Surely that's banned?

A Report for the Royal Society of Chemistry on Chemicals & Procedures Thought to be Banned from Use in Schools

October 2005

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SSERC

CLEAPSS SCHOOL SCIENCE SERVICE

RSC | Advancing the Chemical Sciences

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The CLEAPSS® School Science Service is an advisory service supporting **practical** science (and technology) in schools, colleges, etc. It is largely funded by subscriptions from members. At the present moment every one of the 180 education authorities in England, Wales, Northern Ireland and the various islands is a member and hence all their schools have free access to CLEAPSS services. The vast majority of independent schools, post-16 colleges and teacher-training establishments are associate members, as are many curriculum developers, field study centres, hands-on museums and learned societies. There is a particular focus on health and safety.

CLEAPSS produces a large number of publications for members, ranging from termly newsletters for primary and secondary schools, a 1000-page *Laboratory Handbook*, *Hazcards*®, *Recipe Cards* and many leaflets and booklets. Much of this is now available on CD-ROMs. The members' *Ηελπλινε* takes about 6600 calls per year. CLEAPSS also runs about 180 courses per year, mostly 1-day. We are represented on several committees of the British Standards Institution and maintain a close dialogue with the Health and Safety Executive, the Qualifications and Curriculum Authority, professional bodies and others with an interest in science education.

SSERC fulfills a similar role in Scotland.

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Executive Summary

of a Report for the Royal Society of Chemistry on the Understanding of Schools & Education Authorities of Chemicals and Procedures Thought to be Banned from Use in Schools

There have been concerns nationally about the effectiveness of some of the science currently being taught in some secondary schools, especially to pupils in the period of statutory schooling. The Royal Society of Chemistry (RSC) is concerned about the teaching of practical science and in particular that

- there are a number of myths and misunderstandings about presumed bans on particular chemicals, activities or procedures in school science; and
- much effective teaching of practical science is being inhibited on spurious grounds of health and safety.

It asked CLEAPSS (a national advisory body supporting the teaching of practical science) to investigate whether these concerns are justified in secondary schools across the UK.

Questionnaires were sent to a sample of 1249 secondary schools of all types, in every education authority in England, Wales, Northern Ireland and the offshore islands. This is just over one quarter of all secondary schools in those areas. Similar questionnaires were sent to a sample of 447 Scottish secondary schools by SSERC (a sister body to CLEAPSS, operating in Scotland). The questions related partly to organisational aspects of health and safety in science but there were 40 questions about materials which might be used by schools or practical activities they might undertake. There was an approximately equal mix of biology, chemistry and physics but included some items relevant to all three sciences. The response rate by those circulated was just over 24% which is very good. Results were analysed by type of school and other criteria. Scottish practice is slightly different to that elsewhere. As there was a significant number of returns from Scottish schools, these have been analysed separately as well as within the complete sample.

Parallel questionnaires were also sent to 634 education officers in every education authority in the United Kingdom outside Scotland. The response rate was 10% which covered almost one third of those authorities circulated. About one third were from safety officers and almost two thirds from science advisers, etc. Where possible, results were compared with returns from their schools.

National and local bans of chemicals and science activities

Contrary to popular impressions, there are in fact very few science activities and chemicals which schools might consider using which are banned at a national level. The major ones are benzene (and any mixture or solution containing more than 1% benzene) and various ozone depleters. In addition to these outright bans there are a number of complicated restrictions on the dissection of eyes of various species, holdings of radioactive substances, making explosives, experiments involving cruelty to vertebrates and removal of protected species from the wild. The RSC has a list of banned chemicals, and those not recommended for use in schools on its website at http://www.chemsoc.org/networks/learnnet/cldemo.htm.

Education employers could direct teachers not to use other chemicals or scientific activities, in addition to any national bans and restrictions. Of course, many chemicals and activities present hazards. A risk assessment must be carried out and any control measures implemented. In some cases it may be that there are safer alternatives which achieve the same educational aim. Some activities are suitable only for teacher demonstration or for use by older pupils.

Summary of the main findings

Almost 61% of education authorities replying (all from England and Wales) indicated that they did not ban any chemicals or activities, many amplifying this by saying that they strictly followed CLEAPSS guidance. There was a small number of returns which showed an inaccurate understanding about perceived national bans on a range of activities such as dissection, reduction of lead oxide and use of air rifles. However, almost all of the 40 items in the list, and indeed a few others not listed, were banned locally by at least one of those authorities who had such prohibitions in place. Officers from the same authority were not always in complete agreement about local policy and practice.

There were 45 authorities in which replies were received from both officers and schools. Three quarters of these authorities said they had no bans. Most of the schools in their areas correctly identified national bans on benzene and crude oil. However, the majority of schools also believed incorrectly that at least two or three other chemicals or activities, and sometimes many more, were also banned. Where education authorities had introduced local bans, schools' returns did not match the authority ones.

Almost all schools correctly identified benzene and crude oil as being banned nationally though less than half could produce documentary evidence. Despite this a few schools claim still to be using one or both of these materials. Just under one quarter of schools believed there was a ban on dissection of eyeballs which is only partially true. Beyond these there are a number of misconceptions about what is banned nationally including 70% who believe it is illegal for pupils to sample their own blood and 32% who thought pupils' own saliva samples were banned. At least 15 other chemicals or activities in the list, including keeping giant African land snails, the ammonium dichromate volcano experiment and demonstrations of protactinium generators, were believed to be banned by between 10% and 30% of respondents, despite only a very small number of authorities who had local bans in place. Documentary evidence for these claims was, not surprisingly, rare. Ethical reasons were sometimes put forward as reasons for not carrying out some activities such as keeping small mammals but this reasoning was not often extended to cover activities such as using woodlice in choice chambers.

Fortunately, some of the more exciting or interesting activities are still being undertaken. Thus 97% of schools say they still demonstrate the reaction between potassium and water, 96% the van de Graaff generator and 90% the dissection of hearts.

Schools with and without sixth forms have broadly similar understanding about which chemicals and activities they believe to be banned. However, where significant differences do exist it is mainly those with sixth forms which are more adventurous. Independent schools were more able to provide documentary evidence for bans. Maintained schools incorrectly believed more items to be banned than independent schools. This may arise from differences in employers but the majority of education authorities responding did not have bans in addition to what is banned nationally. There were no major variations between schools of different sizes though smaller schools tended to believe more activities were banned even when they were not, and larger schools were more likely to carry out activities in the list. One might speculate that independent schools, those with sixth forms and larger schools generally would be more likely to have specialist equipment and suitably qualified specialist teachers, and thus more likely to undertake more adventurous activities. However, schools did not identify lack of expertise as a problem. Perhaps they do not realise what they are missing?

Broadly similar responses were received from teachers and technicians but fairly consistently teachers identified incorrectly more chemicals or activities which they believed to be banned. This may reflect the fact that many more technicians than teachers attend CLEAPSS and SSERC courses and use the CLEAPSS Helpline and thus are better informed.

Few items in the list were identified as being discouraged though not banned, despite this being the preferred terminology for many of those education authorities which did have local restrictions. Similarly, few activities were believed to be unsafe even when not banned. Slightly higher percentages were recorded for activities felt to be unsafe with the schools' pupils but even these were mostly below 10%. With some significant exceptions (eg, keeping animals, use of more expensive equipment), activities were not felt to be inhibited by a lack of resources.

Substantial percentages of schools discounted some of the more exciting, entertaining but pertinent activities because they believe they do not have time to use them or feel them not to be relevant to their work. The wide range of examples includes 45% not following the development of frog spawn, 28% not reducing lead oxide with charcoal and 15% not demonstrating power lines. The responses raise anxieties about approaches to teaching and the interpretation of curricular requirements.

Scottish schools were even more cautious than those across the UK generally. For example, over half of the respondents thought that pupils could not take samples of their own blood, use their own saliva in experiments or dissect eyeballs. About a third or more also believed that incubating pupils' own "finger dabs" on agar, lead oxide/charcoal reactions, power line demonstrations and protactinium generators were banned. Generally schools did not have substantiating documentation for these beliefs.

Conclusions

It appears that the Royal Society of Chemistry's concerns are substantially justified. There are significant misunderstandings on the part of teachers and technicians about the chemicals and scientific activities which are banned in secondary schools and some teaching is inhibited by unjustified concerns about health and safety.

With a few exceptions, there is little evidence to support the view that arbitrary decisions or over-reaction on the part of education authority officers is inhibiting good practical science; in practice, education authorities have banned very little.

The lack of resources to enable schools to use some chemicals and approaches is a continuing matter of concern. An equally worrying revelation is that schools do not feel they have time to undertake many of the activities included in the survey or that they do not see them as relevant to their courses.

There is already abundant advice available to schools from CLEAPSS and SSERC. It seems that much of it is ignored. The Royal Society of Chemistry produces many publications for teaching which document safe approaches to practical work. There is a need to improve the understanding of schools and employers about the balance between appropriate safety in science and exciting and stimulating science lessons.

Surely that's banned?

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A Report for the Royal Society of Chemistry on the Understanding of Schools and Education Authorities of Chemicals and Procedures Thought to be Banned from Use in Schools

1. Purpose of the investigation

Concerns have emerged nationally about the effectiveness of the teaching of practical science in some secondary schools, especially relating to pupils in the period of statutory schooling. The Royal Society of Chemistry (RSC) is concerned, in particular, that

- there are a number of myths and misunderstandings about presumed bans on particular chemicals, activities or procedures in school science; and
- much effective teaching of practical science is being inhibited on spurious grounds of health and safety.

The Consortium of Local Education Authorities for the Provision of Science Services (CLEAPSS) was commissioned in 2005 by the RSC to investigate whether these concerns are borne out in secondary schools teaching pupils who are of the statutory school age. The investigation was carried out with the cooperation of the Scottish Schools Equipment Research Centre (SSERC), the counterpart of CLEAPSS in Scotland.

2. Context for the investigation

An article in the journal *School Science Review* commented that

> *Accidents may happen in almost any part of the school building [but] the school science laboratory is … where accidents are very liable to occur unless adequate precautions are taken to guard against them.*

This article was, however, dated 1940 and recent statistics, both from the Health and Safety Executive and from local authorities, show that school science laboratories are one of the safest places in the school in terms of accidents arising from science activities carried out by pupils, teachers and technicians. Although just over 2% of the accidents to pupils in schools reported to the HSE under *RIDDOR*[1] occur in laboratories, due to a quirk of the reporting system, less than half of these result in any injury at all. This is mainly because health and safety is given high priority by school science staff in the light of extensive legislation, supported by guidance from employers whether they be education authorities or school governing bodies or boards.

The down side of this highly desirable concern for the safety of pupils and staff in science laboratories and preparation rooms is that a perceived threat of litigation in the event of an accident, and the occasional journalistic misreporting, has led some teachers to become over-cautious. They have stopped doing some of the more exciting and entertaining science activities which stimulate pupils and are relevant to what is being learned. Teachers feel under pressure because of the requirements of the national curricula and examination courses, the increasing expectations to achieve high standards in national examinations, the shortfall in school science departmental funding, often inadequate technician support and limited time to practice and prepare the more hazardous or spectacular demonstrations. When health and safety anxieties are added, it is not surprising that some teachers retreat at times from practical work to less- stimulating pencil and paper tasks.

More recently there have been pleas from some high profile and potentially influential people such as Professor Robert Winston, the author Bill Bryson and the Director of the Cheltenham Festival of Science, Kathy Sykes, to return to a more exciting and hands-on approach to school science. These moves are strongly supported by the learned societies such as the Institute of Biology, the Royal Society of Chemistry and the Institute of Physics as well as by CLEAPSS and its sister body in Scotland, SSERC. It is not without significance that of an annual 6500 calls from schools to the

[1] *The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations.*

CLEAPSS science ***Helpline***, about 65-70% are related to health and safety. Of the 30-40 calls per day during term time, typically about 15% are queries about perceived or possible bans. In practice, about 95% of these are unjustified concerns, most of which turn out to be misunderstandings by staff. This experience is mirrored in Scotland by SSERC. At least these callers have sought advice, although it is not known what effect this has on the actual activities undertaken in the classroom. Neither is it known how many other activities are simply not pursued because the member of staff does not have the time to obtain such clarification.

3. Methodology

Information was mainly collected through a questionnaire, which had been trialled with a small sample of schools and others and amended in the light of comments. The questions were partly related to organisational aspects of health and safety in science but mainly were concerned with materials which might be used by schools, or practical activities they might undertake. Originally almost 100 activities or chemicals had been identified by CLEAPSS staff and through an analysis of ***Helpline*** records as being plausibly banned. These were whittled down to 50 items for the trial questionnaires and, following discussions with both SSERC and the RSC, a final list of 40 items was used in the full survey. Of these about 14 could be broadly classified as relating to biology, 15 to chemistry and 11 to physics, although some (such as the use of mercury thermometers) are relevant to all the sciences. These questionnaires were sent by CLEAPSS to a sample of 1249 secondary schools of all types, in all its member education authorities in England, Wales, Northern Ireland and the offshore islands. This is just over one quarter of all secondary schools in the country. Whilst every education authority was included, not all of the questionnaires went to education authority schools, some being sent to independent schools. The sample included a reasonable balance between different sizes of school, different types of school and the presence or otherwise of a sixth form. In addition, parallel questionnaires, also trialled, were sent to a total of 634 education authority officers including science advisers / inspectors and health & safety advisers in all the education authorities. Similar questionnaires were sent by SSERC to a sample of 447 Scottish secondary schools but not to Scottish education officers. Copies of the final questionnaires are shown in *Appendices 1* and *2*. Questionnaires were not, however, sent to post-16 colleges as the focus of the investigation was on the period of compulsory schooling, where the problems were thought to be greatest.

In addition, discussions were held with a few school staff and education authority officers to clarify points arising from the questionnaires. The Royal Society of Chemistry, CLEAPSS and SSERC are extremely grateful to all those in schools and local education authorities who took the time to complete the form despite being extremely busy.

Returns were received from 299 schools in England, Wales, Northern Ireland and the islands, representing a return rate of just under 25%. There was a similar response rate from Scottish schools (just over 24%). Although it was not possible to ensure that the returns retained the appropriate balance of school types and sizes, analysis shows that there was a reasonable representation of most kinds of schools. The questionnaire returns were entered into a database. Results for most of the questions posed to schools regarding perceived bans were analysed by type of school, school size, whether or not the school had a sixth form and whether replies came from teachers or technicians. Almost 52% of the school questionnaires were completed by teachers and a further 44% by (senior) technicians. Because Scottish practice is slightly different to that in the rest of the UK, returns from Scottish schools have been analysed separately as well as within the complete sample.

Returns were received from 66 education authority officers, a return of just over 10%. Almost 61% of education authority returns were from science advisers, inspectors or consultants and a further 33% by safety advisers or managers. Where more than one officer from the same authority responded, results were compared. Similarly, where officers and schools from the same education authority responded, results about actual bans and perceptions about bans were compared.

The outcomes of these analyses are discussed in the main findings and detailed figures are given in the *Appendices*.

4. Responsibilities of employers and employees under the *Health and Safety at Work Act*

Under the *Health and Safety at Work Act,* there is a legal obligation on employees to cooperate with their employer on health and safety matters. This means that, if an employer has banned a particular

chemical or procedure, it is just as effectively banned for staff in that employer's schools as if there is national legislation making restrictions.

In England and Wales, education authorities are the employers in community and voluntary controlled schools. However, the governing body is the employer in foundation and voluntary aided schools. This distinction does not exist in Scotland – all maintained (ie, state) schools have the education authority as the employer. In Northern Ireland, the Education and Library Boards act as the employer for controlled schools, the Catholic Council of Maintained Schools for maintained schools and the Board of Governors in voluntary grammar schools and integrated colleges.

For independent schools, the employer may be the governing body, the proprietor or a charitable trust.

5. National and local bans

5.1 The general situation

Despite many misconceptions, there are very few science activities and chemicals which schools might consider using which are actually banned at a national level. The major ones are:

- benzene which is banned for all purposes except in motor fuels, scientific research and industrial processes (*COSHH Regulations* 2002, Schedule 2);
- any mixture or solution containing more than 0.1% benzene (thus including genuine crude oil) (*COSHH Regulations* 2002, Schedule 2);
- ozone-depleters (for use in diffusive purposes), the most likely to have been met in schools being tetrachloromethane and 1,1,1-trichloroethane (*COSHH Regulations* 2002, Schedule 2);

There are some materials which schools might have used in the past which would now be extremely difficult to obtain and/or may be very expensive. An example is white phosphorus which a few schools may still possess and use for demonstrations. It is not banned.

Of course, many other chemicals present significant hazards and a risk assessment must be undertaken and the significant findings then implemented. Often there may be safer alternatives which achieve the same educational effect. Some activities are suitable only for a teacher demonstration, others only for use by older pupils.

There are, in addition to the explicit bans above, a number of restrictions to certain, mainly biological, activities.

The main ones are as follows.

- Dissection of bovine eyes is only permissible if the animal from which the eyeballs came was 6 months old or younger when slaughtered (*Specified Risk Materials Regulations* 1997, amended 2000).
- Dissection of sheep and goats eyes is only permissible if the animal from which the eyeballs came was 12 months old or younger when slaughtered (*Specified Risk Materials Regulations* 1997, amended 2000).

Schools often find it difficult to obtain eyeballs which satisfy the above conditions but may have more success in finding suitable eyes from species not covered by these regulations at all.

Other restrictions include:

- maintained schools (ie all those other than independent schools) may hold a maximum of 100 g of uranium salts (*Administrative Memorandum 1/92*);
- maintained schools may not hold thorium compounds other than in thoron generators (*Administrative Memorandum 1/92*);
- schools are not allowed to make in excess of 100 g (until recently no more than 4 oz) of explosive materials (*Manufacture and Storage of Explosive Substances Regulations 2005*);
- no experiments involving cruelty to vertebrates are permitted in schools *(Protection of Animals Act* 1911);
- protected species must not be removed from the wild (*Wildlife and Countryside Act* 1981, amended 1998).

One can sympathise with busy schools trying to keep up to date with the complexities of some of this information. The best advice is to check CLEAPSS and SSERC bulletins regularly and to seek advice from these organisations. The Royal Society of Chemistry has a list on its website http://www.chemsoc.org/networks/learnnet/cldemo.htm of banned chemicals and those not

recommended for use in schools. This is taken from the 1996 DfES publication *Safety in School Science*.

In addition to these national bans, some education authorities may direct teachers not to use other chemicals or procedures at all and such directives must be followed just as stringently by schools for which they are the employer (mainly community and voluntary controlled schools) as national bans. Some education authorities prefer to use the terms “discouraged” or “not advised” rather than banned. In some of these instances specific additional precautions may be recommended (eg, in the power lines demonstrations) or alternatives suggested (eg, alternatives to the use of peanuts in situations where pupils are known to have nut allergy).

Where governing bodies are the employers, as in foundation, voluntary aided and independent schools, they also have the power to ban chemicals and activities which they believe to be too dangerous, in addition to any items nationally banned as noted above. There is little evidence that any have done so, although in practice the governing bodies of foundation and voluntary aided schools often follow the recommendations of the education authority, even although not required to do so.

Northern Ireland regulations tend to be broadly in line with those in England and Wales, although there is at present effectively a ban on taking cheek cells, saliva and blood samples. Where offshore islands have published health and safety guidance for school science, this tends to be in line with that in England and Wales. Whilst Regulations in Scotland are the same as those in England and Wales, SSERC has made recommendations that certain materials are unsuitable for use in schools. Because significant numbers of Scottish schools have responded to the questionnaire compared to schools in Wales and Northern Ireland, separate comments are made where significant differences have been shown in the analyses of data collected.

5.2 Specific situation about items used in the questionnaires

The following table lists the items which schools and local authority officers were asked about in the questionnaires. It also summarises briefly the position about national bans on these items.

Q1	*Keeping small mammals*	No national ban but must be no cruelty to vertebrates. Risk assessment needed.
Q2	*Keeping giant African land snails*	No national ban. Risk assessment needed.
Q3	*Inflating a sheep's lung (eg, with bellows)*	No national ban. Risk assessment needed.
Q4	*Using a choice chamber with woodlice*	No national ban.
Q5	*Bringing spawn of the common frog from a pond into school*	No national ban on the common frog. Risk assessment needed.
Q6	*Dissection of eyeballs*	No national ban on most species but bovine eyes must be from animals slaughtered at less than 6 months, sheep and goats less than 12 months. Risk assessment needed.
Q7	*Dissection of hearts*	No national ban. Risk assessment needed.
Q8	*Dissection of rats*	No national ban. Risk assessment needed.
Q9	*Pupils taking samples of their own cheek cells*	No national ban (except in Northern Ireland). Was strongly discouraged by DES in 1980s, but later modified. Risk assessment needed.
Q10	*Pupils using their own saliva in experiments*	No national ban (except in Northern Ireland). Risk assessment needed.
Q11	*Pupils taking samples of their own blood*	No national ban (except in Northern Ireland). Was very strongly discouraged by DES in 1980s, but later modified. Risk assessment needed.
Q12	*Incubating "finger dabs" on agar plates*	No national ban. Risk assessment needed.
Q13	*Burning peanuts in experiments*	No national ban but allergy is a common problem. Risk assessment needed.
Q14	*Using spirometers*	No national ban. Risk assessment needed.
Q15	*Exploding cans of custard powder, icing sugar, lycopodium powder or similar*	No national ban. Risk assessment needed.
Q16	*Exploding cans containing methane / air mixtures*	No national ban. Risk assessment needed.
Q17	*Demonstrating explosions of hydrogen / oxygen mixtures*	No national ban. Risk assessment needed.
Q18	*Reducing heated copper(II) oxide with hydrogen*	No national ban. Risk assessment needed.
Q19	*Dropping potassium into water*	No national ban. Risk assessment needed.
Q20	*Heating iron/sulfur mixtures*	No national ban. Risk assessment needed.

Q21	*Demonstrating the thermite reaction*	No national ban. Risk assessment needed.
Q22	*Use of benzene*	Banned under the COSHH (Amendment) Regulations.
Q23	*Demonstrating the iodine/aluminium reaction*	No national ban. Risk assessment needed.
Q24	*Using a blowpipe in lead oxide/charcoal reductions*	No national ban but to be avoided if pregnant or nursing females present. Risk assessment needed.
Q25	*Using bromine in diffusion demonstrations*	No national ban. Risk assessment needed.
Q26	*Demonstrating ammonium dichromate volcano*	No national ban. Risk assessment needed.
Q27	*Use of genuine crude oil*	Banned under the COSHH (Amendment) Regulations as it contains more than 0.1% benzene.
Q28	*Use of naphthalene (moth balls)*	No national ban. Risk assessment needed.
Q29	*Demonstrating reaction between propane-1,2,3-triol (glycerine) & pot-assium manganate(VII) (permanganate)*	No national ban. Risk assessment needed.
Q30	*Use of mercury thermometers*	No national ban. Risk assessment needed.
Q31	*Use of model steam engines*	No national ban. Risk assessment needed.
Q32	*Use of air rifles in momentum demonstrations*	No national ban. Risk assessment needed.
Q33	*Use of starting pistol in speed of sound experiments*	No national ban. Risk assessment needed.
Q34	*Making pupils' hair stand on end with van de Graaff generators*	No national ban. Risk assessment needed.
Q35	*Use of stroboscopes*	No national ban. Risk assessment needed.
Q36	*Showing magnetic fields with iron filings*	No national ban. Risk assessment needed.
Q37	*Use of EHT equipment up to 5000 volts at less than 5 mA*	No national ban. Risk assessment needed.
Q38	*Demonstrating the power line at mains voltage on the transmission line*	No national ban. Risk assessment needed. HSE has advised against certain types of apparatus.
Q39	*Demonstrations using sealed radioactive sources*	No national ban. Risk assessment needed.
Q40	*Demonstrations using protactinium generators*	No national ban. Risk assessment needed.

6. Overall findings from education authorities

6.1 Responses from education authorities (not Scotland)

There were 66 returns from 60 English and Welsh authorities. This represents just over one third of all local authorities circulated. (No questionnaires were sent to Scottish education authorities.) Of the returns, 60.6% were from science advisers (or inspectors or consultants), 33.3% from health and safety advisers or managers and 6.1% from officers with other titles.

60.6% of officers replying indicated that they did not ban any chemicals or activities although many amplified this by saying that they strictly followed CLEAPSS guidance. It is probably reasonable to assume that education authorities which said they did not ban anything actually meant they had not restricted the use of anything other than that which was banned nationally, although most did not make this clear. 33.3% of respondents said they **did** have bans in place, while a further 6.1% claimed not to know. In one of these instances (where there had been no science adviser for some years), receipt of the questionnaire had stimulated the authority to consult CLEAPSS about what advice they should give to schools with respect to health and safety in science.

Of the 33.3% who responded that they **did** have bans in place, all drew on CLEAPSS as their major source of guidance, just over two thirds used the DfES (or its equivalent), one half the HSE (or its equivalent) and one half local officer guidance. Over two thirds said that they implemented bans as a result of agreement between the science adviser etc and the health & safety adviser. It should be noted that not all authorities have a science adviser with responsibility for the whole period of statutory schooling.

Communication about bans and other safety matters is still mainly by newsletter (paper or electronic), though only half of the authorities with bans used training courses as a means of advising on health and safety matters. Over one half claim to include this information in an authority health and safety policy.

Any officer who indicated that his/her authority did not have any bans for school science was not required to complete the detailed section in the questionnaire relating to specific activities and materials. It is likely that these officers were assuming that any material banned nationally should not be included in their response since overall only 14 respondents (23%) correctly claimed that benzene was banned nationally in schools and 13 (21.3%) that genuine crude oil was similarly banned. If it is assumed that all those who said that they did not have any bans in place would have included items nationally banned, these figures would rise to 54 (almost 89%) and 53 (over 87%) respectively.

5 respondents overall (7.8% of the total sample) believed that pupils taking samples of their own blood was banned nationally and a further 3 (4.7%) had introduced local bans with respect to practical investigations of blood. Again, this only reflects responses from those education authority officers who indicated that they did have bans.

Other national bans **believed to be in place** by at least one authority included keeping giant African land snails, dissection of any eyeballs, burning peanuts, reducing lead oxide with charcoal, using naphthalene, reacting glycerine with potassium permanganate, using air rifles or starting pistols in physics experiments, power line demonstrations and using protactinium generators. Some of these were also identified as being subject to local bans, though some authorities were at pains to point out that they only use the term “ban” for nationally-banned materials or activities, preferring to use the term “discouraged” or “not recommended”.

In addition, use of almost all of the chemicals and activities included in the survey were, at the very least, discouraged by between one and seven authorities even though the vast majority were not banned nationally.

A few authorities identified materials or activities not included in the questionnaire which they had banned. These included making nitrogen tri-iodide and using ethanamide, mercury(II) oxide, chloral hydrate and car batteries. Other education authority bans are also known from regular communication with science advisers and health & safety officers in authorities which did not respond to this questionnaire. Reasons for some of these additional bans are not always apparent to schools and, indeed, to the authors of this report.

In only six instances were replies received from two officers in the same education authority so that comparisons of their responses are not statistically significant. The comparisons are nonetheless interesting. In three of these authorities, both the science adviser and the safety adviser agreed that they had no bans. In a fourth authority the health & environment officer indicated no bans while the science adviser banned use of crude oil. In a fifth authority, both officers agree that they have bans but their responses did not agree which chemicals and activities are banned. Interestingly they claimed that bans

are reached by mutual agreement. In the sixth authority there was disagreement about whether the authority had bans or not, though both respondents stated that communications to schools about such matters are mutually agreed.

It is difficult to draw any firm conclusion from such a relatively small sample, also bearing in mind that officers are usually under severe time pressure. It is also difficult to extrapolate the picture emerging to the remaining two thirds of local authorities which did not reply to the questionnaire. However, it seems that about two thirds of education authorities do not ban anything other than that which is banned by national legislation. The remaining one third tend to ban only a very few things but for reasons not entirely clear. There seems to be much confusion.

6.2 Responses from education authorities and schools in their areas (not Scotland)

There were more education authorities represented in the schools' returns (130) than from the authority responses themselves (60). This excludes independent schools. A few education authority officers sent returns where none were received from any of their schools. However, a significant number of schools replied where no response had been received from the education authority. This has made interpretation of the overall implications less easy. Nevertheless, in 45 cases, replies were received from both education officers and one or more schools within the same local authority. Comparisons were made between their replies.

Three quarters of these education authorities said that they had no bans. The vast majority of schools in these authorities correctly identified benzene and crude oil as being banned. However, a similarly large majority of these schools also identified incorrectly a list of two to three activities (and sometimes as many as thirteen) other chemicals or activities which they believed to be banned locally or in some cases nationally. In the vast majority of cases, schools were able to offer no documentary evidence for these perceived bans. Indeed, even when evidence was offered it was often old, sometimes dating back twenty years, and had usually been superceded. In other cases, more careful reading of the evidence would have shown that the material or activity was not actually banned but simply needed precautions during use.

Where local authorities **had** introduced identified bans, schools' returns often did not exactly match the authority bans; most commonly schools identified additional materials, chemicals or activities which they perceived to have been banned.

7. Overall findings from schools

The questionnaire asked respondents to tick a box for each experiment corresponding to the following options:

- **A** I know that this is banned & enclose documentary evidence
- **B** I believe this is banned but do not have documentary evidence
- **C** This is not banned but is discouraged & documentary evidence is enclosed
- **D** This is not banned but I believe it to be unsafe to carry out
- **E** This is not banned but we don't do it because we don't think it is safe with our pupils
- **F** This is not banned but we don't do it because we don't have / can't afford the resources
- **G** This is not banned but we don't do it because we don't have the expertise
- **H** This is not banned but we don't do it because it is not relevant to our courses / don't have time
- **I** We do this sometimes, with appropriate safety precautions

Responses from schools have been analysed under a number of headings, eg, type of school, category of response A to I. Responses from Scotland are included in the overall results but in addition separately from the rest of the UK as there were some significant differences. The relatively small numbers of returns from Wales and Northern Ireland did not justify separate analysis for these parts of the UK. Not every school responded to every question. In order to achieve consistency of approach, the analysis has been based on the percentage of schools responding to each question rather than on the percentage of questionnaires returned. However, whichever system of analysis is used, the main trends remain broadly the same.

7.1 Overall picture, all UK schools

Almost all schools believed correctly that benzene (94.4%) and genuine crude oil (82.2%) were the subject of national bans in schools. Of these under one half (48.7% for benzene and 36.9% for crude oil) could produce documentary evidence for such a ban. A smaller percentage of schools in Scotland

(32.4% for benzene and 14.4% for crude oil) could produce documentation in support of the bans than in the rest of the UK (54.6% for benzene and 45.0% for crude oil).

Despite these figures a small number of schools (0.5%) claimed to still use benzene and a slightly larger number (5.9%) to use crude oil. It is possible that in the latter case there may have been a misunderstanding since it is legal to use a crude oil substitute (CLEAPSS and SSERC having offered guidance) and respondents may not have realised it was a substitute.

Under a quarter of schools overall believe there is a national ban on the use of animal eyeballs in dissection (23.8% overall). Of these only 3.5% were able to provide documentary evidence for a ban. Figures for Scotland were significantly higher with 61% believing that there is a ban though only 6.0% were able to produce evidence. Few schools distinguished between use of eyeballs from different animal species in their returns yet 52.4% claim to still carry out such dissections though this figure is much lower for Scottish schools (17.0%). It is again uncertain whether this lack of detail from schools arises from lack of time to complete the questionnaire.

Beyond these chemicals or activities there are clearly a number of misconceptions about what is banned nationally or locally. For example a majority of schools (70.2%) believe that it is illegal for pupils to sample their own blood and only 2.6% claim to still allow this activity. Only 15.1% could produce evidence of such a ban and much of this did not make a ban explicit or was out of date. The education authority responses showed that only 12.7% banned the activity. In Scotland 93.3% of respondents believe this to be illegal and no schools reported that their pupils carried out such tests.

32.1% of schools thought that pupils using their own saliva samples was illegal though under two percent could produce any evidence for this. One (less than 2%) of the responding education authorities actually banned this activity though several said they discouraged it. 26.0% of schools still carry out such activities. In Scotland, 56.8% of schools believe the use of saliva to be banned and 5.8% claim to have documentary evidence. Nevertheless 21.1% of schools still allow pupils to use their own saliva in experiments.

2.0% of schools overall could produce evidence that taking samples of cheek cells was banned and a further 18.0% believed this to be banned. The figures were higher for Scotland than in the rest of the UK (4.0% against 1.4% for evidence of a ban and 28.0% against 14.6% for undocumented belief). This figure is surprisingly high bearing in mind that cheek cells are explicitly mentioned in the QCA National Curriculum Programme of Study for Key Stage 3 for England.

Only rarely did more than one or two percent of schools claim to have documentary evidence of bans, national or local, for the other chemicals and scientific activities included in the questionnaire and even then it was sometimes not included, even though the questionnaire specifically asked for copies. However, significant percentages (of the order of 20%) believed that at least 15 other chemicals or activities in the questionnaire were also banned and this had a clear impact on the number of schools using the materials or activities. This list included keeping small mammals, keeping giant African land snails, inflating a sheep's lung, bringing frog spawn into school, dissecting rats, pupils taking samples of their own cheek cells, incubating finger dabs on agar, burning peanuts, lead oxide/charcoal reductions, the ammonium dichromate volcano demonstration, use of naphthalene, use of air rifles in momentum demonstrations, use of starting pistols in sound experiments, demonstrating power lines at mains voltages and demonstrating protactinium generators. In the vast majority of these cases figures for perceived bans in Scotland were much higher than in the rest of UK schools. This has resulted in a much lower percentage of schools actually carrying out experiments or demonstrations using these materials or activities in Scotland in particular.

In a few cases schools identified other reasons why they do not undertake certain activities, for example keeping small mammals, keeping giant African land snails or dissecting rats. These are most commonly based on what they describe as ethical reasons and it is clear that the proportions of schools actually undertaking such activities are low (respectively 17.6%, 14.1% and 28.3%). Yet the percentage of schools using woodlice in choice chambers remains high at 89.1%, as does inflation of sheep's lungs at 69.6%.

Some of the more exciting or interesting and relevant activities fortunately remain popular in schools. For example, 96.5% of schools still demonstrate the action of potassium and water, 95.7% still demonstrate the van de Graaff generator, 89.6% undertake dissection of hearts and 73.9% the thermite reaction. Most of the figures for take up of these experiments are lower in Scotland than in the rest of the UK.

Some schools indicating they had evidence for bans sent in photocopies of relevant documentation or made reference to CLEAPSS or SSERC publications. Most of these supported the school's claim but in some cases only gave a warning about precautions needed rather than banning the chemical or activity.

A higher percentage of schools, however, did not enclose any supporting documentation at all, so their responses have been taken on trust.

7.2 Schools with and without sixth forms

Schools with and without sixth forms have broadly similar understanding about which chemicals and activities they believe to be banned, with or without documentary evidence. There were only minor differences in the extent to which many of these are used or carried out in science lessons. However, in the limited number of instances where significant differences between the two groups do exist (mainly in chemistry and physics) it is predominantly, though not entirely, schools with sixth forms which were more adventurous. Examples include use of the spirometer (63.0% to 38.1%), methane/air explosions (54.2% to 41.1%), copper oxide/hydrogen reductions (31.9% to 16.0%), iodine/aluminium reactions (45.6% to 18.9%), use of mercury thermometers (79.9% to 54.0%), use of stroboscopes (67.3% to 40.8%) and use of EHT equipment (82.0% to 38.8%).

Some of this may reflect the better availability of equipment in schools with sixth forms. One might also speculate that there would be more specialist teachers available in schools with sixth forms although most schools insisted that lack of teacher expertise is not a problem (see paragraph 7.10).

7.3 Type of school

The responses have been analysed into three groups of schools with broadly similar characteristics:

- maintained schools under local authority control (ie, community & voluntary controlled schools in England and Wales, the equivalent in Northern Ireland and all state schools in Scotland);
- maintained schools, where the governors are the employer and thus have responsibility for health and safety (foundation & voluntary aided schools in England and Wales and the equivalent in Northern Ireland); and
- independent schools.

In general, independent schools were more able to justify those activities which have been banned nationally with documentation. The maintained schools under local authority control believed more items to be banned (without documentary proof) and this perception gradually reduces across the three groups, with the lowest percentage being the independent school group. This may reflect a difference between employers but this is unlikely considering that the majority of local authorities responding said they did not ban any activities (section 6.1).

It follows that, overall, independent schools believe that fewer chemicals and activities are banned than maintained schools.

The greatest variation was observed in the percentage of schools actually carrying out the specified activities. Here responses indicated that the highest level of take up was most commonly, though not always, in independent schools, followed almost always by the maintained schools where the governors are the employer and then the maintained schools under local authority control. The most extreme examples of this include use of EHT equipment (90.5%, 68.8%, 66.4%), dissection of rats (53.2%, 36.0%, 19.7%) and hydrogen/oxygen explosions (71.4%, 56.4%, 62.6%).

Again, some of this may reflect the better availability of equipment in independent schools. One might again speculate that independent schools would have more confident specialist teachers despite most schools insisting that lack of teacher expertise is not a problem (see paragraph 7.10).

7.4 School size

Returns were based on three broad classifications of school size: under 500, between 500 and 999 and more than 1000 pupils. There are some minor variations in the responses between schools in these three size categories but generally results tended to be similar. Smaller schools tended to believe more chemicals and activities to be banned and a higher proportion of larger schools tended to carry out the activities included in the list.

This may yet again reflect the better availability of equipment in larger schools and the likelihood that they will have more specialist teachers.

7.5 Responses from teachers and technicians

52% of the returns were from teachers and 44% from technicians. Broadly speaking the two groups showed similar responses to the number of substances and procedures they believed to be banned. Fairly consistently a slightly higher proportion of teachers than technicians identified materials and activities believed to be banned (often incorrectly). Examples include 24.4% of teachers who believed that dissection of rats was banned compared with 9.1% of technicians and 43.3% who thought that power line demonstrations were banned compared to 26.1% of technicians. A higher percentage of

technicians than teachers were able to produce documentation to support bans on crude oil and benzene. These differences may reflect the fact that many more technicians than teachers (about four times as many last year) attend CLEAPSS courses. Similarly, about 3.5 times as many technicians as teachers use the CLEAPSS ***Helpline*** and thus may be expected to be better informed.

Scottish teachers consistently identified a higher proportion than English teachers of chemicals and activities as being banned. For example 31.0% thought that the ammonium dichromate volcano was banned compared with 12.4% and 29.9% thought protactinium generators were banned compared with 7.8%. A different distribution route resulted in relatively few technicians in Scotland being given the opportunity to respond and hence too few Scottish technicians replied to be able to make valid comparisons.

7.6 Activities discouraged but not banned

Very few of the activities in the list were identified in the returns as being discouraged though not banned with documentary evidence being produced despite this being the preferred definition by a number of education authorities. Percentages of schools responding to this prompt were all below 10%. The highest figures were recorded for pupils taking their own blood samples (6.9%), use of naphthalene (5.9%) and burning peanuts (4.5%). Results were similar for Scotland and the rest of the UK.

7.7 Activities not banned but believed unsafe

Although higher than the previous category, most of the responses to this prompt were lower than 5%, and even the highest (burning peanuts) was under 20%. Other examples above 5% were using saliva (9.3%), exploding cans of methane/air mixtures (12.3%), exploding hydrogen/oxygen mixtures (8.0%), reducing copper oxide with hydrogen (9.0%), lead oxide/charcoal reductions (9.3%), bromine diffusion (9.8%), use of air rifles (12.0%) and power line demonstrations (9.7%). Broadly-similar results were obtained across the UK.

7.8 Activities not banned but believed unsafe with the school's pupils

Fewer than 5% of schools in England and Wales identified concerns when using the majority of chemicals and activities which are not banned. This is interesting and, perhaps, unexpected given public perceptions about discipline in schools. Activities which were believed to be more significantly unsafe with the schools' pupils included use of pupils' own saliva (17.2%), pupils taking samples of their own blood (9.2%), burning peanuts (23.3%), use of naphthalene (8.0%) and use of mercury thermometers (14.5%).

Generally there were lower percentages of schools in Scotland exhibiting anxieties to the same extent as would be expected. Nevertheless a few concerns were identified, the main ones being burning peanuts (22.2%), reducing copper(II) oxide with hydrogen (11.0%), using bromine in diffusion experiments (12.5%), use of mercury thermometers (13.9%) and use of air rifles in momentum experiments (10.6%).

7.9 Activities not banned but limited by resources

Schools claimed that the use of most of the activities and materials in the list was not inhibited significantly by lack of funds with some notable exceptions. These included keeping mammals (15.8%), keeping giant African land snails (9.7%), using spirometers (20.5%), reducing copper (II) oxide with hydrogen (11.6%), use of air rifles (13.3%), use of starting pistols (25.4%) and use of protactinium generators (26.2%). Whilst this list may not be extensive, many other experiments were identified by between 4 and 10 percent of schools. It would be a great pity if lack of funding was the cause of reduction of any practical activity. The CLEAPSS report for the RSC in 2004 on *Laboratories, Resources and Budgets* drew attention to significant under-resourcing of many maintained school science departments and these data provide further evidence of the impact of this shortfall.

The responses for Scotland were similar although demonstrations of radioactive sources (25.8%) was added to the list.

7.10 Activities not banned but limited by expertise

Few schools across the United Kingdom believed that lack of expertise was a major inhibiting factor to activities undertaken, all responses being lower than 5%. However, this is difficult to reconcile with the fact that schools which were more adventurous tended to be the ones more likely to be well-staffed with competent specialists. Perhaps the more-disadvantaged schools do not realise just how disadvantaged they are.

7.11 Insufficient time or relevance

The results to this section are revealing with substantial percentages of schools excluding consideration of some of the more exciting, entertaining and often pertinent activities because they believe that they do not have time for them or that they are not relevant to their work. 43.4% of all schools expressed this view about keeping small mammals, 49.6% about keeping giant African land snails, 42.8% about tracking the development of frog spawn brought in to school, 10.6% dissecting eyeballs, 40.9% dissecting rats, 11.6% pupils using their own saliva in experiments and 15.7% using a spirometer.

An even longer list of negative responses was recorded for chemical activities such as exploding cans of custard powder (16.6%), exploding air/methane mixtures (18.1%), hydrogen/oxygen explosions (9.3%), reduction of copper(II) oxide with hydrogen (32.5%), demonstrations of iodine/aluminium reactions (36.1%), reduction of lead oxide with charcoal (27.5%), demonstrating diffusion using bromine (13.1%), demonstrating the ammonium dichromate volcano (21.1%), use of naphthalene (31.5%) and reactions between glycerine and potassium permanganate (32.1%). This is despite curricular requirements for pupils to learn about reactions between the elements, oxidation and reduction and so on.

Responses to the physics section showed similar high proportions of schools identifying shortage of time or relevance for some key activities including use of air rifles in momentum experiments (18.1%), starting pistols in sound experiments (24.9%), use of stroboscopes (16.5%), use of EHT equipment (12.3%), power line demonstrations (13.0%) and use of protactinium generators (22.7%).

Although there were a few differences in the returns from Scottish schools, results showed broadly the same kind of trends.

It is unclear whether the high number of activities in this category is caused by a perceived lack of time or by a genuine belief that some of these activities are not relevant. Nevertheless the responses raise some serious anxieties about effective use of teaching time or interpretation of curricular programmes of study and examination specifications and about the interest which the teaching will generate amongst the pupils. Some of the activities above would be highly pertinent either as demonstrations for lesson starters, for example in topics such as reaction rates, or as main activities in topics such as sound.

7.12 Scottish schools

As noted in paragraph 3, a separate analysis was carried out on the 109 replies received from Scottish schools since this was a substantial number in comparison to those received from other parts of the UK excluding England and there were significant differences. Comparisons are made in the preceding paragraphs but the main points are drawn out again below.

A high proportion was aware that benzene and genuine crude oil were banned, though only about a third of these said they had supporting documentation. Over half of the respondents thought that pupils could not take samples of their own blood, use their own saliva in experiments or dissect eyeballs. About a third or more also believed that small mammals could not be kept, sheep's lungs could not be inflated, frog spawn could not be brought into schools, pupils could not take their own finger dabs, lead oxide/charcoal reactions were not permitted, naphthalene was banned, air rifles could not be used, power line could not be demonstrated and protactinium generators were not allowed. These figures are generally higher than in the rest of the UK. Generally schools did not have substantiating documentation for these beliefs.

Despite this the responses to the survey indicated that some of the more interesting experiments are still carried out in a large majority of Scottish schools including exploding cans of custard powder (97.2%), using the van de Graaff generator (97.0%) and woodlice choice chamber experiments (94.0%).

Few activities were described as discouraged though not banned, mostly being under 10% as in the rest of the UK whilst those not banned but thought to be unsafe were also similar to the UK averages, mainly being under 5% with only a few exceptions.

Many activities were not thought to be inhibited by lack of resources, but those which were seen to be inhibited included keeping small mammals (17.8%), using spirometers (14.1%), using starting pistols in sound experiments (21.3%), using sealed radioactive sources (25.8%) and demonstrating protactinium generators (28.9%).

Lack of expertise was not thought to be an inhibiting factor. Criteria for the registration of teachers in Scotland result in there being specialist teachers of biology, chemistry and physics with degrees in those subjects, unlike many schools elsewhere in the UK.

As in the rest of the UK, substantial numbers of schools excluded some of the more exciting and entertaining activities because they did not feel they had time or believed them not to be pertinent to

their courses. Over one quarter of the activities or chemicals in the list were included by more than 25% and sometimes nearly 50% of the schools responding. Almost half of the listed activities were not undertaken by over 10% of the schools. It is not easy to understand this in relation to known syllabuses.

The current 32 Scottish local authorities inherited some of the more restrictive practices that were put in place by their regional predecessors. In recent years, SSERC has attempted to ease many of these restrictions. Clearly, much more is required to publicise this fact.

8. Conclusions

The main conclusions which can be drawn from this survey seem to be that the Royal Society of Chemistry's concerns are substantially justified. There are significant misunderstandings about the chemicals and scientific activities which are banned in secondary schools and some teaching is inhibited by unjustified concerns about health and safety.

The high response of almost 25% from schools gives confidence in the validity of the conclusions. Although the response from education authorities was not as high, at about 10%, this is still one third of education authorities approached and is a sound basis on which to draw at least tentative conclusions.

Schools seem to be well informed about the dangers arising from the few chemicals nationally banned such as benzene and genuine crude oil, and to a lesser extent about dissection of animal eyeballs. However, although schools seem to show proper concern for their pupils in experiments such as working out the energy available from peanuts, these concerns seem to extend to a much wider range of chemicals and scientific activities than is justified by national or local bans or indeed common sense. The net result is that significant numbers of schools are not undertaking a wide enough range of demonstrations or pupil activities which are potentially exciting and interesting. Despite this some potentially hazardous but exciting experiments, such as the reaction between potassium and water, are still being extensively carried out. Ethical reasons put forward by some schools for limiting activities such as the keeping of small mammals do not seem to be consistently extended to other creatures such as woodlice in choice chamber experiments.

Technicians have a better understanding of what is and is not banned than teachers. Schools with sixth forms seem to encourage a slightly wider use of the activities and chemicals explored in the survey. Independent schools, and to a slightly lesser extent maintained schools where governors are the employer, seem to be slightly more adventurous in their choice of activities, as are larger schools.

The lack of resources to enable schools to use some chemicals and approaches is a continuing matter of concern and needs to addressed. An equally worrying revelation is that schools do not feel they have time to undertake many of the activities included in the survey or that they do not see them as relevant to their courses.

Whilst some caution must be exercised in drawing too firm a conclusion about replies from education authorities given the response rate, they could do more to ensure that schools know what is both permissable and desirable to ensure stimulating and safe science lessons. However, with a few exceptions, there seems to be very little evidence to support the view that arbitrary decisions or over-reaction on the part of education authority officers is inhibiting good practical science.

There is already abundant advice available to schools from CLEAPSS and SSERC. It seems that much of it is ignored. The Royal Society of Chemistry produces many publications for teaching, documenting safe approaches to practical work. There is a need to improve the understanding of schools and employers about the balance between appropriate safety in science and exciting and stimulating science lessons. In particular it would be profitable for the above bodies to work, or to continue to work, with a variety of groups, including the ASE, who have an influence on what science is taught and how it is taught in secondary schools. For example, they could work with:

- schools to ensure that there is a better understanding of what is banned and what is not to enable them to teach exciting but safe science;
- education authorities and other employers to ensure that there is a more consistent understanding of what is banned and what is not, to enable them to support schools in teaching exciting but safe science;
- government officials to ensure that there is sufficient funding within education authorities and the school system to support provision of scientific expertise and health and safety knowledge to support all science teachers and not only those lucky enough to be able to attend courses;

- the Secondary National Strategy for School Improvement so that its consultants can convey appropriate messages to schools;
- science learning centres to ensure that the provision which they make to support teachers and school science departments reflects current safe practice whilst encouraging exciting teaching;
- government officials to influence the future direction and style of science teaching both through changes to the national curricula and through broad national examination requirements;
- examination boards to influence the expectations of teaching styles within the national requirements;
- initial teaching institutions and their partner schools to ensure that sufficient emphasis is given to teaching exciting science safely within the context of the limited number of national and local bans;
- the National Advisers and Inspectors Group for Science (NAIGS) so that its members may become the main vehicles for bringing about the above improvements.