"plants need minute quantities of copper because some oxidase type of enzymes require copper to function, and because copper is involved in electron transfer during photosynthesis. However, amounts in excess of 30 parts per million are usually toxic. Root growth is impaired as the copper binds to cell membranes, damaging them"

In this way students can be involved in genuine open ended investigatory work and not a simple experiment where they know what the outcome should be before they start.

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Limited quantities of a CD, produced by the authors, containing further details and ideas for experimental work to support 'How Science Works' are available from the SAPS office (saps@homerton.cam.ac.uk).

The SAPS website - www.saps.org.uk

We hope that you will have noticed (and welcome!) the changes to the SAPS website which have taken place over the past 6 months or so. With its new homepage and improved navigation we feel that the site has much to offer visitors.

Many of the additions/deletions and amendments to the SAPS website take place with minimal input from anyone other than John Hewitson who manages the site on our behalf. With nearly 3,000,000 pages being accessed each year, we asked John just what he gets up to on our behalf!

A Day in the Life of Your Website Manager

John Hewitson

No two days are ever the same. Being employed half-time, I suppose half the days should be on the beach or up the mountains, but in practice I spend some time each day maintaining the website.

Even in the quiet, school holiday periods there are about 5 emails a day for attention. This doesn't include the junk emails which are filtered (but I still need to frisk them as the software makes mistakes). Nowadays there is rarely any post to deal with. I like to be at my desk by 7.30 am.

I receive about 250 questions from students, teachers and others each year. This doesn't include those which come without any details of age, school etc without which it is impossible to give an appropriate answer. Those from UK schools are given the fullest response. Awkward questions are first circulated to the whole SAPS team – 20 teachers, university lecturers, educators and technicians. Some members seem invisible until I get an answer to a question about which they DO know something and I realise that they HAVE been reading the pleas for help all the time! I am very ably supported by this team – some respond within the hour, just to assure me that my suggested response fits with their understanding. All valid questions receive a response within a week and these are copied to the team for 'quality control'. I enjoy this part of the job as it sends me to my books, to the school library, to colleagues, to send emails to professors (who always respond so helpfully), to search the web and read on-line journal articles etc. (Aside - Overnight American students can ask the oddest questions "I grew 4 beans and applied milk to one, benedryl to another, bleach to another and no water to another. Why did they die?" I usually respond along the lines "Why did you do the experiment?" "What was your hypothesis?" "Were there any replicates?" It is a real insight into some differences in our school science.) The best questions and answers are archived on the website – a job which I get round to in quiet times.

Email also brings a variety of jobs:

- *The "Workshop Calendar", "What's New" and "Plants in the News" are regularly updated.*
- *The on-line version of publications like "Plants for Primary Pupils" is first put on our development server and then transferred to the main server after proof-reading.*
- *Presentations from the SAPS Biosciences Summer Schools have grown in recent years ('03=4 Mb, '04=27 Mb, '05=35 Mb, '06=85 Mb, '07=106 Mb)*
- *A report is written for the Trustees twice a year. They are interested to know that the use of the website has increased to about 10,000 pages served each day. The "Trees and Shrubs Website" (a hidden gem of the SAPS website) are the most popular pages on the site. The Trustees are pleased to note that search engines do give SAPS a high priority, but we are careful to keep the development server out of sight. Sometimes a page shoots right up the list in response to an A level board set practical.*
- *Glitches on the site can lurk for months. Documents that came in Word can harbour spurious symbols like õ or ø or in email cm3.*
- *A change in telephone number can result in several days work.*

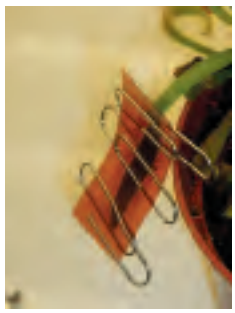
In the background, there is my housekeeping. Systems are frisked for viruses each week (a waste of time as I've never detected a Mac virus in over 20 years!). My laptop is synched to desktop so I can work away from my office (visiting family, in the garden, even at a coffee shop in Cornwall or at a Motorway Service Station). Software is kept up-to-date. Files are backed up (emails and website daily, other files weekly). The webserver is continually monitored and I alert the superb technician at Cambridge University Department of Plant Sciences if there is a problem – he usually responds positively within the hour)

Have fun with sundews (*Drosera* sp.)

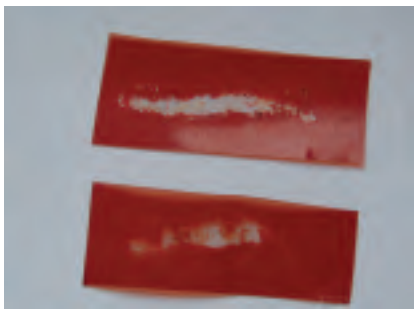
We are all fascinated by plants that are able to gain extra nutrients by catching and digesting insects. Sundews are one such type of carnivorous plant and acquired their name from the fact that the "dew" on their leaves persists even in hot sunshine. Their usual habitat is acid bogs which are poor in mineral salts so the ability to obtain these from a different source i.e. insects through secreting digestive enzymes is a great advantage. This property has been exploited medicinally for hundreds of years and even today extracts of *Drosera* are still used for coughs and other respiratory ailments.

If an insect lands on the leaf it is held by the glandular hairs which slowly curve round it and push it towards the central glands that secrete the enzymes to digest it. You can watch this happen over the course of 24 hr either by adding a small insect or some other form of protein- perhaps a tiny piece of jelly. The plant growth regulator, auxin, speeds up the growth of the outer cells to aid the curling of the leaf and after digestion does the same to the inner cells to help unfurl the leaf again.

Drosera capensis *digesting a cube of jelly*



Photographic film held against a Drosera *leaf*



Digestion of the protein layer on photographic film

Protein in the layer of gelatin on the non-shiny surface of exposed photographic film can also demonstrate its digestion by a *Drosera* leaf. Use paperclips to hold the film close to the leaf and leave it overnight. A wonderful outline appears in the morning showing where every gland has exuded its enzymes.

Another demonstration of protein digestion is to set some jelly (any flavour you like!) in the bottom of a Petri dish and cover with small discs of filter paper that have been wiped over the surface of *Drosera* leaves. 1-2 days later, removal of the discs will expose holes where the enzymes, adsorbed onto the filter paper, have "eaten" the jelly.

Propagation

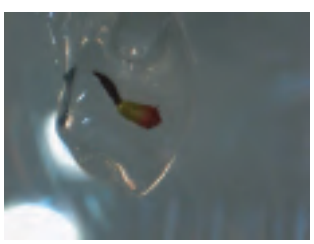
Drosera flowers appear on tall stalks growing from the middle of the rosette of leaves so that pollinating insects can steer clear of being trapped. Self-pollination can occur as well. The seeds from the mature capsules can be collected though often some escape and sow themselves. The temperate species are not difficult to propagate and, despite recommendation, the seed will usually germinate without an initial cold phase to represent over-wintering. Sprinkle the seed on the surface of a mixture of peat and sand (2:1), and stand the pot in rain water in bright light. The resulting seedlings can then be transferred to individual pots and left in similar conditions to grow into mature plants.

A fun way of producing new plants asexually in a matter of a few weeks is from leaf cuttings floated in distilled water and left in the light.

Drosera rotundifolia *grown from seed*

A Drosera capensis *plantlet grown from a leaf cutting*

A more sophisticated method of growing them is to place sterile seeds (soaked in 10% bleach for 5 min) onto an agar plate. After 2-3 weeks the stages of germination can be followed in detail under a binocular microscope and using a flexicam can be projected on to a screen.



A Drosera *seed just germinated on an agar plate, x 50*

A Drosera rotundifolia *seedling growing on an agar plate, x 50*

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