STS
Scope includes
Science,
Technology
and Safety

SSERC Bulletin

For those working in science or technology education

ISSN 0267-7474

ISSUE 211
Summer 2004

CONTENTS

A full list of addresses for this Bulletin will appear on the SSERC Web site at

www.sserc.org.uk

The Bulletin is published by

SSERC, St Mary's Building,
23 Holyrood Road,
Edinburgh, EH8 8AE
Tel: 0131 558 8180
Fax: 0131 558 8191
E-mail: sts@sserc.org.uk
Managing Editor: Fred Young

Editor : Ian Birrell

Educational organisation - a menagerial approach

Post-McCrone has seen a resurgence of reorganisers. How the guid Prof. must cringe at that phrase "Post-McCrone", an unnecessarily tactless and somewhat previous intimation of his mortality surely? Many of these organisers have a zealous managerial liturgy, the theoretical basis for which remains largely hidden. No-one doubts, I trust, that the Principal Teacher system is (was) less than perfect. Whilst, given the right folk in post, it catered well for the specialist subjects there were obvious weaknesses in some schools. Not the least of these has been a tendency to neglect the management of less specialised areas of the curriculum, such as the S1/S2 science bits of Environmental Studies 5-14 or Standard Grade Science. Where they occur, these problems seem to arise because of a lack of clear lines of communication and accountability across specialist subject boundaries - manifestations of the "Awbody, somebody, naebody" syndrome.

Interestingly, such slippage between the cracks has not been ubiquitous. In some schools, science departments have operated superbly on a tight team-based approach, across all of the sciences. It's by no means certain that anyone ever really knew how or why this does or doesn't happen. I was invited, a couple of years back, to give a presentation to advisors and inspectors on "What makes a good science department tick?" Having thought hard about this, and having tried and failed to find any notable results of any specific research on the topic, I was forced to conclude that the honest, couthy answer was, still is, that I dinna hae a Scooby.

Attempts have been made to describe a 'good' department using a performance indicator approach. Honest observation, however, suggests that we can't presently even begin to explain what it is that turns round a whole department. How do you explain an almost moribund science set up, which takes on a few new staff and metamorphoses out of the mire? The changes may not come overnight but, in a year or two, science is suddenly an obvious school success. Such is the change that the department almost has to actively discourage pupils who are queuing up to do science.

Similarly, how come some departments seem able to turn people round? How is it that they can bring the apparent cynics and sceptics into their fold? What do they do that renews a person's own enthusiasm for learning and teaching and makes them again a committed member of a science education team?

I don't think we even begin to know what it is that works such apparent magic. More importantly, I'm not convinced that many of those currently experimenting with secondary school curriculum management models have much of a clue either. That's not to say that heads of faculty or curriculum leadership models can't be made to work. Some work very well, others may prove disastrous. We're led to believe that the inspectorial beady eye has already uncovered successful practice. I just wonder which comes first, the specific successful organisational model or the people working in it.

Given that we don't yet know what makes a good department tick, it seems hasty to erect new frameworks on what may well be shaky analytical foundations. To borrow what's become something of an ecological adage: "If you're going to take a watch apart to see how it works, it's wise to keep the bits". Trouble is we haven't even identified the bits. The alternate solution we thus propose for educational organisation is the zoological method.

The original thesis came from a friend, well-versed in educational renewal. She also introduced me to a variant of the weel kent picture, from *Winnie the Pooh,* of Christopher Robin bumping poor old Pooh up the stairs, his napper stottin' aff every tread. She had scrubbed the caption from the traditional "And, so to bed" and replaced it with "There must be an easier way to do appraisal".

Mrs X (who still works for an education authority and wishes to keep it that way) told me of a crucial study carried out by behaviourists and psychologists on managers in the National Health Service.

cont./back page

Safety guidance on radioactivity

SSERC has written a set of papers (Table 1) each on different aspects of health and safety guidance on working with radioactive materials. See the SSERC website to download the relevant files (Excel, Word and pdf):-

http://www.sserc.org.uk/members/Safety%20Messages/radioactivity.htm

Many of these documents will be familiar to teachers who have attended radiological protection training courses recently. If so, be warned, as all of the documents have been revised since your last course. Therefore make sure you download from the website to get the latest versions.

The new advice makes our 1987 publication *Explanatory notes on local rules* obsolescent, but not quite redundant as it provides an overriding structure to safety management and radiological protection. It also has the dose estimate calculations from which our new papers on risk assessment and source storage are derived.

Risk assessment

The risk of harm from working with school sources is very, very low – so low as to be about 100 times lower than the level set by radiologists below which the risk is considered to be negligible. Underpinning the safety regime are two engineering controls. One specifies that radioactive materials shall be in the form of a sealed source (Fig. 1) whenever possible, preventing inhalation or ingestion of contaminants; the other limits the maximum activity per sealed source to quite a low level – 370 kBq - ensuring that the external dose from ionising radiations is very low indeed.

Figure 1 Sealed source – a type of source made by Amersham, in widespread use.

Document name	Comment
Working with radioactivity: What you should know and do	Poster
Working with radioactive substances: Record and management list	Pro forma
Risk assessment: Use in schools of sealed radioactive sources	Word file
Contingency plans	Planning for unusual occurrences
Protocol on the ageing and leak testing of sealed radioactive sources	Word file
Leak test analysis	Excel file for analysing leak test results
Radioactive source storage	Word file
Radiological protection in schools: Training needs	Guidance for Councils

Table 1 Health & safety guidance on working with radioactive materials (SSERC)

With the application of the following simple procedures, the practice of working with radioactivity is said to be *optimised*, i.e. the demonstrator has taken all reasonable steps to reduce the dose to him(her)self and others to as low a level as is reasonably practicable :-

- Never directly handling radioactive sources
- Handling sources with tongs or tweezers
- Carrying the box of sources in a tray
- Not directing the source at yourself, or anyone nearby
- Standing to the side of, or behind, the source
- Screening beta radiation with Perspex
- Standing back one metre during counting
- Minimising the exposure period to that which is sufficient for showing the educational demonstration, but no more.

For sources causing external irradiation (beta- and gamma-emitters), ICRP[1] recommends that the design of the source should restrict the dose rate to below certain specified values (Table 2). This differs from the restrictions on school sources adopted by UK legislation, which, as indicated above, limit the maximum permitted activity to 370 kBq a source.

All gamma sources in Scottish schools comply with the ICRP dose-rate restriction. Provided that the above procedures for optimisation are followed, (in particular, standing back one

Source	Rate (microsievert/h)
Beta-particle	50
Gamma-ray	10

Table 2 Recommended restriction on dose-equivalent rates at a distance of 10 cm from sealed sources used in teaching exercises (ICRP 36).

1 International Commission on Radiological Protection

metre during counting), the dose to the demonstrator is unlikely to exceed 100 nSv per demonstration. The dose to pupils will be rather less than this.

With beta-particle emitters, the story is more complicated. The standard source is Strontium-90. The maximum activity of a Strontium-90 source that complies with the ICRP restriction is 74 kBq (2 μCi). Nevertheless, UK legislation allows for activities of up to 370 kBq a source. In practice, sources of this nuclide with activities of 185 kBq and 330 kBq (the Panax collimated source, type S4 [Fig. 2]) are commonly found. What is the risk? Our dose estimate for carrying out a demonstration experiment with a 185 kBq Strontium-90 source and applying optimised procedures is, again, 100 nSv to the teacher.

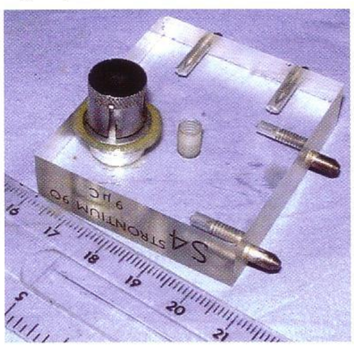


Figure 2 The Panax collimated sealed source (Type S4). The dose rate is rather high with the collimator removed.

So here we have two dose estimates resulting in the same value. Whether you work with a young gamma-emitting Cobalt-60 source, or a beta-emitting Strontium-90 one, both with the same activity of 185 kBq, the external whole-body dose is about 100 nSv.

How does this compare with background radiation? The average value to UK citizens is 2.4 mSv/year, or 270 nSv/h. Thus the estimated dose from a single demonstration experiment from a source capable of inflicting external irradiation on the experimenter is equivalent to about 25 minutes' worth of background at sea level, or cosmic radiation from about one minute's flying at 10 km.

Recent ICRP proposals recommend that where the dose from a single practice undertaken throughout a year is less than 10 μSv a year, then the risk of harm can be thought of as negligible. Using this proposal, even if a teacher were to carry out numerous demonstration experiments with several classes, there would be little likelihood of getting anywhere near as much as 10 μSv in any year. The same applies to the S6 student carrying out research for an Advanced Higher investigation. The dose would be negligible; and there is no need for the teacher to carry out a dose estimate because the outcome would be a result which was negligible.

Contingency planning

A misfortune that hit the teaching of radioactivity in schools was the appearance of the Ionising Radiations Regulations (IRR) before any of the other big sets of regulations on health and safety – particularly COSHH. Therefore radioactivity seems to be over-regulated because it was the first to be subject to regulation.

A contingency is a chance occurrence. This may be an accident or incident that takes you by surprise. The law requires that employers plan for contingencies. These are abnormal events that, within reason, are likely to happen. They need to plan courses of action that either render these foreseen contingencies even less likely to occur, or provide a set of responses restricting any resulting radiological exposure. Likely events include fire, theft or loss. The law does not require you to plan for events that, although conceivable, are highly improbable.

We have drawn up guidance for employers on contingency planning. It has been trialled on a training course and was well received.

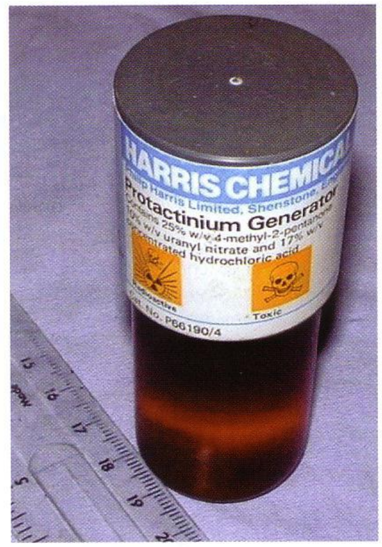


Figure 3 Philip Harris protactinium generator.

Protactinium generator

This is the source-type held for exhibiting radioactive decay and the half-life concept. Most generators were bought from Philip Harris in 1989 (Fig. 3). Others (Fig. 4) were school-made – again in about 1989. Because the generators are held in plastic bottles, a material that degrades with time, SSERC assigned these sources with a 10 year working life. In 1999, partly because no company was making this product any more, we reassessed the protactinium generator. It had had an excellent safety record; it performed well; we recommended in *Bulletin 199* in 2000 that schools should continue to use the generators for a few more years yet. As generators are now about 15 years old, and taking into account their highly hazardous contents, we believe that the usage of generators be prohibited forthwith and the sources disposed of. We have written to Councils, SCIS and the government regulator, the Scottish Executive Education

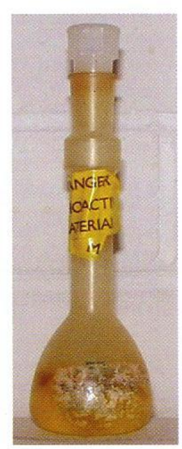


Figure 4 School-made protactinium generator, to SSERC design.

Department (SEED), recommending prohibition with immediate effect. We are looking at arrangements for their disposal from every school. Until then, sources should be kept in secure, locked storage, cap upright, inside a glass beaker.

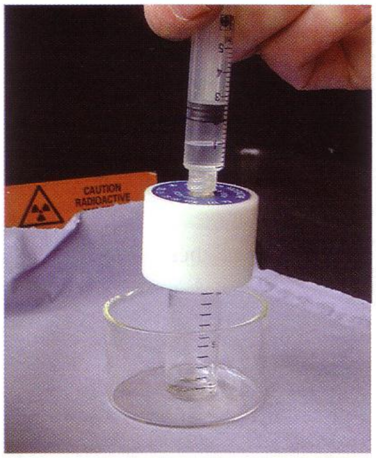


Figure 5 Eluting the short-lived radionuclide Barium-137m from the Isotope Generator.

A source well suited to superseding the protactinium generator is the Caesium-137/Barium-137m Isotope Generator (Fig. 5). Like the protactinium generator, it is an open source. The short-lived nuclide, Ba-137m, is eluted out of the parent source into a small glass vessel for isolation and counting. It performs well and, from a teaching stance, its mode of operation is simpler to explain and understand. Better still, from a safety stance, it presents a negligible risk of either chemical or radiological harm. In both these respects it is much less hazardous than the protactinium generator. The decision on whether the Isotope Generator should be approved for use in schools now rests with the government regulator (SEED).

Aged stock

Relative to the sealed sources and other radioactive materials held by schools, the protactinium generator is still quite a youngster. Typically these older sources were obtained before 1970 and are now between 35 to 40 years old. There is no evidence that any of the sealed sources are currently leaking and causing contamination. The hazards they present will increase however since their integrity depends on the continuing soundness of their construction. The *Protocol on the Ageing and Leak Testing of Sealed Radioactive Sources* advises that any source should be disposed of after a period of three recommended working lives (RWLs). In practice, this means either 15 or 30 years after purchase, depending on the type of radionuclide.

SSERC has been in contact with several agencies about aged radioactive stock. We will report back on the outcome of these contacts in due course

Leak testing

Our original wipe test method, based on the international standard, tested for an activity of less than 185 Bq on the wipe to decide whether the source was free from leaking. Being an absolute test, it required the use of a calibrated GM counter or a new instrument whose tube could be relied upon to perform within its specification. Because educational sources have low activities, 185 Bq of contamination on a wipe could represent quite a large fraction of the total source activity. The test was not very appropriate because of this.

We have therefore modified our advice towards recommending relative testing. A wipe is tested relative to background radiation. If there is a significant amount of radiation off the wipe, then the source is suspect. This revised test method depends on a statistical analysis of the results: if the difference between the mean count from the wipe and the mean count from background is more than two times the standard deviation in the difference, there is at least a 95% chance that the source is leaking. Although the arithmetic is simple, we have provided an *Excel* spreadsheet to perform the analysis.

A calibrated counter is not needed for relative testing. What matters is that the detector works efficiently.

Radium sources

Radium is not an ideal material for use in sealed sources. Being an alkaline earth metal, it is highly reactive even with nitrogen. In

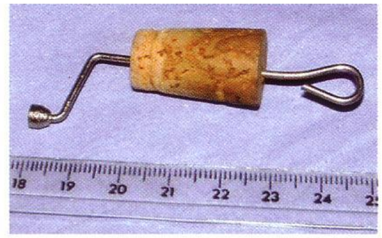


Figure 6 Cloud chamber source with radium-based radioluminescent paint.

radioactive sources, radium is therefore always present in the form of salts which are much less reactive. Being soluble in water, there is therefore often water of crystallization present in the source. If the source encapsulation were to rupture, the salts may easily be dispersed as powder. Five atoms of helium are produced from each radium atom from the alpha particle emissions in the decay chain. If there is water of crystallization present, then some water molecules will decompose to oxygen and hydrogen because of the irradiation by alpha particles. From the build up of gases – helium, hydrogen and oxygen – the source can become over-pressurized, causing the seal to rupture. Consequently the production of radium sources was stopped in the 1960s. A range of artificial, less hazardous, radionuclides has superseded radium in sealed sources.

Because school sources have low activity, the risk of a school-type sealed radium source rupturing from over-pressurization would seem to be small. There have been many instances of radium sources failing the radon emanation test for leaking by around 100%. Several such failed sources were sent to Amersham and NRPB for tests, including immersion in a liquid scintillator. The results revealed that each of the sources was emanating trace amounts of radon gas – to be expected – whereas none exhibited the leakage of radium. From these results, we are reassured that there is still no tendency for school sources to leak radium.

Nevertheless, we have to recognise that the radium legacy presents us with a problem. Radium is one of the more commonly found materials in school radioactivity holdings. It is found in the form of sealed sources, and radium-based radioluminescent paint (Fig. 6). We recommend that such sources should be disposed of, where arrangements allow.

Figure 7 Orphan sources - Panax open sources (Types S6 and S7, uranium and thorium oxide) – examples of orphan sources that should have been disposed of in the 1980s, but whose disposal is now inordinately difficult to arrange.

Orphan sources

These are sources that you are not allowed to keep, or work with, for both legal and health and safety reasons. Uranium or thorium compounds are the most commonly-found types of orphan sources in schools (Fig. 7). The Scottish Education Department (as then was) prohibited the holding and use of these compounds in the 1980's.

Mostly, schools complied with this at the time. Those who didn't are now finding difficulty in disposing of these compounds. There is at present no landfill site in Scotland where these substances will be accepted.

Figure 8 Sealed educational source made by AEA Technology.

Disposals

Let us state the principles we are working towards, the :-

- removal, in the short term, of aged stock and its replacement with appropriate new stock of modern design (Fig. 8), and
- provision, for the future, of a straightforward route for the disposal of redundant radioactive materials.

At the time of preparing this article, we are at the final stages of obtaining an authorisation from SEPA allowing us to dispose of most types of radioactive materials held by schools. The materials will be disposed of in a landfill site. The two nuclides our authorisation will not allow us to handle are uranium and thorium. Issues with disposal are complex and will take time to arrange. Please bear with us. We will let you know when we are ready to proceed.

Justification

Some things have to be experienced to be believed. Radioactivity is a property of nature that was hidden and unknown until, historically, quite recently[1]. The experience of seeing a source brought up to a detector, hearing the rate of clicking increase, but noting the arrhythmic, irregular sound; seeing the stopping power of paper, but the transparency of lead, to alpha and gamma radiations respectively – provides a form of tacit learning that is irreplaceable by other means.

Science is evidence-based. Wherever practicable, school science education should be evidence-based. It is one of the marvellous facets of our subject that all of the theories in the syllabuses can be teased out of inferences made from observations and experiments. A demonstration, well done, is a potent tool to opening the minds of pupils to scientific thought and reasoning. The teaching of radioactivity should be underpinned by practical demonstrations.

Over and above these are some phenomenological experiences which shed light on some of the really big ideas of science: the atomicity of matter, indeterminacy and the Uncertainty Principle, and uncertainty in scientific measurement.

Several good reasons justify the teaching of radioactivity in school education, especially if supported by practical demonstrations :-

- human prejudice
- bias
- how the risk of harm is perceived and not tolerated

What is the justification in not having radioactive sources? If it is the mistaken view that the materials are too dangerous, the message that that conveys to children is misleading. Radioactivity is a natural phenomenon: we should seek to open the minds of children to this fact rather than reinforce prejudices, closing minds to reason.

And finally, there are lots of science-based career opportunities working with radioactivity, or, more generally, ionising radiations, in the nuclear and other industries, and in the health services. The DTI estimates a skills' shortfall of 50,000 over a 15-year period from 2002 to 2017, assuming no additional nuclear power stations are built.

1 The reason why Kelvin famously under-estimated of the age of the Earth by at least a factor of ten was that radioactivity had yet to be discovered.

Recirculatory fume cupboards

We have recently heard that some recirculatory (filter) fume cupboards were inefficient at capturing ammonia. In one case where this had occurred, the filter was only a few months old and the release rate of ammonia was low i.e. from 100 cm³ of 880 ammonia left in the cupboard in order to allow pupils to dispense 10 cm³ into an aqueous solution. On investigation, we found out that the fume cupboard manufacturer had recently changed the supplier of filters used in the assembly of the cupboard. If your recirculatory cupboard is not functioning well, despite having a new or little-used filter, you should contact the manufacturer immediately. Here we make a few points about how recirculatory cupboards work.

Principle of operation

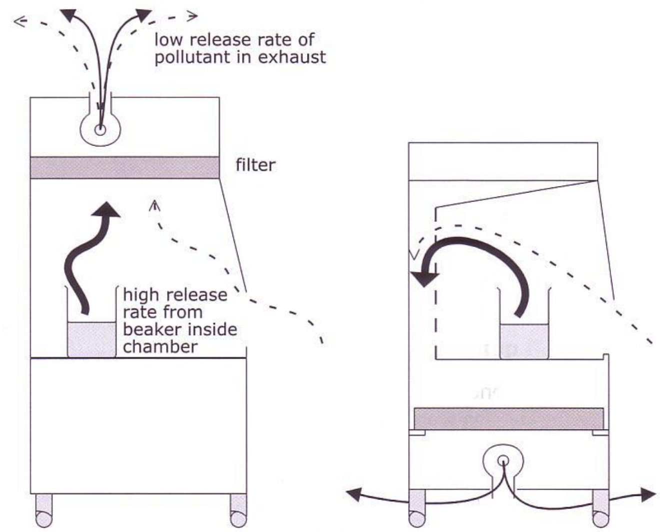
The contaminated air stream is drawn through a bed of fine particles of activated charcoal, which fairly efficiently adsorbs many gases and vapours (Figs. 1a & 1b).

Some gases are less well captured by the carbon alone so it is treated with appropriate chemicals to increase the efficiency of their capture e.g. one layer is often treated with either phosphoric acid or copper salts to improve the removal of ammonia. Manufacturers will have, in the operating instructions and on a permanent notice on the front of cupboards, a list of the gases for which they consider the cupboards to be suitable.

No "filter" traps 100% of gases released inside the cupboard. Frequently efficiencies of near 100% are found for new filters but this falls off with use as the active sites on the carbon become saturated. For this reason the term "filter" is, strictly speaking, a misnomer. **The recirculatory fume cupboard is best thought of as an attenuator and not a filter which stops all.** If it has an efficiency of 98%, then 2% of the fumes get through and mix with the air of the laboratory; this will reduce the concentration in the laboratory air to 1/50th of what it would have been had it been released in the open lab. Thus, the resulting room concentration will normally be well below the Occupational Exposure Limit (OEL) of the particular gas unless it is a toxic gas which will have a low OEL.

Fig.2 shows how the air concentration in a 250 m³ lab with different levels of ventilation (given in air changes per hour) rises when a gas is released in the **open lab**. If we focus on the room with two air changes per hour, after 30 minutes the room concentration has reached 228 ppm. The effects of attenuation by the filter can be seen by comparing with Fig.3. This shows the room concentration when the same release is made in recirculatory fume cupboards of varying efficiencies. On the half hour the room concentrations will have reached 22.8 ppm and 2.28 ppm for filters with capture efficiencies of 0.9 and 0.99 (or attenuation factors of 0.1 and 0.01) respectively. The cupboard with an attenuation of 0.01 may be acceptable for use depending on the harmfulness of the gas, but the other is unlikely to be so.

When the filter is new it might have an efficiency of 99.8%. The room concentration will then reach 0.5 ppm after 30 minutes, but if after some use the efficiency has fallen to 95%, the concentration would reach 11 ppm in the same time. For this reason the recirculatory fume cupboard must be treated as a source of contaminant in laboratory air and reasonable room ventilation is essential.



Figures 1a and 1b *- two common designs.*

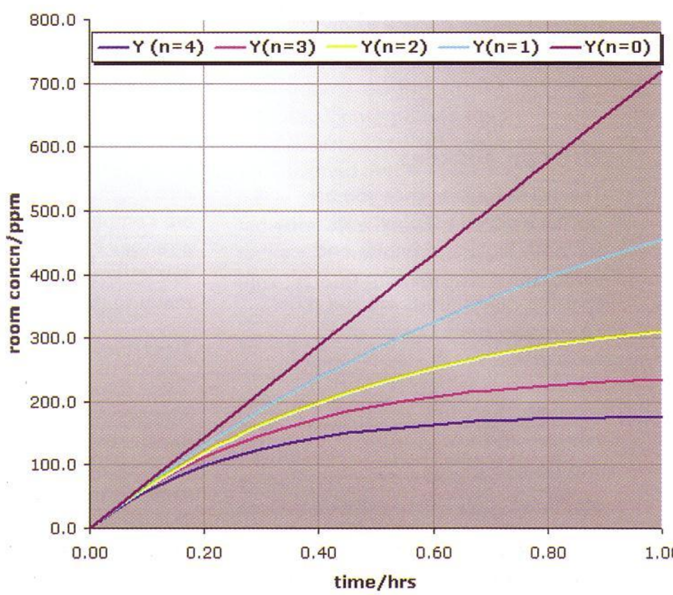


Figure 2 *Room concentration v. time for release in open lab of 250 m³ with different number of air changes/hour*

The other factor to consider is the total capacity for adsorbing a particular contaminant. This may be large for organic solvents or for sulphur dioxide, but maybe much lower for other gases, e.g. ammonia. This means the capacity for such gases can soon be used up and thereafter filter efficiencies for them will fall drastically.

Construction design effects

First generation cupboards

Virtually all of the early cupboards had the filter above the chamber (Fig 1a). The main advantage of this design is that the exhausted air carrying the small percentage of contaminants which failed to be trapped is expelled upwards towards the ceiling and is thus very well mixed with the room air before reaching people in the room. However, these designs have the following disadvantages:-

- they are tall and therefore difficult to get through doorways,
- stability is poor on account of the high centre of gravity and
- a difficult manual handling exercise occurs when removing and replacing heavy filters above head height.

Second generation cupboards

The next generation tends to have the filter under the work surface (Fig 1b) and therefore avoids the previous above noted difficulties. However, the exhaust air is now directed downwards and, after hitting the floor, spreads outwards in all directions. Compared with cupboards where the filter is on top, this exhaust air will be sparingly mixed with the room air before it reaches the operator (pupil using the cupboard, teacher demonstrating or the class viewing from the other side). The concentration of contaminant reaching pupils and staff near the cupboard will therefore be much higher than those calculated on the assumption of complete mixing as in Fig.3. Contact will also happen almost immediately i.e. there will be exposure to concentrations much closer to the values of C_x rather than to C_r in Table 1

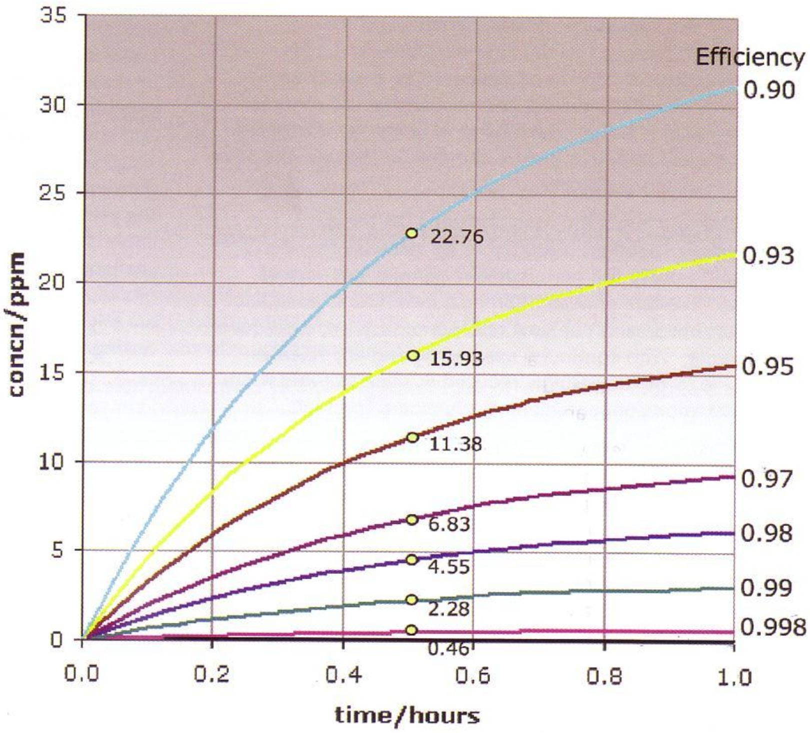


Figure 3 - *Room concentration vs. time for filters of different efficiencies (0.9 to 1) for 250 m³ room with 2 air changes/hour from a release of 50 cm³/s in the cupboard.*

Release rate ($cm^3 s^{-1}$)	Efficiency	Fraction of gas escaping	Exhaust concn. (ppm)	Room concn. after 30 mins (ppm)
R	E	1-E	C_x	C_r
50	0.995	0.005	2.5	1.14
50	0.99	0.01	5	2.28
50	0.98	0.02	10	4.55
50	0.97	0.03	15	6.83
50	0.96	0.04	20	9.10
50	0.95	0.05	25	11.38
50	0.93	0.07	35	15.93
50	0.9	0.1	50	22.75

Table 1 - *Calculated concentration in the exhaust air before mixing with room air and (ii) room concentration after 30 minutes in 250 m³ room ventilated with 2 air changes per hour for 'filters' of different efficiencies*

Sense of smell

We all use our own sense of smell as a guide to whether a gas or vapour is present and also to indicate a very rough idea of the concentration. And very useful it is too, but a number of points should be made :-

1. The sense of smell becomes fatigued and after a while a gas or vapour may not be noticed to the same extent.

2. The threshold of smell, i.e. the minimum concentration at which a human nose can detect, varies greatly from person to person. If we take ammonia as an example, this is quoted variously as 1 ppm, 5 ppm, 54 ppm. The Canadian Centre for Occupational Health and Safety quote a range and give its geometric mean as 17 ppm. The Occupational Exposure Standard for ammonia is 25 ppm for those exposed to it for an 8 hour day and 35 ppm for exposures limited to 35 minutes. Thus many, but not all persons, will smell ammonia at levels well below concentrations which may cause ill health effects.

3. The situation for many other gases is reversed and they will not be noticed even at concentrations well above the OES of the gas. Thus in general terms you do not necessarily detect a gas, by smell alone, before it reaches harmful or dangerous levels.

Summary

No filter removes 100% of contaminants and the percentage captured by the filter decreases as it ages. Therefore treat a 'filter' fume cupboard as a source of pollution, albeit attenuated, and ensure that the room is ventilated. It is best to use a window at the far side of the laboratory so as not to disturb the flow in through the sash opening of the cupboard.

Although the cupboard manufacturers list the gases for which their cupboard is judged to be suitable, they don't generally supply the permissible maximum safe rate of release. The rate of adsorption by a new filter is adequate to deal with smallish or slow releases or faster releases for a short time. With continued use and ageing any releases will have to be increasingly reduced in scale to avoid room concentrations of contaminants becoming too high.

Very toxic gases should only be released at low rates, for a short period of time. For those listed as toxic there will still always be an uncertainty as to the safety. Such a limitation or doubt will have an adverse effect on the depth and quality of practical work. The tail should not wag the dog: fume cupboards capable of meeting the requirements of the chosen work should be purchased.

The initial installation costs of recirculatory cupboards are low. They are virtually nil in the case of the most basic model without gas, water or drainage. They simply needs to be plugged into the electrical mains. Because of their off-the-shelf and instant plug-in capability, recirculatory fume cupboards seem an easy and cheap choice for PPP contractors and others. They should however be made to reconsider, as the disadvantages are great. These cupboards can, over the years, prove to be more expensive than a ducted cupboard. The regular extra costs of filters and of the challenge tests will be considerable. Presently some EAs replace the filter every year and some authorities are paying around £400 per cupboard per year for testing and replacement of the filter.

There could be some situations where purchase of a recirculatory fume cupboard is justified. This would be the case if, for example in refurbishing a school, a chemistry laboratory was moved to the ground or first floor of an existing multi-storey building or if the building is listed and a duct exit above roof level is not practicable or permitted.

Ducted cupboards with all round vision are also available. Fitted with a length of flexible duct, connecting them to the fixed duct on the ceiling, these may be pulled out from the wall, giving all round vision.

Conclusion

We would recommend that the first choice is always a ducted cupboard. This is especially so for senior work and for decanting from bulk and preparing diluted stock solutions. We have come on examples of schools with existing mobile, ducted cupboards where these were replaced by new recirculatory cupboards. If there is already a duct, all that might be needed is a new fan. Both the initial and ongoing costs would be less and there is the considerable benefit of not worrying about the uncertainties associated with filters.

Scots Online

With the initial support of BP, the Scottish Chemistry Online Teachers' Service (SCOTS), web-site has been developed. It went live as from the 10th May and can be accessed at http://www.scots.org.uk

The site is intended to share useful information for chemistry teachers, e.g. on all CPD activities, resources, useful links to web-sites, support for students, etc.

Gas-cartridge air rifles

On the 1st May 2004 it became illegal to possess a gas-cartridge air rifle without having a firearms certificate. The prohibition does not apply to air rifles of the traditional type that are cocked by breaking and shutting the barrel, or to ones using an internal carbon dioxide bulb.

The prohibition has come about because many air weapons with a self-contained gas cartridge look like real guns and can be converted to fire live ammunition. We understand that at least 75,000 of such air guns are thought to have been sold in the UK since 1989. Failure to comply with the legislation[1] is punishable with a minimum of five years imprisonment and a maximum of ten.

Air rifle experiments in kinematics and dynamics used to be very common before the Dunblane incident. A justification of the practice, along with an ethical code and safety arrangements, can be found in Bulletin 190. These safety arrangements should also include a prohibition on the use of gas-cartridge air rifles.

1 The Anti-Social Behaviour Act 2003.

Fixed wiring colours have changed

What with Spring in the air, now is the time to head for B&Q, get a few colour charts for paints, and plan a bit of interior decoration. It seems that the boys and girls from the IEE have been doing this too. The identification by colour of conductors in fixed wiring (behind-the-wall wiring) was changed, with effect from the end of March, to harmonize with European regulations (Table 1).

Conductor	Traditional colours	European harmonized colours
Phase (or live)	Red	Brown
Neutral	Black	Blue
Protective earth	Green-and-yellow	Green-and-yellow

Table 1 New colour scheme for single-phase fixed wiring.

Some of the common anomalies are of interest. What happens if you want to add an extension socket, or replace a section of wiring? Provided that the existing cables are correctly identified by the old colours, cables with the new colours may be connected such that all of the wiring is unambiguously marked.

Then consider the anomaly of switch wires, where the supply goes to a ceiling rose, a pair of conductors drop to a Class 2 pendant lamp, and cable is taken to a switch. In this instance, because both the brown and blue conductors going to the switch are phase conductors, the brown conductor is correctly coloured, but the blue conductor must be marked with brown sleeving slipped over both of its terminations.

This information may be of relevance to the Electricity sections of Physics syllabuses: it is not a guide to rewiring schools or homes, which should be left to competent electricians.

Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)

Until now, the way in which flammables were handled and stored, whether as liquid, solids (especially when finely divided) or as vapour, was governed by a mish-mash of legislation. Things were made more systematic with the:

Health and Safety at Work etc. Act 1974, which place on the employer the duty of setting up "arrangements for ensuring, so far as is reasonably practicable, safety and absence of risks to health in connection with the use, storage and transport of articles and substances" and,

Management of Health and Safety at Work Regulations 1999, which required the employer to carry out risk assessments of **all** kinds of dangers and then to set up and monitor the control measures decided on. Under these Regulations, employers were also required to establish procedures to be followed in the event of serious and imminent danger.

Bits of the older legislation relating to flammables have been revoked, e.g. the very useful *Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972* and others were modified. There were some discrepancies between these different bits of legislation, even in the definition of what was a Highly Flammable liquid. *DSEAR* replaces this confusion.

The systematic approach of *DSEAR* is akin to that taken by the *COSHH Regulations*, but applies to the dangers posed by the flammable and explosive nature of substances rather than to their toxic/ harmful or corrosive/irritant effects. Thus DSEAR and COSHH complement each other in the coverage of hazards. DSEAR require that:

- assessments be made of the risks from flammable and explosive substances;
- appropriate control measures be taken to eliminate or at least to greatly minimise the dangers; and
- persons concerned be informed of these and trained.

The management of flammables now has a greater emphasis on the requirement placed on employers to do a risk assessment of how flammables are stored, generally managed and used. The latter two aspects are covered in the *SSERC Hazardous Chemicals Manual (now CD2)* which contains the control measures, sometimes called preventive measures, needed to eliminate or minimise hazards of **all** kinds, including those of an explosive or flammable nature. When Education Authorities adopted this publication, they could use it both as a source of model or generic assessments for both practical work in laboratories and as a source of general advice on the storage of flammables and other chemicals. However, the construction, size and position of stores and the arrangements for flammables therein vary. This aspect cannot be covered by a general assessment. Hence, employers should carry out a risk assessment of their particular storage arrangements and methods used for decanting and transporting flammables between the store and laboratories. The results and conclusions of these assessments should be recorded along with the safety policy.

Error in Bulletin 210, Page 11 Blue Bottle - now low hazard [Simple method (B)], Table 1 (Small scale)

The volume of 0.1M copper(II) sulphate used should read 3 cm^3 and not 12 cm^3. Web version has been amended.

Microbiology and biotechnology at levels E and F

Revision of the national guidelines for Environmental Studies has led to the introduction of several new "attainment targets". Some of these, at levels E and F, pertain to topics microbiological and biotechnological (see Table 1).

As part of the national ISE 5-14 (Improving Science Education 5-14) programme SAPS and SSERC have been developing and trialling practical protocols, and other active learning strategies, for these new topics. That work programme, also, is summarised in Table 1 below.

We recognise, of course, that the forthcoming comprehensive review of the whole curriculum 3-18, will see a marked degree of simplication and slimming down of both content and summative assessments in secondary science courses.

Nonetheless, microbiology and biotechnology are rich seams to mine for more challenging investigative work set within contemporary societal, economic and ethical contexts. It is thus hard to credit that at least some of these current developments will fail to retain relevance beyond the review. In any case, we've built in an element of redundancy in the range of learning and teaching strategies offered within our materials. The idea is to re-introduce, long overdue, elements of professional choice and judgement, rather than try to make teachers mere 'deliverers' of other people's materials.

Attainment Targets within Living Things and the Processes of Life	Strategies for Introducing and establishing preconceptions	Investigation Practical Activity	Applications/ Issues (Developing informed attitudes)	Third party resources Industry or Research Institute	Homework
Give the main distinguishing features of micro-organisms (ISE Code LT-E1.1)	Card sort exercise (True/False/Not Sure type). Used at beginning to get some indication of children's existing ideas. May be revisited after activities to explore changes in pupils' thinking.	Life in the littlest loch - a microscopy exercise with a variant on the 'hanging drop' technique. ICT applications with video (Motic and others). Photomicrography and simple measurement exercises. Observing budding yeasts etc.	Water and sewage treatment. Eutrophication and algal blooms because of agricultural run-off and domestic waste.	Sciento (algal and protozoan (protoctista) cultures. Society of General Microbiology (SGM) posters and resources. Sewage treatment works at BP Grangemouth. Scottish Water resources (visits, web based resoures etc).	Not yet developed
Describe the harmful and beneficial roles of micro-organisms (ISE Code LT- F1.1)	Data interpretation - food poisoning figures. Case study on *Salmonella* - 'Chicken Runs' Concept Cartoon on compost columns 'Odd one out' game ("are all bugs bad?")	Culturing organisms from the environment (contained cultures). Effects of various cleaning agents. Temperature effects on growth and survival. Compost column models. Bread moulds. Oyster mushroom cultures. Bread making (dough races). Making cheese and yoghurt.	Ubiquitous nature of microbes. Personal and domestic hygiene. Disease prevention and cure. Apparent increase in domestic hygiene v. loss of immunity. Harm and good with microbes depends on context. Waste disposal, composting, recycling and landfill. Preservatives in food. Antibiotic resistance.	SGM posters - food spoilers, food producers. Rowett Institute. Scottish Crop Research Institute and the SAC network. Scottish Food and Drink Federation. MISAC competitions.	'Research' exercise. Talking to family and others about food poisoning, causes and effects. Reporting back in a show and tell session. Create PPt shows or posters on food/hygiene. Compost column make & observe.
Explain the role of chromosomes and genes in inheritance (ISE Code LT-F1.3)	'Fact or Fiction' game on heredity, chromosomes and genes. KWL analysis (What I know. What I want to know. What I've learned.)	Extraction of DNA from fruits/fruit juice. 'Wizard Genes' a simple electrophoresis exercise.	Genetic testing. DNA 'fingerprinting'	National Centre for Biotechnology Education (NCBE). Scottish Institute for Biotechnology Education (SIBE). BioRad. The 'media' - clips and clippings from TV and press etc. Wide range of materials from 50th Anniversary of discovery of structure of DNA.	Yet to be developed. No good ideas will be turned away!

Table 1 *Relevant attainment targets in the current National Guidelines for Science within Environmental Studies 5-14. The table shows activities and associated resources which been developed, trialled and redrafted (or about to be) under the auspices of the ISE 5-14 programme. Some trials included teachers who were not biology specialists (chemists and physicists). Still to come is a set of similar materials and strategies for the attainment target "Outline the principles of modern biotechnology and explain its significance now and for the future (ISE Code LT-F1.2). First trial editions of many of these resources are referenced out of the relevant sections of the electronic versions of the guidelines on the ISE 5-14 website (www.ise5-14.org.uk). Given a fair wind, these should gradually be replaced over the Summer with the redrafted versions.*

Abstracts from SAPS/SSERC resources

Distinguishing features

The central part of this section is an investigation into the variety of shapes and sizes of a range of micro-organisms. The technique used is a variant on the weel kent 'hanging drop' preparation. Pupils look at cultures of algae and protozoa (protoctista we now have to call them) and answer simple questions such as :

Do all micro-organisms look alike? Are they all the same size? Just how small are they? Can they move? Do they change shape? Are they all actually alive?

A card sort of the "true, false, not sure" type is used to introduce this practical, set up as a small group activity. This is done rather than simply saying, as teachers may often do, "Today we're going to (learn about)".

The idea is to begin probing what the pupils already think about aspects of this topic. This can begin to reveal some of their pre- and mis- conceptions many of which are likely to have come from the media. Figure 1 shows a sample card which probes a mix-up commonly seen in the press or heard on TV.

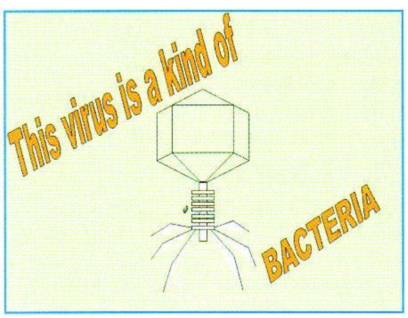


Figure 1 *One only of a set of 12 slides or cards used to probe pupil's existing ideas on micro-organisms.*

Working in small groups and the use of visual images are intended simply to make a pre-activity assessment less apparently threatening than teacher interrogation or written answers to, possibly closed, questions. The cards were originated in *PowerPoint*™ and so can be used either in their original form with an lcd projector (whiteboard where available) or as printouts of the PowerPoint file in 'handout' format.

At an appropriate point the cards may be revisited so as to determine whether any of the pupil's ideas have changed as a result of their practical experiences.

Harmful and beneficial effects

Organisms are also grown in closed culture dishes so as to demonstrate the ubiquitous nature of microbes. This then bridges into a section on beneficial and harmful effects of micro-organisms.

A number of other resources fail to get across the point that many organisms can be either good or bad depending on where and how they grow, just as a weed is simply a very efficient plant growing where it's not wanted. Therefore, an "odd one out" game is to used to try to get this point across. This leads on to work related to hygiene and food poisoning followed by some work on anti-bacterial and anti-fungal substances. Figures 2 and 3 illustrate results from some of these practicals.

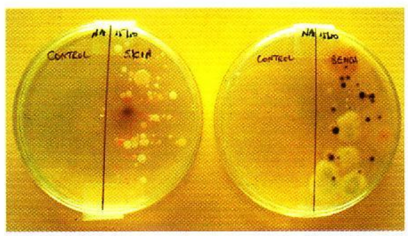


Figure 2 *Ubiquitous nature of micro-organisms. Cultures from surfaces. Risks are controlled through containment (plates closed after inoculation through to disposal).*

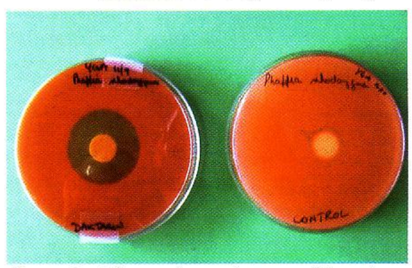


Figure 3 *Effects of proprietary antifungal substance (treatment for athlete's foot, thrush etc) on the red yeast Phaffia rhodozyma.*

The harmful effects of food spoilage and the roles of preservatives are investigated, through activities such as looking at mould growth on different types of bread.

The beneficial effects of micro-organisms are also emphasised through investigations on ways in which they can be used to make useful products like bread. Their vital role in recycling is the subject of a longer term observational exercise using a compost column which itself is constructed from recycled plastics (Fig.4).

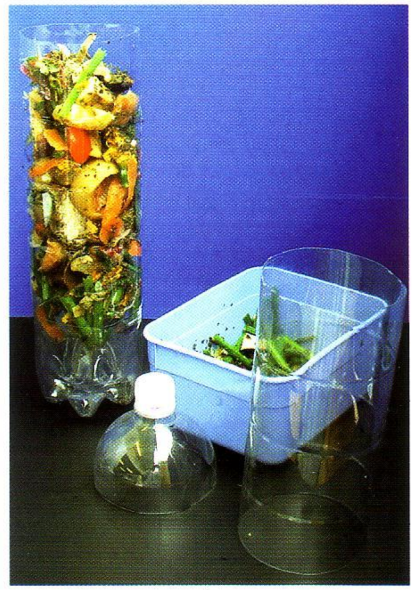


Figure 4 *Compost column components cut from plastic drink bottles, vegetable waste and a finished, filled column.*

Chromosomes and genes

Protocols for this section include the extraction of DNA from strawberry and kiwi-fruit using washing-up liquid and salt followed by precipitation with cold alcohol (meths - see Figure 5).

This activity is preceded by a 'self-assessment' exercise. This is a KWL activity using a three column format wherein pupils set out: what they Know already about DNA; What they want to know and then complete with what they've Learned as a result of their work in the practical activity.

The other significant practical in this section is "Wizard Genes" - an exercise on electrophoresis using the NCBE kit.

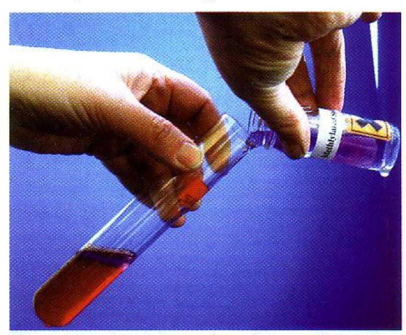


Figure 5 *Careful pouring of ice-cold meths down the side of a tube of chilled strawberry juice to precipitate the extracted DNA. (Small volume of meths - gloves not necessary. Clear drop on container is condensed water.)*

Enzyme investigation using catalase

We've had an enquiry (more of a complaint) recently. This related to one of the Science 5-14 books published by Hodder and Gibson [1]. On page 102 of the S2 Pupil's Book there is a description of an 'experiment' using hydrogen peroxide and liver (as a source of catalase). There is also a related section on page 164 of the Teacher's Guide [2] suggesting "Further Activities". In each case there are substantive hazards and risks but little or no relevant health and safety advice is offered. In addition, the account in the pupil text has the distinct flavour of a 'thought' experiment since its theoretical basis is so obviously flawed (see the web version of the Bulletin for a fuller explanation). In fairness to the authors and publishers, we report that variants of this ill-advised procedure have appeared elsewhere and in teacher originated materials.

We brought these points to the attention of the publishers, who responded responsibly and with good grace, as follows:

"Many thanks for drawing our attention to the material on Page 102 of the S2 Science 5-14 Pupil Book. We have discussed the matter with the authors, and can only apologise that this has slipped through our normally rigorous control procedures. We shall be correcting this material at the next reprint, and – although schools will clearly be made aware of the error via your good offices – we shall be contacting all schools we know to have adopted the course with details of this correction in the very near future. We shall also forward it to you.

Yours

John Mitchell, Managing Director, Hodder Gibson"

References:

1. *Science 5-14 Pupil's Book S2*, 2003, Chambers, Marshall, Souter and Stark, Hodder & Stoughton, ISBN: 0340800429
2. *Science 5-14 Teacher's Book S2*, 2003, as above but ISBN:034080047X

Acknowledgement:

We are most grateful to the teacher who brought this matter to our attention and who took the trouble to correspond with us on it.

Socket-outlet testers

Beware! Those little plug-in testers of 13 A socket-outlets cannot be relied upon to provide full assurance that socket-outlets are safe to use.

There are many plug-in devices on the market purporting to show whether 13 A socket-outlets are safe to use. These devices generally look like 13 A plugs with a series of LED indicators on the plug-top face. They are simple to use and lots of schools have them. If there is a fault condition, the pattern of LEDs identifies what the fault type is. However, if the tester fails to find a fault, it indicates that there is no fault, misleadingly indicating that the socket is OK.

The Health and Safety Executive (HSE) are concerned that users can be misled. These simple testers are generally believed to have two limitations. They :-

1. are unable to show whether the neutral and protective earth conductors are transposed; and
2. cannot prove the adequacy of protective earthing arrangements.

If the protective earth is sound, then the protective conductor path from the earth socket to earth should have a resistance of less than 1 Ω to ensure that automatic cut-off devices operate in the requisite time. The HSE have failed to find any testers that correctly discriminate down to this value; they even found one tester where the 'earth OK' indication was given when the earth fault loop impedance was as high as 50 kΩ.

Part of the problem is that information given in adverts, instruction leaflets and on the backs of devices can be wrong by over-statement, giving the user a false sense of security. Testers are useful for certain tasks e.g. if the electricity supply to a room were to be deliberately isolated so that the area was made safe for children to practise wiring plugs, a tester would be a convenient way for checking that the socket outlets were dead. But restating the message, they must not be relied upon for showing that socket-outlets are safe. Nor, for that matter, can they show that an extension lead is safe.

Editorial - cont. from front cover

This study looked at attitudes and behaviours as signs of an informed awareness of small "p" politics in the workplace. Also examined were factors thought to indicate principled behaviours based on a sense of fairness, of doing the "right thing" by employees and colleagues. One way in which the findings can be illustrated is to produce a block graph with "politics" as one axis and "principles" as the other. For clarity (or possibly just a bit of fun) positions or ranges at various points on these graphs were assigned pictures and names of animals.

For example, those managers with no signs of awareness of the establishment's politics and no signs of principle (or, in a few cases, even of life) were christened *donkeys* (not a lot of PC usage there, then). Continuing the theme, those with some inkling of the politics but little or no principle were *sheep*. We get to the more interesting bits with the *foxes* and the *owls*.

This doesn't take a lot of working out. Foxes generally do well because of their well-honed, workplace, political skills. Foxes tend to leapfrog (to mix our menagerial metaphors), over others. Often, in some cases always, this is done by unprincipled means. Lastly, as rare as hens' dentures, come the owls.

'Owls are folk of unwavering principle, with a deep sense of natural justice, but who are also acutely aware of the human interactions and motivations of those around them.

One such behavioural survey, of a health board in the Midlands of England, threw up an unusual incidence of owl types. This was so far out of kilter from the usual pattern, the survey had to be repeated. The data were re-gathered and analysed a second time. Many of the so-called owls were then revealed in their true guise. You guessed it - they turned out not to be owls at all, just extremely smart foxes.

So, there you have it. Reforms post-McCrone should, above all else, be about the conservation of owls and the rigorous population control of foxes. Anyroads, in Scotland, dinna try gaun efter them wi' dugs. Oor wonderful new wee Parliament, in a' it's wee wisdom, cried that illegal. Lang syne, it was one of its major priorities. I rest my case.

Despite his current secondment, and a total lack of popular demand, John Richardson has returned to guest here occasionally. He's practising to take over Gregor Steele's part time job and column in the TESS. This is so he can save up for his retirement and also buy a Skoda.