SCIENCE & PLANTS FOR SCHOOLS

OSMOSIS

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Biodiversity and management for conservation in the Welsh Borders

We tend to think of 'biodiversity' as something that happens in (and disappears from) tropical rainforests. It is true that vast areas of tropical rainforest have suffered, and continue to suffer from deforestation. In the decade 1990 to 2000, estimates suggest that an area approaching 12 million hectares (about the size of England) disappeared from tropical rainforests each year. Along with deforestation, there is usually a loss in biodiversity - including plant species and the many animal species dependent on plants. But in the context of human impact on the environment, deforestation is not just a 20th or 21st century problem. With increasing human population over the centuries, loss of forest and reduction in biodiversity has accompanied the exploitation of land by humans, mainly because of their need for land for agriculture and as a result of urbanisation.

We can see 'biodiversity' in locations much closer to home - in hedgerows, patches of waste ground and roadside verges. The key to maintaining or increasing biodiversity is often in the management practices adopted, particularly relating to grazing or mowing strategies. This article describes how land can be managed within a farming structure in a way that enhances biodiversity. It also offers suggestions of how students can use small areas in their own locality to become aware of ways of maintaining and enhancing biodiversity.

Meadowsweet Fields - an example of management for conservation

Management of hill habitats within a farming structure in a way that enhances biodiversity can be illustrated by a small group of fields on the Shropshire / Welsh borders (in the UK). This is land that has probably never been ploughed and is still being farmed in the traditional way of 50 years ago. This system entails grazing with low stocking levels of cattle and sheep for part of the year, and taking a hay crop which is used for fodder. In 1998, after some years of neglect, Chaseleyfields Farm was up for sale. There were fears that the land would be swallowed into adjacent farms where intensive systems of frequent ploughing, reseeding, application of fertiliser and herbicides are the norm, thus losing the interesting flora and fauna (including both diversity and a number of rare species). One group of fields, known as Meadowsweet Fields, approximately 11 hectares, was purchased with the determined aim of restoring the traditional system of management and retaining the biodiversity. Some financial help has been obtained from agricultural grants aimed at encouraging more sensitive management of the environment and advice has been obtained from interested conservation bodies. Five years later, the project has progressed and, for the new owner, the rewards have well justified the expenditure and hard physical work.

Meadowsweet fields - overgrown willows on a field boundary - this shows the initial neglect that had to be gradually and sympathetically restored. If the branches stay on the ground, valuable pasture is lost, the ditches get blocked and the ground becomes waterlogged.
© Anne Stephens

Mature trees along the field boundaries include oak, ash, wych elm and willow. There is also a copse of aspen. The hedges are a mixed array of blackthorn, hawthorn, field maple, hazel, damson, wild apple, elder and holly. A scrub of bramble, dog rose and blackthorn had encroached into substantial areas and was cut back to the original boundaries. Huge overgrown willows have been pollarded before they die. Clearance was never total at a particular time, to ensure that some habitats remained for birds and insects. Where possible the old hedges that had grown tall and spindly and were full of gaps were trimmed back and laid (a traditional craft) to form new stock-proof structures. These are left wide and only cut on a 3-year rotation to generate good 'wildlife corridors' providing shelter and food for small mammals and birds alike.

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The wetter pastures (unsuitable for hay) are grazed by beef cattle during the summer months. Their hooves 'poach' the surface of the ground, maintaining an open structure to the soil and providing holes for seed germination. Cattle also break up the tussocks of rapid growing tough grasses and prevent them from becoming dominant. A hay crop is taken from the drier fields. To qualify for conservation support grants, there can be no cutting until after 15 July. This gives time for the seeds of annual plants (including grasses) to develop and mature after flowering. The hay is cut with a mechanical scythe, and turned more times than is now usual to ensure the seeds fall back on to the soil. In the autumn, when reasonable re-growth has formed, there is 'aftermath' grazing. Sheep, being lighter than cattle and nibbling rather than pulling at vegetation as they feed, maintain a better sward for a hay crop, but must be moved off to higher pasture if the ground becomes too wet and in time for the vegetation to grow into the next hay crop.

Cows in the meadows play a critical role in the management scheme, through their grazing and also because of the way their hooves 'poach' the ground. *© Anne Stephens*

A view of the meadows, showing its richness of flora during the summer flowering period. Cutting cannot be done until after 15 July in any year, to ensure the flowering period is complete and seeds fall to the ground. *© Anne Stephens*

Each spring and summer month brings a profusion of flowers, peaking in June. The sequence starts in March and by April there are adder's-tongues (ferns) and cowslips, marsh-marigolds in the stream beds, dog's mercury, primroses and bluebells at the woody edges. By May, pignut (a particular indicator of old meadow), cuckooflower, wavy bitter-cress, early vetches and ragged-robin are in flower and in June yellow-rattle, common and heath spotted-orchids, St John's-wort, betony, black knapweed, agrimony, various sorrels, ox-eye daisy, red clover, mints and meadowsweet form colourful swathes across the fields. Annual grasses include crested dog's-tail (another indicator of old meadows), timothy, bromes, fescues and quaking grass. Sedges and rushes dominate over grasses in the wetter areas. Thistles, nettles and docks, so often conspicuous on badly managed over-stocked pasture, are present but are controlled naturally by competition from the other plants.

So far, over 200 species of flowering plant have been recorded in these fields, and almost certainly there are more. This diversity of flora in turn supports a rich fauna of small mammals, birds and notably insects, including many dragonfly and moth species. Ditches and stream banks are maintained, creating a suitable habitat for aquatic and damp-loving species but the modern system of inserting land drains will not be undertaken. Antibiotics and worming agents are not used routinely, but only when necessary for the welfare of the animals. The reason for this is that they are passed out in dung and spread through the ground, killing natural microorganisms in the soil. To avoid the build-up of animal parasites the stock are regularly moved from one field to another. The animals are fed only hay from the meadows and are not given supplementary feeds from outside as this might introduce seeds of undesirable agricultural hybrid grasses. By law, bracken must be controlled; this is crushed or pulled by hand to avoid using chemicals. The odd plant of poisonous ragwort is controlled naturally as it is eaten before flowering by the caterpillars of the bright red cinnabar moth, which have a safe haven on the land.

In the last five years, neighbouring fields from the original farm have, as predicted, been turned over to more intensive management systems. They are grazed at much higher stocking rates, treated with fertiliser, reseeded and drained. Vigorous grasses out-compete the rarer species; there are no orchids or other flowers so conspicuous in the fields described above. At best, the 'intensive' fields probably support around 20 species of flowering plants, including woody hedge plants. The profits may be higher, but the biodiversity has been dramatically impoverished.

Small-scale opportunities for enhancing biodiversity

There are opportunities to encourage enhancement of biodiversity on quite a small scale and for students to make first-hand observations or become involved in conservation schemes. Roadside verges represent a major loss in habitat, since they are now rarely grazed by cattle. However, in many places, certain lengths of the verge are designated as conservation areas, and the mowing regime adopted can encourage flowering of species in a similar way to that described for Meadowsweet Fields. There is increasing awareness of the value of churchyards as conservation areas, particularly as many represent ancient sites that have not been subject to cultivation. If available, small areas of playing fields in school grounds can also be subjected to different mowing regimes and so illustrate both succession and increasing biodiversity - with an opportunity on site for students to carry out monitoring in successive years. It is worth contacting your local Wildlife Trust to find out about any schemes in your own locality and more information is available on the websites below.

Useful contacts and websites:

www.btcv.org/	BCTV - useful for practical conservation, guidance for teachers and opportunities for volunteers
www.crtbarton.com	Countryside Restoration Trust
www.floralocale.org	Flora Locale
www.plantlife.org.uk	Plantlife - the wildlife plant conservation society
www.wildflowers.co.uk	a provider of native wildflower plants

Grazing Animals Project can be contacted at gap@cix.co.uk

Adapted (with permission) from NAS Genetics, Evolution and Biodiversity, by Adds, Larkcom and Miller, published in 2004 by Nelson Thornes.

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News from SAPS

Teaching award

In case you missed our announcement on the website, we are happy to report that Roger Delpech, Head of Biology at The Haberdasher's Askes' Boys School, recently received an Award for Education in Biology. The award was presented by Lord Sainsbury in Parliament on 22nd June 2004, as part of Parliamentary Links Day. Roger was nominated by the Institute of Biology "for contributing significantly to teaching and learning in Biology through his inspired teaching, innovative approach, contribution to Institute of Biology activities for Education, sharing of good practice and other activities enhancing teaching and learning in Biology".

Personnel changes

There are a number of personnel changes within SAPS. We are delighted to report that Ann Chapman has joined the team in Scotland. Ann has been seconded for a period of 23 months from her current post as Principal Teacher in Knox Academy. John Hewitson, our webmaster, has retired from his post at Oundle School but we are delighted to say that John has agreed to continue his association with SAPS for the foreseeable future and so it is business as usual! Finally we are pleased to have appointed Jenny Edrich to the post of Development Technician based with the team in Cambridge.

Website developments

Cell Division, Cancer and Cancer Treatment

A new resource has been developed to support the teaching of Cell Biology and to develop an understanding of cancer and its treatment. It has been produced by the SAPS Biotechnology Scotland Project in partnership with AstraZeneca, Cancer Research UK and the Scottish Institute for Biotechnology Education. The resource was launched at the 2004 Summer School for Biology teachers at the University of Edinburgh and can be downloaded at www-saps.plantsci.cam.ac.uk/articles/broad_cancer.htm

The effect of light colour and intensity on the rate of photosynthesis

The immobilised algal system described in *Osmosis 23* has proved to be a very popular practical procedure. It is possible to study a number of variables with the algal system when measuring the rate of photosynthesis. We describe some resources (available at www-saps.plantsci.cam.ac.uk/articles/broad_light.htm) which may be useful when designing experiments to investigate the colour of light, and light intensity on the rate of photosynthesis.

Forensic Palynology . . . solving a crime and a scheme for developing good microscope skills in students

Students use microscopes relatively infrequently in the school laboratory. Thus they rarely have an opportunity to develop the skills needed to get the best from their work. In particular, student drawings from slides are often sloppy and unrepresentative. Students also have difficulty when using high power objective lenses and graticules to estimate size. Setting a microscope session within a forensic scenario seems to generate greater student interest and enthusiasm, possibly because of the relevance of their laboratory work to 'real life' forensic analysis.

Background

Pollen has been used for some years in helping to solve crime, from the adulteration of commercial honey to murder. (*For further information, see the websites and references listed on page 6*.) This article provides a useful simulation of 'solving a crime' by using pollen samples, and an opportunity to develop students' microscopy skills. It is particularly suitable for post-16 students, but can also be used successfully with younger pupils.

Preparation for the activity and identifying the 'suspect'

First you need to collect some pollen, using the method for collecting and storing pollen as described opposite. You then use the collected pollen to make up class sets of 'mixed' pollen slides. For the class sets you need to include a 'crime scene' sample and a series of 'suspect' samples. (We suggest three to five suspect samples.)

You also need photographs of a number of pollens, giving their names and size. Some of these photographs must be of pollen that you use to make up the slides. For the photographs it is appropriate to use laminated A4 sheets, with eight photographs per page. One set of sheets (we suggest a maximum of three sheets per set) is needed for each group of students (two to four students per group). As an example, a group of four photographs is shown on page 6. So you may have three laminated sheets (i.e. a total of 24 photographs) and eight of these photographs represent pollens which have been used to prepare the slides – the other 16 being chosen at random.

To identify the pollens that they see on the slides in the 'crime scene' sample, students need to draw the pollens and estimate their size. They then compare their findings with the photographs to identify the pollens. Ultimately they should be able to identify one of the 'suspects' as being the same as the 'crime scene'.

Outcomes

As well as 'solving the crime', after completing this exercise, students should be skilled in the following techniques:

- finding and focusing pollen using the low power objective
- scanning a slide using the low power objective to look for the different pollens
- using the higher power objective to draw a sample pollen
- using a graticule with a high power objective to estimate pollen dimensions

Selecting which pollens to use

Most plants flower in a particular season, so to collect sufficient different pollens, it may be necessary to collect pollen over several seasons. You may be fortunate in having a wide selection growing in the school grounds or in your own garden. You may be able to grow some plants at school that will provide you with samples, or you can always try using a florist or supermarket.

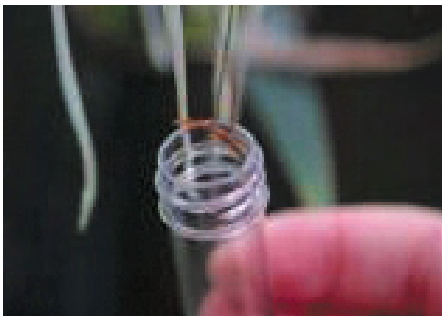
Plants that produce large amounts of pollen include the following:

horse chestnut (*Aesculus hippocastrum*)
hollyhock (*Alcea rosea*)
courgette / marrow (*Cucurbita pepo*)
sunflower (*Helianthus annuus*)
Christmas rose (*Helleborus niger*)
hibiscus (*Hibiscus* sp.)
St John's wort (*Hypericum* sp.)
evening primrose (*Oenothera biennis*)

In addition, species of apple (*Malus*), plum and cherry (*Prunus*), poppy (*Papaver*), pine (*Pinus*), mallow (*Lavatera*), daffodil (*Narcissus*), lily (*Lilium*), fritillary (*Fritillaria*), and tulip (*Tulipa*) are useful as sources of pollen. As a rough guide, a loaded microspatula tip of each pollen is enough to make up a class set of slides.

Making a set of pollen slides

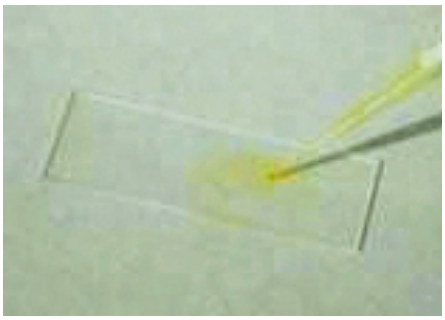
You need to collect several types of pollen or anthers (*see boxes 1 and 2*). Both pollen and anthers store well in the freezer (in stoppered containers) until required. You may, for example, have eight samples (A to H), two of which are pure pollen (A and B), and the rest anthers (C to H).



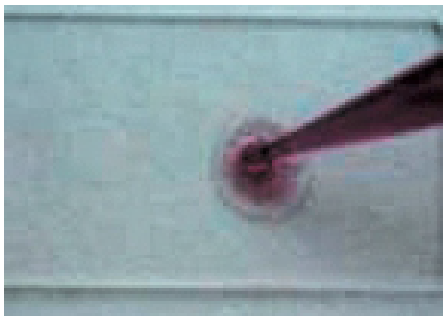
❶ *Collecting pollen 1*

❷ *Collecting pollen 2*

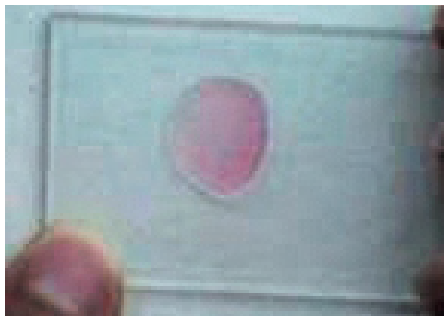
❸ *Mixing pollens*



❹ *Spreading pollen*



❺ *Adding the stain*



❻ *Laying on a cover slip*

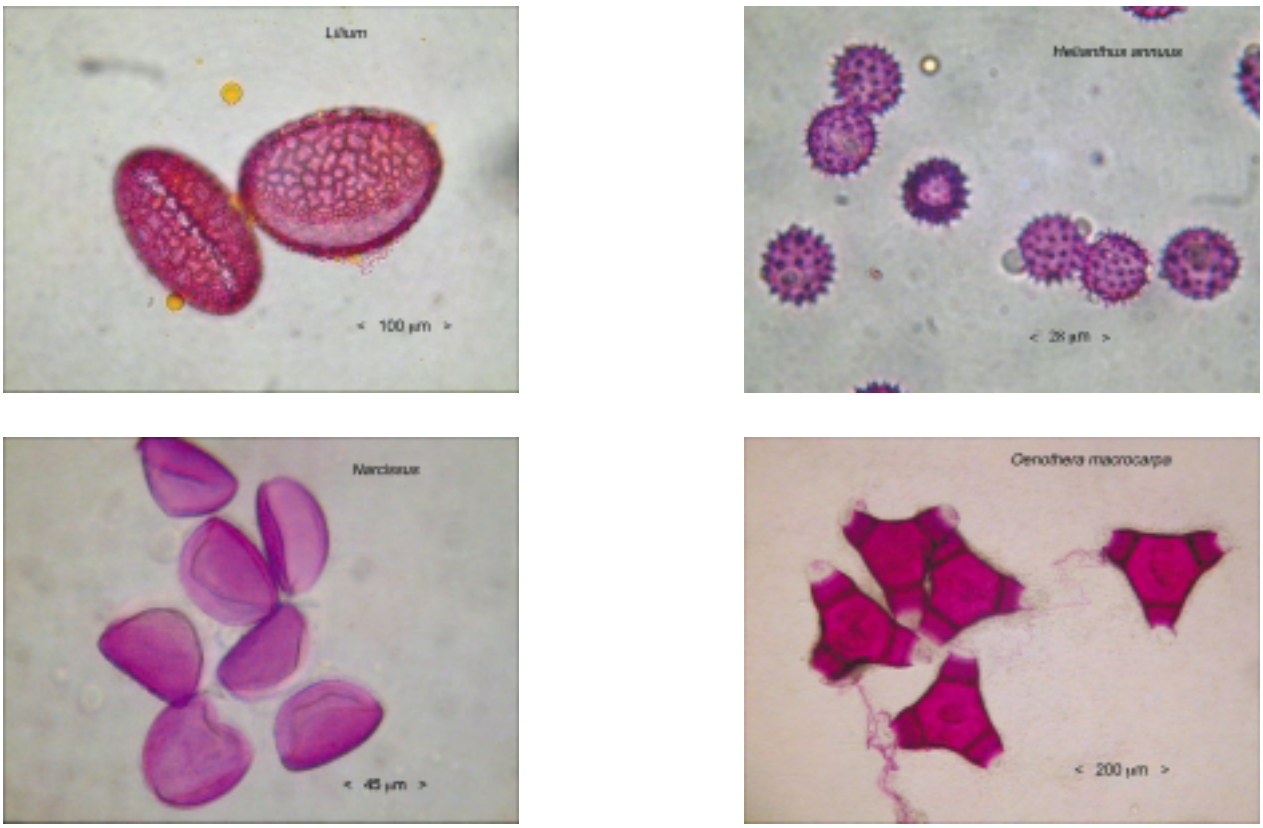
- Add about 500 µl water to each tube of anthers, shake vigorously, and leave for about 10 minutes to allow the anthers to release their pollen.
- Label six tubes as follows: CS (for crime scene sample), S1 to S5 (for five suspect samples). Decide which pollen samples you will mix together for each sample - one of the suspect tubes will match the crime scene one. Add a very small amount of pollen from tube A or B, or a drop of suspended pollen from tubes C to H. It is recommended to have no more than four pollens in each sample, otherwise the analysis becomes too long. *See box 3*.
- Once you have loaded the tubes, shake vigorously to mix evenly, then pipette a drop from the CS tube onto a number of microscope slides labelled CS (enough for your student group). Spread out the pollen onto each slide, and either place in a cool oven or leave to dry. Repeat for the suspect slides. *See box 4*.
- Once dry, add a drop of basic fuschin stain (warmed in an oven at about 50 °C to melt it), and lay on a cover slip. If possible, use large coverslips (22 x 50 mm). *See boxes 5 and 6*.
- Leave your samples in the oven until the stain has spread throughout the specimens (about 5 minutes) and then remove them and press the cover slip down on the slides gently to remove any excess stain and air bubbles (a cocktail stick is the recommended tool!). Excess stain around the edges of the cover slip can be removed with a scalpel blade when set.

The stain

The stain is based on Basic Fuschin, which colours most pollens pink. It can be made up as follows.

Add 7 g of gelatin (this can be found in most supermarkets) to approximately 42 cm^3 of tap water. Warm gently to dissolve. Add 50 cm^3 of glycerine and 10 drops of 80% phenol (care!). Keep warm so that the mixture remains liquefied. Dissolve 0.1 g basic fuschin in 10 cm^3 IMS. Add this drop-wise to the liquefied jelly until a rich pink colour is obtained. The stain may be stored indefinitely at room temperature (as may the excess fuschin), and then warmed to about 50 °C before use.

Some examples of pollens that could be used to make up 'crime scene' and 'suspect' samples



*Pollens of lily (*Lilium*), sunflower (*Helianthus*), daffodil (*Narcissus*), evening primrose (*Oenothera macrocarpa*).*

These photographs are as viewed using a high power objective of a light microscope (total magnification x 400). Note the scale on the photographs.

References and websites

There are several websites with images of pollen that may be freely downloaded. SAPS also has access to a collection of about five hundred digital images and, from early in 2005, a range of these images will be available through the SAPS website.

Osmosis 23 Autumn 2002. Using plants to solve crime. www-saps.plantsci.cam.ac.uk/osmos/os23.htm#8
Randerson, J (2 March 2002) Grassed up, New Scientist, 173 (2332), p 32 .
George, A (28 June 2003) Close examination, New Scientist, 178 (2401), p 54.
The official site for the Forensic Science Service www.forensic.gov.uk/forensic_t/index.htm
The University of Arizona Palynology Unit www.geo.arizona.edu/palynology
The New Zealand Government's Institute for Forensic Services www.gns.cri.nz/services/paleo/forensic.html

The larger size coverslips are available from BDH.

Dr Leighton Dann, SAPS Cambridge

ASE Annual Meeting, University of Leeds January 6th - 8th 2005

The programme for the ASE meeting is now available (see www.ase.org.uk). We are planning a comprehensive series of workshops covering a range of SAPS activities. Come and visit us at our stand and talk to us about the resources we have to offer (both old and new!).

Trainee teachers . . . and some misconceptions about plants

The findings presented here arose out of a number of workshops held with trainee teachers in England, over four years from 2000 to 2004. Some glaring misconceptions, concerning the structure of a plant and its flower, became apparent.

Several cohorts of trainee teachers (in total 40 primary and 200 secondary teachers), attended these workshops on 'Investigations with plants'. In the workshops, the trainee teachers carried out a range of experiments that would demonstrate the use of 'fast cycling Brassicas' in schools and at a level appropriate to their training. All the primary trainees had some scientific background, generally biological (GCSEs or equivalent in Science and some with A levels or equivalent). These workshops were part of a core science course. The secondary trainees were all science graduates on a one year PGCE course, but only about 50% were biologists. The remainder were chemists, physicists or geologists. Of the biologists there were few plant science specialists and others often had diverse degrees in which there was minimal plant science content.

At each workshop the participants, generally working in pairs, were presented with a warm-up or starter activity. They were asked to label two diagrams (diagrams A and B on page 8) - one of a mature fast plant and one of a half-flower. The actual diagrams can be found on the SAPS website (www.saps.org.uk) on the following URLs:

www-saps.plantsci.cam.ac.uk/worksheets/activ/br2a.htm
www-saps.plantsci.cam.ac.uk/worksheets/activ/br3a.htm

On the website, these diagrams are fully labelled whereas these details were missing from the diagrams presented in the 'warm-up activity'.

To enable the trainee teachers to complete the task, several examples of these fast plants at different stages of their life-cycle (5, 15 and 22 days old) were provided on their work bench. However, the trainees were not explicitly made aware of this fact but equally they were not prevented from looking at them. They were given 10 minutes to complete the exercise individually. A summary of these results are given in the two graphs below. Note that these graphs show the percentage of INCORRECT answers.

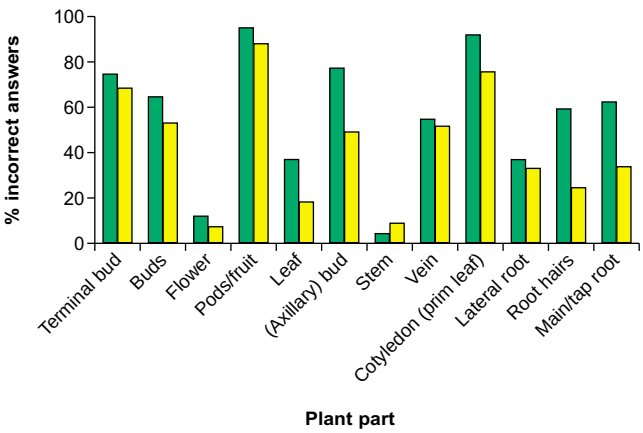


Figure 1. Summary of the incorrect labelling of parts of a mature fast plant by trainee teachers on primary (BEd) and secondary (PGCE) courses.
[= primary trainees (n=40), = secondary trainees (n=200)]

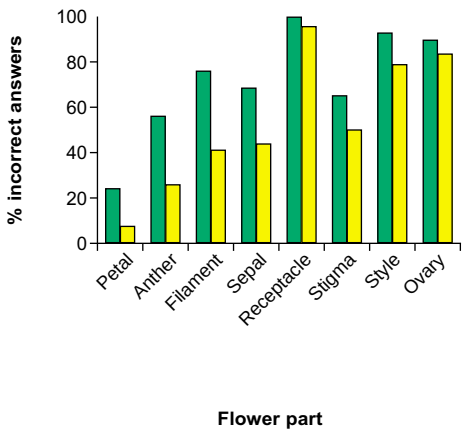


Figure 2. Summary of the incorrect labelling of flower parts by trainee teachers on primary (BEd) and secondary (PGCE) courses.
[= primary trainees (n = 40), = secondary trainees (n = 200)]

In the results from these two exercises there is a similarity, shown by both sets of trainees, in the apparent lack of knowledge of plant and floral structure. The parts of a plant (flower, leaf, stem and root) are taught at key stage 1 of the Science Curriculum in England and Wales, and the majority of the students could identify these structures in diagram A. It is in the finer detail, not unexpectedly, that many had difficulties. For example, all could recognise the root but were not aware of the differentiation into tap root, lateral root and root hair. Perhaps most surprising was the inability of the majority to appreciate the formation of a fruit (pod in this instance) from the flower parts. The pod was generally identified incorrectly as a leaf.

Floral structure has been part of the Science Curriculum at key stage 2 since 2000 when this section was moved from key stage 3. However, pollination and fertilisation are explicitly mentioned at key stage 3, so there is an implication that the floral structure is taught here and indeed a flower labelling exercise generally appears on the SATs papers at this level. It is, therefore, disconcerting that so many trainees have forgotten (or never knew) basic floral structure. Many found the sections of the carpel (stigma, style and ovary) difficult to determine. The main problem in the diagram appears to be that the receptacle is frequently identified incorrectly as the ovary. The weakness of some trainees with respect to spelling also became apparent – 'petle', 'seple' and 'sepul' are some examples of incorrect spellings.

During the practical activities the trainees were given opportunities to rectify their mistakes and discuss their misconceptions, and finally they were given a correctly labelled set of diagrams. Using practical activities, such as recording the heights of a range of different aged fast plants and dissecting a fast plant flower, gave opportunities for improving their comprehension. However, it is clear that very basic knowledge and understanding of plant science has evaded some of our future science teachers.

Some misconceptions about plants . . . can YOU get it right?

So can you label correctly these two diagrams, of a mature 'fast plant' and a typical diagram of a flower?

Then look at the graphs on page 7 for some interesting findings with trainee teachers.

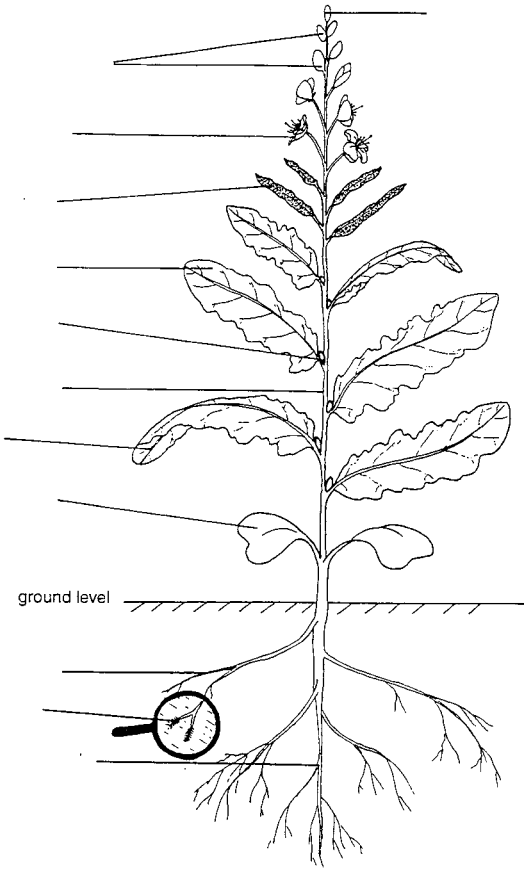


Diagram A

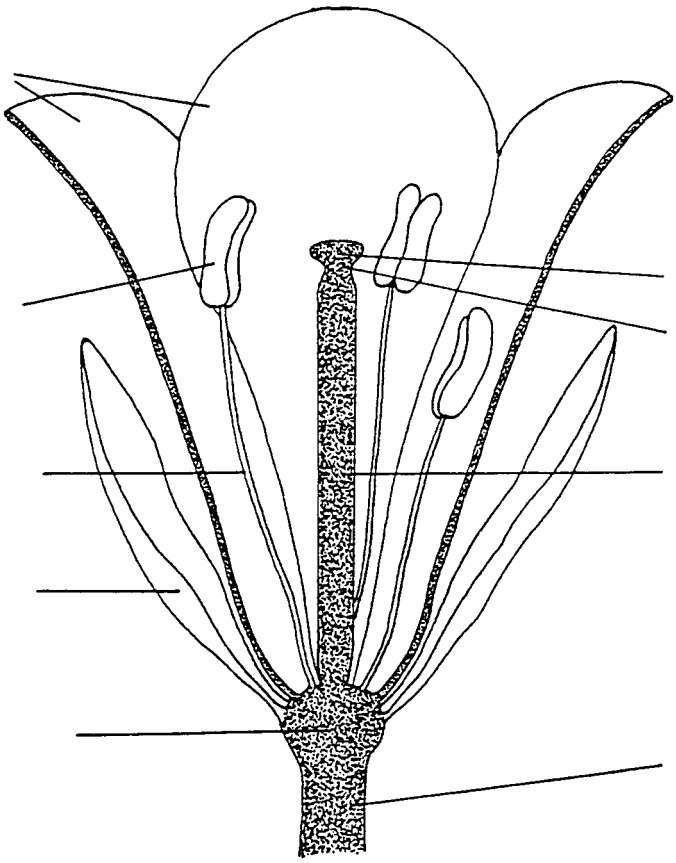


Diagram B

These diagrams are available on the SAPS website (see page 7). Alternatively, they can be located by navigating from the **SAPS Homepage** to **Publications and Resources** then onto **KS2** to **Curriculum links** and finally to **QCA schemes of work** where you scroll down to Unit 5b life cycles. Then click on Structure of a flower to open the half-flower diagram of rapid cycling *Brassica rapa* or **Structure of a flowering plant** for a diagram of a mature rapid cycling *Brassica rapa*.

A longer article is in preparation on this study of Science Teachers' and Trainees' misconceptions about floral and plant structure. This will include a more comprehensive breakdown of the labelling exercises and a set of responses to a series of questions on plants such as 'are seeds alive?'.

Dr Colin Bielby, Manchester Metropolitan University