

STS

Scope includes
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Technology
and Safety

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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:
John Richardson

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Mucking out the midden

More people are staying on at school and taking part in tertiary education. Workers by hand are seen as being of lower status than workers by mind. Manufacturing industries are vanishing. As a farmer's daughter I can barely stand to think about the state of agriculture. There are fewer time-served plumbers, plasterers and other tradesmen than there used to be. Most of them are over 40.

It is said that it is easier to get a home visit from a general practitioner than from an electrician. Problems arise because trades are not considered important enough to regulate effectively. An incompetent gas fitter can kill just as many people as an incompetent doctor. Serious rail accidents have been caused by maintenance failures. The rise of hospital-acquired infections seems to be proportional to the decrease in the number of cleaners.

The attitude starts at school. Primary school children hardly ever do any cookery, or simple science or basic carpentry because the schools either don't have the facilities or are too concerned about health and safety risks. But playgroup-age children can saw and nail bits of wood under supervision without incident. Scottish secondary school children have a few periods of home economics and technical subjects in first and second year. Some carry on to Standard Grade and Highers but the departments are not highly regarded. My youngest daughter is seriously concerned about the lack of respect she will be given for her Standard Grade craft and design. She and her classmates spent six months of physical and mental effort planning, designing and making complex and functional units from wood, metal and plastic. She made a lovely piece of furniture.

What happens after school? Not everyone goes on to university or college. The old style apprenticeship has vanished into the mists of time replaced by skillseekers, YOPs or whatever acronym is used for youth training today. Employers have to be bribed to take on trainees.

Even at university, arts subjects and pure science generally have higher status than applied science. It takes fewer Highers to get into an engineering course than to get in to study English or history. Why? Do we really need more English and history graduates? There are exceptions: medicine is an applied science but are the doctors who work in the hospital of so much more value than the civil engineers who built it? Is the dentist who uses the drill more important than the electrical engineer who designed it?

Is this all cost-driven? After all it's possible to teach English with a handful of cheap paperbacks. Practical subjects need specialised facilities and special teachers. But if we are to be served lattes by graduates isn't it better that they graduated from Costa College?

During the ICS's tourism debate in Cupar, we heard that visitors to Scotland are disappointed by the quality of service. In the USA and in continental Europe the chefs, waitpersons and cleaners seem to care more about pleasing the customer. Is that because they are nicer people, because they are paid more or because their society values their work?

My final example of the proposition is a particular hobbyhorse of mine. This is almost a joke but if I had spent 18 years in Cornton Vale having murdered four people there would be an army of

CONTINUED OVERLEAF

Diary dates

International Science Conference

The *Science Education 20:20* Conference is to be held in the International Conference Centre in Edinburgh from 5th - 7th March, 2003. Organised by the Scottish Executive, the Science Education 20:20 Conference will look forward to a world where teaching and the school curriculum will have radically changed. The event will raise the profile of science education, recognise the importance of public understanding of science and highlight concepts of risk management in science. This conference is an event for teachers, educationalists, scientists and, indeed, for anyone with a passion for science.

A number of internationally-renowned speakers are to address the conference, from astronauts to academics, including Sir James Black, Sir Kenneth Calman, Professor Richard Dawkins, Dr Bonnie Dunbar, Sir Gareth Roberts and others.

IoP Congress 2003

The 2003 Congress will be held at Heriot Watt University from the 23rd to the 27th of March. The education programme for Congress 2003 will be extensive and include 'School Physics in Action' each day from Monday to Wednesday and an INSET programme. The latter is likely to be a series of short one day events with the opportunity to visit the Physics in Action programme at the end of the day. Specific days are being planned for primary teachers, technicians and secondary teachers.

There will also be a series of workshops on topics such as: educational software

in the Scottish Curriculum and Science for the 21st century. There is also going to be a special NQT/PGCE student afternoon on Wednesday.

Institute of Biology Events

The Scottish Branch of the Institute of Biology has arranged a day course for biology teachers on *Protein Technology* on the 1st of February 2003 at the Quest Biotechnology Laboratory in Dollar Academy. Details from Peter Anderson (see Address List). The branch has also announced the date for the *8th Biology Teachers' Day*. That event will be held on Tuesday the 3rd of June and the venue, as usual, will be the University of Stirling. Further details, including of the programme, will be posted on our website as they become available.

Chemistry Teachers' Day

The National Scottish Meeting for Teachers of Chemistry organised by the Royal Society of Chemistry and St Andrew's University, supported by the Royal Society of Edinburgh, will again be held at St Andrew's University on 30th May 2003.

Summer schools

The residential Summer Schools in Biotechnology, Chemistry and Physics are to be run again at the University of Edinburgh in 2003. The dates have been set as 23rd to the 27th of June 2003. There are also developing possibilities for similar residential courses at other Scottish locations both for secondary science specialists and primary teachers. We'll do our best to keep you informed as soon as we have any more detail on these.

ASE Scotland - Annual Meeting

The 2003 annual conference and the Annual General Meeting of the Scottish Branch of the Association for Science Education will be held in Aberdeen on 7th - 9th March 2003. The Conference will be based at St Machar Academy and The Patio Hotel, Aberdeen. The *ASE Scotland Technician's Conference* will run as part of the Annual Conference over Friday 7th March and Saturday 8th March.

A wide range of talks, lectures, workshops, seminars and visits have been organised to support science courses from 5-14 to Advanced Higher. There will also be a wide range of exhibitions of books, publications, apparatus and other resources to teach science. A full programme for these ASE conferences and a booking form are inserted in this issue of the Bulletin.

PPP out-takes

PPP - as we all have come to know and love - stands for *Public and Private Partnerships*. In our recent experience, occasionally the final "P" might be better translated as "pear-shaped". Lately, we've begun collecting PPP anecdotes relevant to science education facilities. Some of these may well be apochryphal. We do hope so. Other stories carry the frightening ring of truth. Many are traced back to non-specialist architects in the private sector without any previous experience of school design. Thankfully, most such boobs are trapped out at the initial design stages. Our favourite to date has to be the ordinary, double, under-bench cupboard labelled:

"For fumes"

EDITORIAL: *Mucking out the midden* continued from Page 1.

professionals ready to help me re-integrate into society and the world of work. However, I stayed at home full-time for 18 years to bring up four people and what help was there? The black hole in my CV was a problem and my life experience didn't count.

Let me think - two toddlers, one toy - that's conflict resolution. Three children in different activities starting at 5 p.m. in places three miles apart - that's logistics and time management. I'm angry about how little value is given to childcare, arguably the most important practical skill of all. Why should stay-at-home parents be treated like second-class citizens?

But there is a strange dichotomy here. Given the number of cross stitch and needlework magazines, there must be thousands of people sewing as a hobby but with the closures of clothing manufacturers in the Borders and other areas there are very few sewing for a living. Practical skills are OK as a hobby but not as a job?

In other countries, engineers and technicians are respected, not the subject of jokes. "What is the difference between an engineer and a technician? A technician knows that you need to hit it to get it to work, an engineer knows where and how hard." Other countries? Fifty years ago they were respected here.

Catering staff, building trades, manufacturing workers - few of them get the respect or rewards they deserve. We need to re-examine our priorities and start looking at the value we attach to practical skills. Short-term cost saving should not be more important than long-term gains.

We have to recognise that practical skills are of value to us as individuals and as a society. After all, every utopia needs someone to muck out the midden.

This guest editorial was written by Ella Smith, parent and School Board member. The article was first published in *The Scottish Review*, Summer 2002. The *Scottish Review* is the journal of the Institute for Contemporary Scotland.

Health effects of low-level radiation

The mainstream view that risk falls roughly in a linear fashion with dose is under attack from some who maintain that there is a threshold below which radiation is harmless, or even beneficial, and from other groups asserting that very low doses are extraordinarily dangerous.

There is sound scientific evidence that a large dose of ionising radiation is dangerous, with a significant risk of the induction of cancer, or genetic damage in progeny, or, if the dose is massive, death in the short-term. Below moderately high levels of dose the evidence trails off. It is then a matter of conjecture as to what the risk of harm, if any at all, actually might be. Epidemiological studies show that risk falls with dose down to a value of about 200 mSv. Below that value it is unclear what the relationship is. The mainstream hypothesis is that risk continues to fall with dose in a linear or linear-quadratic way down to zero (Fig. 1). It is known as the Linear No-Threshold model (LNT). The model implies that all ionising radiation, no matter how small, is potentially harmful. Notwithstanding that, for pragmatic reasons it is customary for an extremely low dose to be regarded as negligible, trivial, or tolerable, provided that it is very much lower than a dose from background radiation (about 2.4 mSv a year on average).

There are many scientists who do not accept the LNT model. It is under attack from both sides. One group, with many representatives in the US, France and the Far East, hold that LNT greatly over-estimates the risk at low doses, pointing to evidence for a threshold effect below which radiation would be harmless. Some go further, taking evidence for adaptive responses to assert that low doses are beneficial because they stimulate natural

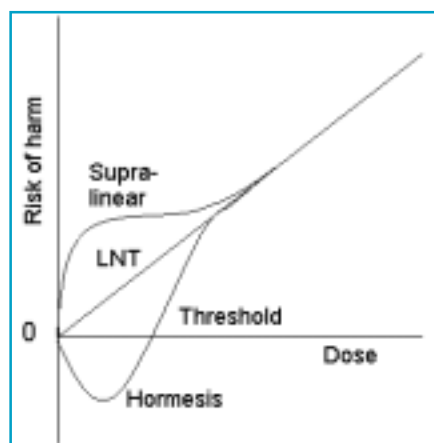


Figure 1 Models illustrating the dependence of risk upon radiation dose.

Table 1
Average annual dose from natural radiation sources (UNSCEAR 2000).

Radiation source	Average annual adult dose (μSv)
Cosmic rays	380
Cosmogenic radiation:	
¹⁴ C	12
²² Na	0.15
³ H	0.01
Primordial radionuclides (²³⁸ U, ²³² Th, ⁴⁰ K, etc):	
External exposure	480
Internal exposure excluding radon:	
⁴⁰ K	165
U and Th series, ingestion	110
²¹⁰ Po	70
²¹⁰ Pb	21
U and Th series, inhalation	5.8
Radon and progeny:	
²²² Rn indoors	1010
²²² Rn outdoors	95
²²⁰ Rn indoors	84
²²⁰ Rn outdoors	7

defence mechanisms in biological systems. This effect is known as radiation hormesis. Biological systems are known to show hormesis effects when under attack from other hostile agents. It is seemingly akin¹ to the theory that a glass of red wine a day is good for you though no one is yet advocating that we should pop a pill of Caesium-137 a day to glow with health.

Anti-nuclear groups stand on the other side of the dispute, maintaining that LNT grossly underestimates the risk to health from low doses. Many of their attacks are based on scepticism. Their questioning can be healthily provocative because it stimulates a considerable amount of scientific research and prevents complacency. However it can be unhealthy if it creates paranoia, or irrational fear, or if the protests themselves are irrational.

¹ A glass of red wine a day is not really a hormesis effect. Alcohol in any quantity is harmful: benefit from the daily glass comes from relaxation, and the action of the tannins in mopping up free radicals and sweeping them out of the system. A better example of hormesis is vaccination.

That sets the scene for the debate. As it proceeds, there is no meeting of minds between the disputatious parties. In reaction there has been much scientific endeavour on the health effects of radiation. From this, a lot is being learnt on how biological systems work and how disease is induced. In the rest of this report, we outline some of the research findings and discuss the implications for radiation protection.

Background

Background radiation sets a standard against which any discussion on low level radiation must be compared with. The annual dose to an adult is typically 2.4 mSv. At present, it is almost entirely from natural sources (Table 1); less than 1% is from man-made sources, mainly nuclear fallout from atmospheric weapons' tests. At the height of the testing programme, in 1962, the annual dose from fallout (Table 2) was 5% of the dose from natural sources – an experiment conducted on all biological species including the human race.

	Average annual dose (microsievert)	
	1962	1999
Northern Hemisphere	125	5.9
Southern Hemisphere	59	2.7

Table 2 Average annual dose from weapons testing (UNSCEAR 2000).

Radiation in medicine and industry

The average contribution from medical irradiation received by the UK public is 370 µSv per year, whereas that from the nuclear industry is about 2 µSv annually. The dose from medical treatment depends on the type of examination or radiotherapy (Table 3).

Under the National Health Service Breast Screening Programme, all women between the ages of 50 and 64 years of age are invited for mammographic screening every 3 years. A single image is taken of each breast, the average dose to breast tissue being either 2.0 mGy or 2.5 mGy per film depending on the aspect.

Examination	Typical effective dose (mSv)
<i>X-ray examinations:</i>	
Limbs and joints (except hip)	<0.01
Chest (single film)	0.02
Skull	0.7
Barium meal	3
Barium enema	7.35
CT head	2.3
CT abdomen	10
<i>Radionuclide studies:</i>	
Kidney (^{99m} Tc)	1
PET head (¹⁸ F)	5

Table 3 Effective dose for some radiological and radionuclide examinations (Griffiths, BNES).

Epidemiology

Epidemiology is the study of the distribution and causes of disease by looking at groups of humans exposed to the potential risk factors of interest. There are 4 basic types of epidemiological study (Table 4), given in order of strength from

weak to strong. With the exception of the ecologic study, measurement of exposure and disease takes place at the individual level. A weak study may not be able to determine correctly the cause because of confounders; a strong study will be less affected by random and systematic error.

The best known epidemiologic study is the cohort study with the survivors of the atomic bombings of Hiroshima and Nagasaki to find whether there is an association between radiation dose and increased risk of disease (cancer and cardiovascular). The main study looks at individuals who were within 2 km of the explosion hypocentres, matched by age and sex against those between 2 km and 10 km from the hypocentres. From bomb yield and questionnaires to ascertain the orientation and shielding, dose estimates have been obtained for 86,572 survivors. Information on possible confounders and effect modifiers has been obtained by questioning individuals, and the incidence of disease and mortality noted. The study is ongoing.

This gives the scale of a cohort-type of epidemiological study. There are other similar studies with cohort sizes of 50,000 or more on Sellafield workers, patients treated with what would now be considered to be massive X-ray doses in therapeutic medicine, and workers in the nuclear industry in the former Soviet Union.

Type of epidemiologic study	Conduct of study	Example
Ecologic study	Disease rates are correlated with exposure prevalence in a population defined by geography or time	Determining cancer incidence and mortality around nuclear sites
Case-control study	Exposure status of individuals with the disease is compared with the status with those who do not have the disease (the controls)	Case-control study of lung cancer amongst uranium processors
Cohort study	Follows up a group of individuals with varying exposures through time to monitor the occurrence of disease	Japanese a-bomb survivors' study
Experiment	(Seldom possible for ethical reasons)	Following up cancer patients participating in randomized trials of the use of radiotherapy in treating Hodgkin's disease

Table 4 Four types of epidemiologic study, in order from weakest to strongest, with examples.

By comparison with cohort studies, ecologic studies are seldom capable of yielding useful results because it is generally impossible to make valid inferences from the information they provide.

Cellular damage response

Health can be harmed by radiation from 3 types of biological damage:

- Cell death, in the sense that the cell becomes unable to reproduce.
- Mutation in germ cells, leading to defects in progeny.
- Malignancy in somatic cells, possibly leading to carcinogenesis.

Carcinogenesis is the most important harmful effect of low doses of radiation.

When radiation is absorbed in living things, the energy deposited is localized along the tracks of the moving charged particles, disrupting chemical bonds within large molecules, and so causing changes that are biologically significant.

If a photon is directly incident on DNA, the photon is absorbed by the medium resulting in a secondary fast electron which directly hits and breaks the DNA strand. DNA can be indirectly damaged if the fast electron hits a water molecule (tissue is mainly water) producing a hydroxyl radical. This free radical, with an

unpaired electron in its outer orbit, is highly reactive, chemically speaking, and diffuses to the DNA causing a strand break. Two thirds of DNA damage from photon irradiation comes from the indirect action, whereas most of the damage from alpha particles and neutrons comes from direct collisions and bystander effects.

Single strand breaks are of little consequence since the molecule is readily repaired using the opposite strand as a template. However if both strands directly opposite one another are broken, then the 2 broken chromosomes may rejoin in such a way that either the cell dies, or an aberration occurs. Cell death is not harmful if the dose is low because the cell death frequency will be low also.

Genomic instability

The genome is the source of genetic information in cells. It is encoded in the DNA molecules and is continually under challenge by destabilizing factors:

- Normal DNA replication and cell division
- Environmental stresses such as oxidation
- Exposure to genotoxic chemical agents
- Background radiation

To counter these attacks, cells have worked out elaborate ways for maintaining genomic integrity:

- To assure correct DNA replication
- To repair DNA damage
- To control the progression through the cell cycle

One positive outcome of genomic instability is that it can help genetic diversity. Negative outcomes are mutagenesis, which can change cell function or lead to death, and carcinogenesis.

Genomic instability is often associated with either the cell cycle going out of control, or the DNA repair processes being altered. The p53 tumour suppressor gene has a key part in how a cell responds to DNA damage. It works in cell cycle control, delaying the cycle to give the cell time to repair DNA damage before DNA replication or mitosis. It also helps to remove heavily damaged cells by apoptosis, the deliberate killing off of sick cells. However if the p53 gene is itself inactivated, perhaps by radiation damage, then these functions would not be performed.

There is now evidence of the role of instability in carcinogenesis. Most tumours show instability. They show up with multiple, unbalanced, chromosomal aberrations. It is believed that there needs to be 6 to 8 separate stages to convert a normal cell into one with a fully malignant phenotype. Under a simple model, if each mutation arises independently and at a frequency of 10^{-5} , it becomes highly improbable that a cancer could be induced in a human lifespan.

Bystander effect

Whilst it has been hitherto accepted that the main cause of heritable effects is a direct hit on DNA, there is evidence of a biological response occurring in cells which are not themselves directly irradiated. Technically, it is now possible to target a single cell, or a localized part of a cell such as the nucleus, with a microbeam of alpha radiation, irradiating the target with a set number of particles – even a single alpha particle – and recording the result. One outcome of this technique has been the demonstration of a bystander effect, i.e. some cells die or mutate that had not been targeted.

Furthermore it is possible to cause mutations in cells by alpha particles that traverse the cytoplasm, not the nucleus.

The bystander effect challenges the current model that direct damage to DNA is the only initiating event in triggering carcinogenesis. An inference from this model is that risk increases linearly with dose.

Experiments on irradiating cell cultures *in vitro* with microbeams show a saturating response above a threshold dose: in one experiment, saturation occurs after one alpha particle. Irradiation of either a single cell, or different cells, with up to 15 alpha particles do not produce additional damaged cells, suggesting that for very low doses, there is a non-linear response. This is a possible mechanism for hypersensitivity at very low doses.

It now seems that carcinogenesis by radiation is not down to one mutation occurring in a specific gene in a single cell, which then gains a selective growth advantage. Rather, radiation may induce a process of genomic instability in many cells in the irradiated tissue, boosting the rate at which multiple mutations would occur. Radiation could thus act at any stage in the development of a tumour. As we have said, there are 6 to 8 stages between the first and final instability. A radiation exposure during any of these

steps could facilitate an aberrant chromosome proceeding one further step towards making a fully malignant tumour.

Adaptive response

It is quite normal for biological systems to adapt in response to stress – a phenomenon which is also called hormesis. There is now evidence of an adaptive response in many biological systems after small doses of low LET radiation (beta, gamma, x-ray), but not with high LET radiation (alpha, neutrons). The resulting dose from low LET radiation tends to be reduced by between 1.5 and 2. The induction of DNA repair is believed to occur. However these processes do not universally happen. There is a dependence on dose rate. It has not been observed in cells from the pre-natal stage in animal development. Also hypersensitivity to radiation can sometimes be seen.

Summing up, it is doubtful if radiation protection should give credit to adaptive response to radiation.

Genetic risks

What is the additional risk of inducible genetic diseases in human populations exposed to ionising radiations, i.e. over and above that which occurs naturally as a result of spontaneous mutation? Answers are emerging from experiments on mice, human data on baseline frequencies of genetic diseases, population genetic theory and models, and some plausible assumptions. No statistically significant increases in adverse genetic effects of parental radiation exposures have been seen in a-bomb survivors in Japan. Geneticists now believe they can reconcile these findings with their present understanding of the genetic risks of exposure to ionising radiation.

There are 738,000 cases per 1,000,000 of genetic diseases in the human population (Table 5). In Mendelian diseases, the relationship between mutation and disease is simple and predictable. In multifactorial diseases (e.g. congenital heart defects, cleft lip, etc.) there are no simple patterns of inheritance, but these tend to run in families.

The incidence of mutant genes in the population tends to be stable, being balanced between the rates at which spontaneous mutants enter the gene pool in every generation and the rates at which they are eliminated by natural selection, i.e. through failure of survival or of reproduction. If there has been irradiation,

the balance is disturbed by the influx of induced mutations, but the prediction is that the population will eventually reach a new equilibrium between mutation and selection.

Radiation-induced mutation tends to differ in kind from spontaneous mutations. The former tend to be mainly random deletions in DNA causing loss of function; the latter include point mutations, DNA deletions and large multi-gene deletions, causing loss as well as gain of function. Most human disease-causing genes are not of the type produced by radiation. Radiation-induced genes tend not to recover in live births. If they did, they would show predominately as multi-system developmental abnormalities. These factors explain why radiation induced genetic disease has not been found in humans.

Summing up, the risk per Gy is only about 0.41 to 0.64% of the baseline risk of 738,000 per million live births, a very small proportion indeed.

LNT debate

The above report delineates the main areas of research into the effects of low level radiation on health. The findings are complex, confusing and sometimes contradictory. It is therefore possible for lobbyists from one side of the debate or another to cherry-pick a basketful of results and make seemingly convincing cases. For instance the radiation-hormesis camp have trumpeted an ecological epidemiological study into the incidence of cancer in US states showing the decrease of cancer mortality rates with increase in radon concentration. Ergo the linear-no-threshold model does not hold, they say. In another example, the Greens are using the finding that the incidence of cancer in communities living within 1 km of the Irish Sea is higher than average as evidence that a little radiation is bad for you. For the convenience of their arguments, ecological studies give plausible results when they suit the case the lobby groups are advocating, ignoring the fact that they are generally incapable of yielding sound scientific results.

One of the main props of the radiation hormesis group is adaptation. But there is evidence for and against adaptation. Even if adaptive effects help to ameliorate harm from low doses to the general population, there is a small group of hypersensitive individuals in need of protection.

A big issue with anti-nuclear lobbyists is the idea of hot-particles, that if radiation is inhaled or ingested it is unlikely to be

Disease class	Baseline frequency per 10 ⁶ live births	Risk per Gy per 10 ⁶ progeny
Mendelian	24,000	750 to 1,500
Chromosomal	4000	Subsumed above
Mulifactorial:		
Chronic	650,000	250 to 1.200
Congenital abnormalities	60,000	2000
Total	738,000	3000 to 4,700
Total risk per Gy expressed as per cent of baseline		0.41 to 0.64

Table 5 Estimates of genetic risks to the first generation progeny of a population sustaining continuing exposure to low-LET, low dose or chronic irradiation.

uniformly distributed, but could be concentrated in a single radioactive fragment, resulting in surrounding tissue getting a very high dose. So although the average whole-body dose would be very low, the localized dose would be very high, from which they infer that the risk of harm from cancer induction would be very high also, and certainly very much higher than the tiny whole-body dose would appear to indicate. However a recent review of many experiments into the risks from hot-particles failed to reveal the excess risk the anti-nuclear group believes is plausible.

Another argument from the Greens is that man-made radiation is bad, natural radiation is OK. Following this line: ²¹⁰Po and ⁴⁰K are tolerable, ¹³⁷Cs, ⁹⁰Sr and ²³⁹Pu are bad. Somehow humans have evolved to tolerate, by adaptation, radiation from natural radionuclides, but man-made ones

are especially insidious. Estimates have been made by Greens that the risk of harm from man-made radionuclides could be 500 times greater than the present protection system admits. However this does seem unlikely in view of the massive dose of man-made radionuclides the entire population has been receiving from fallout over 5 decades – an epidemiological experiment of worldwide scope.

The middle ground of the debate is occupied by the national and international scientific bodies charged with advising governments on setting radiation protection regulations. These include UNSCEAR¹ and ICRP². They hold the view that, taking aboard all of the evidence to

¹ UNSCEAR: United Nations Scientific Committee on Effects of Atomic Radiation.

² ICRP: International Commission on Radiological Protection.

Band of concern	Description	Level of dose
Band 6	Serious	>100 x normal
Band 5	High	>10 x normal
Band 4	Normal	1-10 mSv (Typical natural background)
Band 3	Low	>0.1 x normal
Band 2	Trivial	>0.01 x normal
Band 1	Negligible	<0.01 x normal

Table 6 ICRP proposals: Bands of concern about individual effective doses in a year.

date, the best position to adopt for the present is the linear no-threshold (LNT) model, that the risk of harm diminishes from the well understood values at moderate to high doses in a linear or linear-quadratic fashion to zero at zero dose, with no threshold effect. The principles of radiation protection which follow from the LNT model are:

- No one should be exposed to radiation unless there is a justifiable reason.
- The dose to the irradiated person shall be kept as low as reasonably achievable – the ALARA concept.

Recent proposals from ICRP classify radiation exposures by estimating how the risk compares with background radiation (Table 6). If the estimated dose is less than one hundredth the value of annual background radiation, then the dose would be classified as negligible, implying that no further effort should be expended in trying to reduce the risk any further. Under this proposal, any dose less than 10 μ Sv would be negligible. The typical dose to the demonstrator of a school experiment with either beta or gamma sources is about 100 nSv. With the best judgement we have today, the risk is negligible.

Acknowledgement

This report is drawn from papers read at the 4th International Conference of the British Nuclear Energy Society held at Oxford in September 2002 to debate the health risks of low-level radiation. Papers were by M Thorne, C Griffiths (Royal Hallamshire Hospital), G Howe (Columbia University), E Hall (Columbia University), J Little (Harvard School of Public Health), K Price (Gray Cancer Institute), C Streffer (University of Essen), M Charles (University of Birmingham), K Sankaranarayanan (Leiden University), R Clarke (ICRP), R J Preston (US Environmental Protection Agency), M Pollycove (University of California), C Busby (Green Audit) and N Gentner (UNSCEAR).

New HSE guidance

Electrical testing

The HSE have recently published two 4-page information sheets [1, 2] and a 14-page booklet [3] all on safety in electrical testing. They would be relevant to anyone working in or operating a technician repair centre, or in any school where electrical equipment was repaired or tested.

The scope of the information sheets covers the servicing and repair of, respectively, domestic appliances [1], and audio, TV and computer equipment [2]. For greater relevance to the school workshop or laboratory, the scope of the sheet on domestic appliances can be taken to mean electrical equipment.

When carrying out a risk assessment for electrical testing, the four questions to ask are:

- Can the work be done with the equipment dead?
- Is it really necessary to work at dangerous voltages or currents?
- Have suitable precautions been taken to avoid danger?
- Is the person doing the work competent for that type of work, or, if not, adequately supervised?

It is essential to set up a safe work area for testing where access is limited to what is strictly necessary. A safe work area would carry no risk of unauthorized entry. If such an area cannot be set up, then work at dangerous voltages or currents should not be undertaken. This may restrict the scope of electrical testing in schools, limiting it to technician service centres.

Other issues addressed include live working, use of temporary insulation, RCD

protection, test equipment specification, power supply earthing and legal requirements.

The booklet [3] covers the same scope, but in more detail. On the thorny issue of competence, we are told, "When setting up a testing area, it is important that people who are electrically unskilled or inexperienced are protected from electrical danger at all times"; and "someone's personal electrical competence should not be relied on as their main protective measure". As with the Good Book itself, these HSE leaflets provide much to reflect on.

References

1. *Safety in electrical testing: Servicing and repair of domestic appliances* Engineering Information Sheet EIS35 HSE Books 2002
2. *Safety in electrical testing: Servicing and repair of audio, TV and computer equipment* Engineering Information Sheet EIS36 HSE Books 2002
3. *Safety in electrical testing at work* General guidance INDG354 HSE Books 2002 ISBN 0 7176 2296 7

Metalworking fluids

Metalworking fluids are used to lubricate and cool metals during machining and to help carry away debris such as swarf and fine metal particles. They can also improve machining performance, prolong the life of the cutting tool and protect the surfaces of workpieces from corrosion.

So far as we understand, metalworking fluids are rarely used nowadays in Technical departments, although they may still be used with machine hacksaws or in turning large pieces of metal.

These fluids are harmful to the operator. They can enter the body by inhalation of

the mist, aerosol or vapour, through skin contact, through cuts and by ingestion. Health effects include skin disorders, respiratory illnesses and skin cancer. Also oil-soaked clothing and oily rags kept in overalls can cause cancer of the scrotum.

Addressing this hazard, the HSE have recently published a free leaflet for employees [1] and manual [2], which includes a set of 8 instruction sheets for employers to issue to staff. These 8 sheets describe what you need to know to control the hazard (storage, water-mix mixing methods, sump top-up procedures, sump cleaning and clearance, and spillages).

References

1. Working safely with metalworking fluids Guidance for employees INDG365 HSE Books 2002
2. Working safely with metalworking fluids Good practice manual HSG231 HSE Books 2002 ISBN 0 7176 2544 3 (£10.50)

Superwool 607 - Update

In our last issue (Bulletin 206) we reported on the hazards of thermal insulating ceramic wools, recommending that traditional wools should, for many applications be replaced with Superwool 607, a new material shown to be free of carcinogenic properties. When the article was written, it was unavailable from educational suppliers. We have now been informed that Superwool 607 can be purchased from Philip Harris Education:

Superwool 607, blanket,
600 x 300 x 25 mm (about 500 g),
Cat. no. C0H71636, £10

PIC and display

Messages can easily be produced on liquid crystal displays driven by PIC controllers.

Liquid crystal displays (LCDs) are within the ken of pupils, from the ubiquitous mobile phone to games' consoles or microwave ovens. There are two types of LCD display. In one, the picture is made up of a series of dots forming a graphical display; this type is used on mobile phones and some game consoles. The second uses words forming a text display, usually in the form of 2 to 4 lines of a set number of characters; it is mostly found in vending machines. The complicated circuit and cost have precluded their use with school project work, particularly those with a graphical display. Now thanks to the interest of schools in Basic Stamp and other PIC controllers a textual serial LCD (Fig. 1) is available at a reasonable price. This serial LCD is a 2 row, 16-character per line display offered as a modular package with all necessary circuitry and the option of a real time clock. The microcontroller on the module carries out the complex driving instructions letting pupils use simple BASIC commands to output messages from a variety of systems. These include PICAXE, Basic Stamp and PIC-Logicator. All of the following instructions were carried out using PICAXE-18.



Figure 1 Picture LCD showing date and time.

Programs

A simple BASIC program to send the message "welcome" to the LCD would need a command:

```
serout 7,N2400,("welcome")
```

or any other text message up to 16 characters per line. A more practical use could be to output the variable, temperature.

```
serout 7,N2400,("Temperature = °#temp)
```

Messages

A most useful aspect of the module is the ability to store up to 7 user-predefined messages, remembering that each message must only include 16 characters.



Figure 2 Picture LCD showing temperature with thermistor.

This ability to predefine a message greatly reduces the display text stored within the PIC or Stamp. They are stored, instead, within the LCD module. Messages 1,3,5,7 appear on the top line of the display and messages 2, 4 and 6 on the bottom line. Examples of the necessary commands are shown below:

```
init: pause 500
main: serout 7,N2400,(253,1,"Welcome to the") '
      show on top line
      pause 1000
      'time to write text
      serout 7,N2400,(253,2,"TTA Conference")
      'show on bottom line
      pause 1000
      end
```

The predefined message "Welcome to the TTA Conference" is now stored in the LCD module. To retrieve and display the message the following program could be used:

```
init: pause 500
show: serout 7,N2400,(254,1) 'clears LCD display
      pause 500
      serout 7,N2400,(1) 'show message 1
      pause 500
      serout 7,N2400,(2) 'show message 2
      pause 500
      goto show
```

If some form of switch (pressure pad or optical switch, etc.) were to be employed to start the display, the program would then read:

```
init: pause 500
main: serout 7,N2400,(254,1)
      pause 500
      if pin1 = 1 then show
```

```
show: serout 7,N2400,(1) 'show message 1
      pause 500
      serout 7,N2400,(2) 'show message 2
      pause 500
      goto show
```

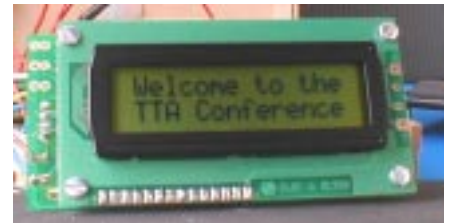


Figure 3 Picture LCD showing Welcome to the TTA Conference.

Presentation

The PICAXE project board and the LCD module were built into a spare plastic instrument housing. We decided on 4 pre-defined messages plus date and time. These account for the 5 push switches seen in Figure 4. The toggle switch allows the batteries to be switched off when the box is not in use. Figure 5 gives an idea of our internal layout.

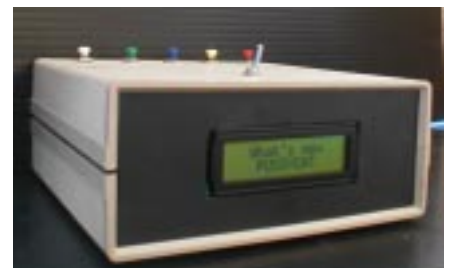


Figure 4 Box with PICAXE board and display.



Figure 5 PICAXE board inside box.

Alarm

A further useful addition to the module is an optional real time clock with an alarm facility. This enables pupils to display time on the LCD module or, using the alarm, to trigger outputs at periods between 10 seconds and a year. The lithium cell in the clock module should maintain accurate time for up to 10 years. To set the

alarm to a specific time interval, say the end of a school 40 minute period, the program would be:

```
init:  pause 500
main:  serout 7,N2400,(253,9,"00:40:00  ")
      'sets time 40 mins
      pause 1000
      end
```

Summary

Using only a few of the features available with a serial LCD and clock module pupils will be able to incorporate time and display into their work with PICAXE, Basic Stamp or PIC Logicator.

Further details on the LCD module can be found on www.rev-ed.co.uk

The Serial LCD & Clock module is supplied by Revolution Education Limited (stock no. AXE 033, price £12.00).

Bumping during the preparation of potassium trioxalatoferrate(III)

Some improvements are recommended to the method of preparing potassium trioxalatoferrate(III) (Advanced Higher Chemistry PPA, Unit 1, PPA 1)

"Then nightly sings the staring owl:

'Tu-who;

Tu-whit, Tu-who' - A merry note,

While greasy Joan doth keel the pot"

LOVE'S LABOURS LOST Shakespeare

We recently received a report of a problem regarding this PPA. This incident occurred during Step 4 of the Procedure, when bringing the aqueous solution and the yellow precipitate of iron(II) oxalate (ethanedioate) to the boil on a hotplate. It was reported that the solution sometimes erupted violently and ejected the contents some distance, and that this happened before reaching the boiling point. We have taken the opportunity here to highlight a second potential problem which can arise during the addition of hydrogen peroxide solution in Step 8.

We repeated the preparation several times and confirmed that the problem exists, but that it can be overcome. Hotplates are often difficult to control; they are fine for hard boiling and refluxing or for slow simmering, but unless you know the peculiarities of the particular hotplate, can be difficult to control at in-between rates of heating. The delay in response to any change of the heat setting, whether an increase or decrease, often catches out the uninitiated or the impatient. The surface temperature of a hotplate on a high setting is typically in excess of 300 °C and even water, if small in volume, will bump

on this. It is useful to roughly calibrate your hotplates by trial and error and mark the setting at which water just boils gently.

The following points relating to the procedure were identified:

Step 4 - When the beaker is placed on the hotplate adjusted to a low rate of heating as per instructions (setting 3 on our hotplate), then this Step can take a long time, - too long. It is possible to heat the solution faster (setting 5 on our hotplate), but then stirring **must** be continuous to prevent the solution from splattering, the best method being to use a magnetic stirrer hotplate. Hand stirring with a glass rod will do the job, but must be continuous.

Step 6 - Once you have decanted off the hot water, let the solution cool slightly before continuing. We found the temperature of the beaker at this point to be well above 40 °C.

Step 7 - Addition of the 10 cm³ of potassium oxalate (ethanedioate) solution cooled the beaker contents to a temperature of 35 °C. The solution was heated until it reached 40 °C and then removed from the hotplate.

Step 8 - The initial addition of the 20 volume hydrogen peroxide needs to be in amounts of less than 1 cm³ as the oxidation is highly exothermic and the temperature of the beaker contents can rise well above 40 °C. The reaction is very vigorous and the liquid can froth over. We would recommend cooling the beaker in a cold water bath during the hydrogen peroxide additions until more than half of the hydrogen peroxide (approximately 13 cm³) had been added. Thereafter the addition can probably be made more rapidly.

So the general advice on good practice in preparations is:

- to stir well and
- when adding reagents, to initially make small additions with efficient mixing and check that the reaction is occurring and that most of the portion just added has been used up before making the next addition.

"Make the gruel thick and slab;

Add thereto a tiger's cauldron,

For th'ingredience of our cauldron.

Double, double toil and trouble;

Fire burn, and cauldron bubble."

MACBETH Shakespeare

New chemical nomenclature!

Recently spotted on the wrapper of a bar of soap are two names based on yet another system;

"Sodium tallowate and sodium cocoate"

Here sodium cocoate (presumably either sodium dodecanoate or hexadecanoate or perhaps a mixture of the two) combines the new and the old; the IUPAC ending of "oate" has been grafted onto the cocoa palm tree, indicating the natural source of the substance. Would sodium rhubarbanoate or sodium sorrelanoate be alternatives to sodium ethanedioate or would sodium willowate tell us more about its origins than sodium 2-hydroxybenzenecarboxylic acid?

Anodising again

We've gone Naturalist!

Our resident chemistry guru has been having fun suggesting possible sources of dye. He supplied some red onion skin from onions grown in his allotment.

Never able to resist a challenge, we boiled the skins for an hour in distilled water till the water turned a muddy red brown colour, decanted the liquid into another beaker, popped in a piece of anodised aluminium (we just happened to have one

ready), and followed the method for dyes we told you about in Bulletin 205. The anodised aluminium turned out an antique gold colour (green/yellow/brown). Who says chemists and nature can't get along? Maybe the beetroots and the grass might work too!

Dye scarcity

Since publication of our article in Bulletin 205 we have experienced difficulty in obtaining the inks used. Pelikan are reducing their range and supplies are scarce. We've tried some others and have

obtained good results with them. Winsor and Newton's range of drawing inks are supplied in 14 ml bottles costing £1.99 each. Dilute 2 ml to 75 ml using distilled water and heat. We obtained good results with Vermilion, Ultramarine and Violet.

If you're trying the dyes - Dylon Multipurpose dyes work best. (Don't try cold water dyes because they don't work.) We used Dylon No 33 Kingfisher, Dylon No 15 Windsor Purple and Dylon No 34 Forest Green - all gave good results. These cost approximately £1.50 depending on where you get them.

Signals from a radio transmitter

If a single turn of wire short circuits the low impedance output of a power signal generator tuned to produce 100 kHz, or thereabouts, then it is possible to generate and transmit an RF signal.

Communicating by radio is one of the themes in Unit 1 of Standard Grade Physics. In one of the standard practical activities¹, a radio transmitter is set up in the classroom to broadcast a radio signal. The pupils monitor the signal by connecting a CRO to test points on the transmitter; an amplitude modulated waveform should be seen. However there is now no radio transmitter on the educational market. The sole product that used to be available (Irwin, EB0058) is now obsolete, leading to some schools being unable to perform this activity. We are grateful to Alex Marsh, of Unilab, for suggesting this method. It requires the apparatus listed in Table 1. Although the 2 signal generators recommended in the table became obsolete at the beginning of this year, they are both very common; other models may be substituted.

Procedure:

1. Set up a radio receiver about 2 to 3 m from where the RF oscillator is placed. Tune the radio receiver to a long wave broadcast programme, showing that the receiver works.
2. From bench tests in SSERC, the Unilab Power Signal Generator 062.101 is capable of delivering greater power than other types of generators. Therefore this is our preferred apparatus for producing the RF carrier signal. Set the frequency at near to 100 kHz and turn the gain to maximum. Apply the signal to the Y-input of the CRO.

¹ SG Physics: Unit 1: Activity 10: Signals from a radio transmitter.

Sub-system or function	Apparatus specification	Example of, or recommendation on, apparatus	Comment
Radio frequency (RF) oscillator	Power signal generator with amplitude modulation (AM) facility	Unilab Power Signal Generator 062.101	Frequency output = 100 kHz nominal. Amplitude modulation facility switched on. Gain = max.
Audio frequency (AF) oscillator	Power signal generator, preferably with dc offset	Harris S Range Power Signal Generator	Frequency output = 1 kHz nominal. DC offset = 0 mV. Gain = low. Apply output to AM input of RF oscillator.
Aerial	4 m wire formed into a single turn loop in a vertical plane		Connect wire across low impedance output of RF oscillator
Waveform monitor	CRO >10 MHz bandwidth		Use External Trigger. Trigger off signal from AF oscillator.
Radio receiver	Demonstration radio receiver kit	Unilab Alpha boards: Tuned Circuit 020 Radio Receiver 220 Power Amplifier 221 Ferrite core	Power off 5 V dc regulated supply
Loudspeaker	Loudspeaker, 4 to 16 ohm impedance		Connect across output with capacitive filter on Alpha Power Amplifier 223.221

Table 1 Apparatus for radio transmission and reception (using original Unilab product numbers).

- From bench tests at SSERC the Harris S Range Power Signal Generator is the preferred instrument for generating an audio signal because its output level can be shifted with a potentiometer. It is perhaps the only signal generator with this feature. In this demonstration ideally the audio signal should have no dc offset so as to correctly modulate the RF signal. Because we find that the output from most models of signal generator has a dc offset component, only the Harris signal generator can properly modulate signals. Set the frequency to 1 kHz and apply to the AM input on the Radio Frequency oscillator. Connect this 1 kHz signal also to the External Trigger input of a CRO to stabilize the composite waveform on the AF signal. Adjust the gain of the 1 kHz signal so that the signal from the 100 kHz oscillator is a maximum without distortion.
- Short out the low impedance output of the 100 kHz generator with a length of wire 4 m long. Arrange the wire to form a loop in a vertical plane such that a normal to the plane points at the radio receiver. We supported the wire with 2 wooden stools, one upturned on the other. Retune the receiver to detect the 1 kHz signal.

Cause	Effect
Sweep up the audio signal frequency from 1 to 10 kHz	The audible tone from the receiver corresponds to the AF oscillator
Sweep down the carrier wave frequency from 100 kHz to 50 kHz	The volume fades and strengthens, suggesting that the receiver has broadband reception and picks up overtones of the RF signal
Reduce the carrier wave amplitude	Radio receiver volume fades
Reduce the audio frequency amplitude	Radio receiver volume fades
Increase the audio frequency amplitude (beyond the original, optimal setting)	Radio receiver volume fades because the RF signal becomes distorted
Retune the receiver to a radio broadcast programme, then sweep through the audio signal frequencies	No signal is heard from the laboratory transmitter
Displace receiver 1 to 2 m away from the transmitter	Radio receiver volume fades
Rotate the plane of the transmitting aerial through 90°	Radio receiver volume fades
Twist the transmitting aerial into a figure of 8	Radio receiver volume fades
Replace the AF source with a microphone	Broadcasts speech

Table 2 Radio transmission demonstrations.

Demonstrations:

It is suggested that the effects shown opposite (Table 2) should be produced (in every instance starting from the original, optimal setting of the transmitted signal):

RF noise nuisance

Whilst modern electronic apparatus is designed so as to be relatively unaffected by electromagnetic disturbance from external sources, it is not immune from gross disturbances. Any laboratory RF transmitter could cause neighbouring computer and other IT and telecoms systems to crash, with the potential for major risk of harm to the health and

safety of others. The Wireless Telegraphy Act prohibits unlicensed radio transmissions. However an amendment to the Electromagnetic Compatibility Regulations allows education equipment to cause an electromagnetic disturbance provided that:

- it is used for the purposes of experimentation, learning or practical training; and
- it is used within a school classroom or laboratory.

Regarding EM disturbance caused by a laboratory source, we recommend the

following practice:

- If there is any safety critical system in the vicinity of the school laboratory, do not operate this RF transmitter without checking with the operator of the other equipment that your signal source is harmless.
- In consideration of others in the school, the laboratory RF transmitter should not be left switched on for a prolonged period. The signal strength transmitted is not great: at 3 m it is roughly equivalent to signal strengths from broadcast radio stations.

Laser equipment offer

Five laser diode modules and photometers from the Physics Department of Heriot Watt University are on offer for long-term loan to schools.

This equipment has been specially designed for schools by Heriot Watt University and is available, through SSERC, for extended loan. The first lending period will run from now until June 2004. Future periods will run for one session. Schools will be selected by ballot. To declare an

interest, contact the Centre by the end of January 2003.

The laser diodes are Class 2, emitting 640 nm radiation at a radiant power of about 0.4 mW. The diode temperature is controlled by a Peltier effect device and may be set to between 8 °C and 40 °C. The

operating current is also adjustable, allowing the threshold of lasing to be determined. Light intensity is measured with a large area photodiode. With lots of parameters to adjust and measure, there is ample scope for an Advanced Higher, or even Standard Grade, Investigation.

Portable radiation detectors

This trade review tells you what's on the market and the sorts of radiation hotspots to search for in your school environment. Are portable radiation detectors worth having? That's for you to judge.

If the intention is to measure the count rate from environmental sources, then the main natural sources are ^{238}U , ^{232}Th , ^{222}Rn , ^{210}Po , ^{210}Pb and ^{40}K . Generally you would be looking for a hotspot whose activity was less than background – a tall order with a primitive instrument and short sampling period.

- Probably your best, low activity, natural source would be a potassium salt such as KCl, or the common food additive, LoSalt. A teaspoonful of either can provide you with a count rate that is perceptibly greater than background.
- The concentration of radon varies considerably from place to place and time to time. It is generally lower outdoors than indoors. The concentration can be greater in a poorly ventilated basement than elsewhere in a building. The outdoor, ground level concentration can increase during the stillness of the night caused by the formation of a cold, dense blanket of air trapping radon near to the surface. This layer is destroyed by daytime breezes or winds because of the vertical mixing of the air these effects generate. Concentrations tend to increase with a fall in atmospheric pressure. Typically any of these effects can change the background count rate by a factor of between 0.7 and 3.
- Extracting air through a filter can build up a concentration of mainly Po-210 on the filter, causing the background count rate next to the filter to double.

Depending on the efficiency of the detector, a typical count rate from background radiation usually lies between 10 and 30 counts per minute. Thus a suitable range for a portable radiation detector to be used to hunt for environmental hotspots might be 0-100 counts per minute.

Of the instruments listed (Table 1), the Harris SensorMeter has been tested by us and is quite unsuitable for studies of very low activity sources because of its short counting periods (Bulletin 194). The three that would seem to be most suitable are the ones from Ascol, SEP and Vernier. None of the three has been tested by SSERC. The SEP Geiger Counter is a new

Supplier	Product name	Order code	Price	Notes
Ascol	Geiger Counter and Ratemeter	P73-1350	£267.52	Spec seems OK
Carolina	Geiger Counter	BA-75-9470	£293	Spec seems OK except that dose rate units are mR/hr
Frederiksen	Ratemeter, Analog	5135.55	£224	Rather insensitive Electrical output can be counted by a PASCO interface
Harris	Radioactive Count Rate SensorMeter	B5A00681	£180	Too insensitive for very low activity sources. See Bulletin 194
PASCO	Beta Gamma Nuclear Sensor	SN-7928	£230	Count detection is primitive when used as stand-alone instrument. Can be used with PASCO interface.
Scientific & Chemical	Ratemeter, Analogue	XAR 050 010	£225	Supplied by Frederiksen, as above
SEP (Middlesex University)	Geiger Counter	GEI 003	£128	Counts reset by hand, counting non-automatic. LCD display.
Unilab	Geigerteller	E5C51008	£282.20	Primitive indicator. Electrical output to dataloggers.
Vernier	Radiation Monitor	RM-BTD	£214	From photograph, this product resembles the one from Carolina. Stand-alone instrument, or can be used with Texas CBL2 datalogger, Vernier datalogger and probably dataloggers from DJB and PASCO.

Table 1 Trade review of portable radiation detectors.

production from the Government's Science Enhancement Programme (SEP). It is on sale through Middlesex University but currently SEP are offering some Counters free to schools. Since the SEP

Counter is switched by hand, it is able to detect very low-level radiation by letting it count for a very long period. It can therefore be used for environmental monitoring.

New ICT packages

Simple Data Handling

This new software from DJB Microtech has been produced for the 5-14 market to allow data to be presented in a variety of formats, namely: pie chart, bar chart, line graph or histogram. Having selected the format, the pictorial presentation appears and builds up as data is keyed in.

The features are minimalist, befitting the intended age-range. It produces simple charts and graphs in brilliant colours, but doesn't provide any analytical tools, because that is seen as being an unwanted complication. Tables and charts can be copied and pasted to other packages. Data can be saved either as an *SDH* or *Alba* file; the latter route allowing data to be analysed with *Alba* software. Alternatively, *Alba* files can be transferred to *SDH* - for instance, to utilize the histogram facility (Fig. 1). The program runs on Windows 98 or above, costs £35 for a single user, or £100 for a site licence.

LogIT products

Explorer Controller

The *Explorer Controller* set (curricular relevance: 5-14) is a new accessory for the *LogIT Explorer* providing computer control of motors, lamps etc. The controller plugs into an *Explorer* with a jack lead. Simple sequential or feedback control can be achieved using the standard *LogIT Lab* or *Insight* software, which is supplied with the *Explorer*. The controller board is battery powered and can operate 3 V to 4.5 V devices. The set includes a motor, fan blade, bulb, bulb holder, buzzer and a pair of crocodile clip leads. Also included is a guide with suggestions for several investigations. The set costs £49.99 (DCP reference number D 105150).

DataLogging Insight 4

Logotron have released Version 4 in the *Insight* software family. New features include comprehensive formula and maths modelling facilities, and *Insight Laboratory*. This has interactive tutorials with photographs of the equipment, step-by-step instructions and other enhancements such as multiple tiled windows and automatic sampling rates.

- Available for Windows 98 or above, single user software costs £85 with 5-100 user licences also available (single user pack DCP reference number D100550).

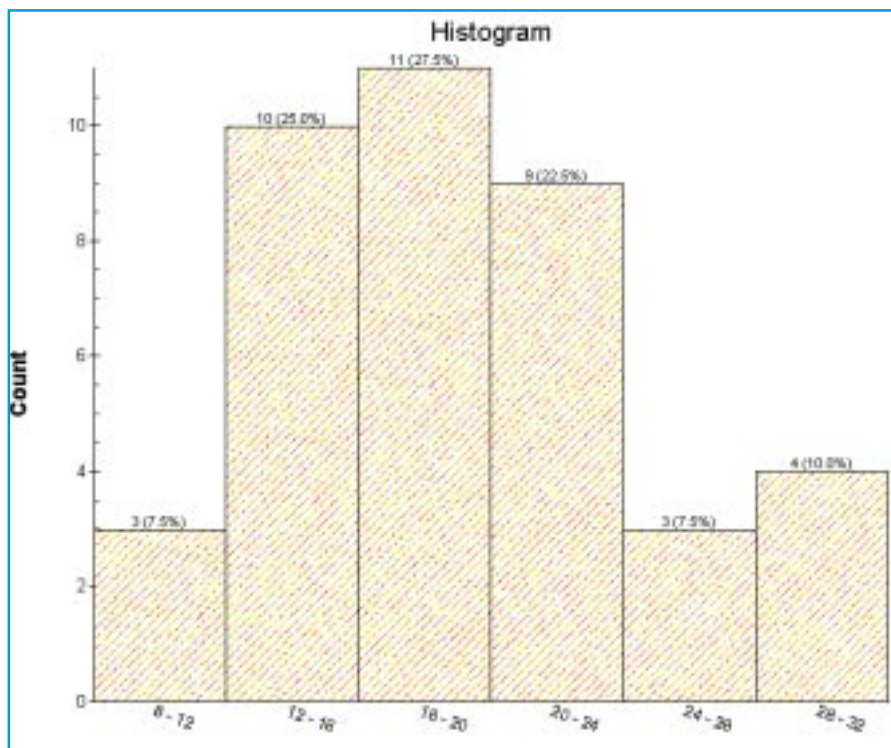


Figure 1 Simple Data Handling histogram (DJB) showing the distribution of radioactive count per minute from a few grammes of a potassium salt. The label 'Count' (LH axis) is the number of samples in the histogram bins and is not to be confused with radioactive count rate. The program lets you relabel the title, but not the histogram axes.

- Upgrades from previous versions of *Insight* are available at 30% discount - please note upgrades are only available direct from DCP with proof of purchase, or a copy of the original licence.
- A Macintosh version will be available from early 2003.

Packs purchased via DCP also include an *Insight 3* CD free of charge, which will work with both Apple Mac and Windows computers.

Junior Datalogging

Coming soon - *Junior Datalogging Insight*, with features such as animated characters.

DataMeter USB Windows Starter Pack

This all-in-one starter pack for Windows is supplied with a USB cable instead of a serial port cable. The pack contains *DataMeter 1000*, a mains adapter/charger, light and temperature sensors, *LogIT Lab* software for Windows, USB link cable and manuals, all packed inside a carrying case. A pack costs £310 (DCP reference number D 100332)

PASCO products

PASPort Xplorer

This small, hand-held instrument logs data without initial recourse to a computer. Only once your measurements have been taken need you plug into a computer via a USB port and download your data for display and analysis, either at a simple level with *EZscreen* software (supplied with *Xplorer*), or *DataStudio* (extra purchase). The *Xplorer* is operated by a set of 6 button switches, with cues on a 2-line LCD display. One *Xplorer* on its own costs £199 (14-1244); if bundled with a group of sensors, prices start at £405.

DataStudio

To make full use of *Xplorer*, you would also need the program *DataStudio*. The latest release is Version 1.7.2. Existing users can upgrade at no cost by downloading from the PASCO website. For new users, the cost is £122 for a single user (14-1196), £429 for a site licence (14-1197), or £467 for home use also (14-1195).

USB/Serial Converter

This (CI-6759, £110) lets you run a 300, 500 or 750 *ScienceWorkshop* interface through a USB computer port.

Botanical and ecological fieldwork - new Floras

The several new Floras that have recently been published provide invaluable aids to fieldwork.

This note mentions a number of recently published resources that will be of interest to teachers of Geography and History as well as of Biology. These resources provide, in addition to the Flora listings, many coloured plates and a wealth of very readable background information on topics such as the influence of geology, climate and the activities of humans on the distribution of plants. These new publications are valuable tools which can be used by schools in studies of ecology, land use and related topics.

A major work, the "Atlas" covers the British Isles:

The New Atlas of the British and Irish Flora, Preston, C.D. et al., 2002, (ISBN 0 19 851067 5), Oxford University Press, website: www.oup.com. The Atlas contains 912 pages and 2412 colour maps, price £99.95, HB. Supplied with the book is a CD-ROM that enables users to view and print out distribution maps and add on overlays containing environmental information.

Recently published local Floras include:

Flora of Assynt, Evans, P.A. and I.M., and Rothero, G.P., 2002. Those of you who go walking and climbing among the Lewisian gneiss, Torridonian sandstone or Cambrian quartzite of the area can have your days enriched. Names of plants are in Gaelic in addition to the usual Latin and English. Containing over 300 pages it is available from Summerfield Books at £17.50.

The Changing Flora of Glasgow, Urban and Rural Plants throughout the Centuries, Dickson et al., 2000, (ISBN 0 7486 1397 8), Edinburgh University Press, 402pp, price £30, HB. The plant distribution maps in this book are based on a 15 year survey carried out by The Glasgow Natural History Society. Available from bookshops and from Summerfield Books.

Plant Life of Edinburgh and the Lothians, Smith, P.M. et al., 2002, Edinburgh University Press, (ISBN 0 7486 1336 6), 416pp, price £25, HB. The plant distribution maps in this book are based on a 20 year survey carried out by the Botanical Society of Scotland (formerly the Botanical Society of Edinburgh). A CD-ROM containing habitat and frequency data and maps showing the distribution of all the species recorded in the survey is currently being prepared. Requests for copies of the CD-ROM should be sent to the Secretary of the Botanical Society of Scotland. A small fee will be charged. Marketing arrangements for the book are not yet finalised, but presumably will be the same as those for the book on the Flora of Glasgow.

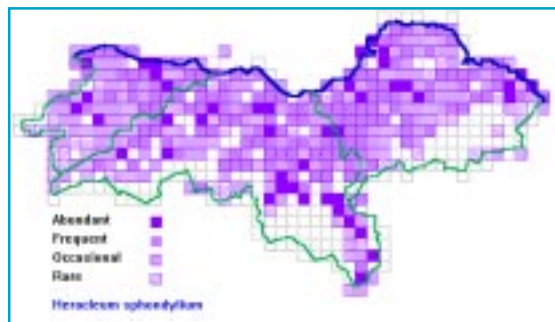


Figure 1 Distribution of Hogweed in the Lothians (Smith P.M. et al.).

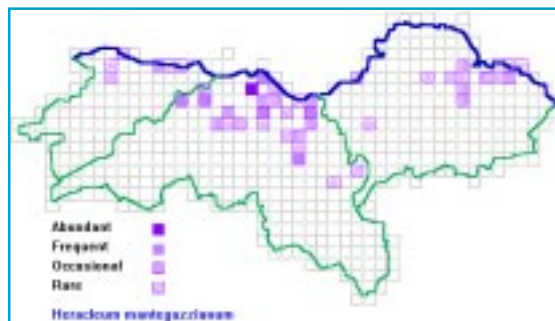


Figure 2 Distribution of Giant Hogweed in the Lothians (Smith P.M. et al.).

Flora of the Outer Hebrides, Pankhurst, J.R. and Mullin, J.M. (Reprinted 2001), 185 pp, price £30, (Paperback) from Summerfield Books.

Flora of North Aberdeenshire, Welch, D., (1993), published by author, 184pp, price £21, from Summerfield Books.

Local Floras for many other areas of Scotland including Iona, Arran, Fife, Shetland and Perthshire have been published. These can be found in the list of the Botanical Society of the British Isles (BSBI) publications sold by Summerfield Books, or possibly from local libraries and bookshops.

One of the ways in which the plant distribution maps in *Plant Life of Edinburgh and the Lothians* can be used is illustrated in the following example:

Hogweed (*Heracleum sphondylium*) is a native plant. The map (Fig. 1)



Figure 3 Giant Hogweed (*Heracleum mantegazzianum*), photographed at Sheriffhall, Midlothian, spreads by windblown and waterborne seed along roads, railways and rivers. C. E. Jeffree.

shows that it has a widespread distribution in lowland areas and the habitat data indicates that it is commonly found on roadsides. In contrast, Giant Hogweed (*Heracleum mantegazzianum*) is

a non-native plant, i.e. an alien or introduced plant. Contact with the sap of this plant can cause skin irritation and attempts are made to destroy the plants. The distribution map (Fig. 2) shows that

these attempts are not being successful and that Giant Hogweed (Fig. 3) is well established in some parts of the Lothians, particularly along river valleys.

Phenomenology

An example of the science of phenomena with Chladni's plate.

Malin Starrett did not have a normal science education. Although getting A Levels in science and electronics, he went off to art college, where he got his first degree. After that, having a burning desire to study science, he returned to art college 3 years later to work for a doctorate in the subject. This allowed him to study what he wanted. He is thus largely a self-taught scientist.

I give you this background because when you hear that someone with such an unusual training has applied his mind to how science might be taught, you expect a fresh approach. As it turns out, you will not be disappointed.

One of Malin's present interests is Chladni's plate¹. Although a standard piece of apparatus, it is not, I believe, much used nowadays. Indeed I do not ever recall handling an enquiry on it in my 20 years at SSERC. But let me describe why Malin thinks this apparatus is significant.

Chladni's plate in its simple form consists of a square metal plate with sides about 13 cm long supported quite tightly in its centre. When lightly dusted with sand if an edge of the plate is bowed with one strong stroke of a violin bow, the plate can resonate, emitting a strong ringing tone. The vibrating sand settles to form striations running along nodal lines in the plate. The resulting pattern depends on where the plate had been bowed and where else it had been held with a finger. With correct positioning, a nodal line runs from where the edge had been touched with a finger while an anti-nodal zone extends from where the bowing took place.

Bowing the mid point of an edge and gripping one corner produces a St Andrew's Cross pattern. By alternating these positions, you end up with a Cross

of St George. More complex patterns and higher order resonances can be created with other bowing positions and finger restraints. In all, a set of 12 patterns can be produced. Once the first 2 or 3 patterns have been shown, most observers can work out the rules and find fresh patterns (Fig 1).

What might pupils get out of this? First and foremost, they would probably be amazed and marvel at these phenomenal sand patterns. The lines are so finely uniform, they appear to have been drawn with a machine tool. Secondly, they would get a thrill out of witnessing events that

sense vibrations in the air above anti-nodal zones, but fail to sense vibrations above nodes. If an empty 330 ml bottle is inverted with its open end 1 cm above the plate, air in the bottle can be heard to resonate long after the plate itself has ceased to ring audibly. The lesson can lead on to effects with other related apparatus, such as resonances in a stretched elastic with mechanical oscillator².

But rather than stray into the science of sound, musical instruments, oscillations, or waves, let's return to the phenomenon with a fresh eye. What do we see? A

sprinkling of sand scattered at random over a flat plate. What do we do next? We apply some energy to the system by bowing the edge of the plate. We apply a white noise source³, with its jumble of assorted frequencies, and this causes the grains of sand to jump about and form these remarkable patterns. Where else do we get patterns? Look around at nature: the morphology of a snow flake, the regular geometry of a crystal, the structure of a leaf, the branching of a tree, the architecture of DNA. How did these shapes all form? Matter is particulate: apply an energy source; the particles move at random: resulting from their

random jiggling, they can sort themselves out into clusters to form larger objects such as rock crystals, fluffy clouds, or DNA.

Attracted by the weird wails from Chladni's plate, 2 colleagues came along to see what was happening and, as a matter of record, spent the rest of the day watching, trying, being amazed and discoursing. Sometimes science is phenomenal. Here is just such an example.

² Chladni's own research began with 1-dimensional vibrating systems.

³ The bow seems to act as a white noise source for the first instant only of bowing. Thereafter it starts to match the resonant frequency of the system, building up the amplitude of vibrations.



Figure 1 The Argyll pattern on Chladni's plate.

would be totally unexpected and reproducing the effects for themselves. And thirdly, they would quickly see how to render different patterns and ringing tones because the rules can be worked out by thought, and trial and error. It is really a lesson on phenomenology, where the aim is to study the science of phenomena. With some classes, that might be quite sufficient.

Where else might the lesson lead? Inferences can be drawn from watching the movement of the grains of sand. On nodal lines, the grains are stationary. Elsewhere they jump and a few can be seen to oscillate. If a finger is held 1 cm above the plate, nerves in the fingertip can

¹ Malin Starrett can supply a basic kit of 2 square plates, stand, 105 page manual and other items, but without bow, for £170.

Trade news

Chladni's plates

Malin Starrett (storyline overleaf) has 3 versions of his Chladni's plate kit costing between £170 and £230. These kits all depend on using a violin bow to cause the plate to resonate. Two other manufacturers, Frederiksen and PASCO, produce plates that fit on vibration generators; with these, the plates are brought into resonance by adjusting the oscillator frequency to match one of the plate's natural modes of vibration. The effect with an oscillator is probably less phenomenal than with a bow, but may be simpler to explain.

Frederiksen	Resonance Plate, Square	2185.20	£6
Frederiksen	Resonance Plate, Round	2185.25	£9
PASCO	Chladni Plates Kit	WA-9607	£87

Harris and Unilab repairs

In the last issue we directed you to contact Techlab for the repair of electronic boards, such as Alpha. We are sorry to say that this is incorrect. If you have any Harris or Unilab equipment that needs repairing, whether Alpha kit or anything else, please contact the Harris repair number listed opposite.

Middlesex University

The Teaching Resources catalogue from Middlesex University features many things of interest to teachers of Science or Technology, including these smart materials:

- Brass shim (TS6 005) £2.23 - for making switch contacts
- Smart wire (PAC SW1) £5.01 - a shape memory alloy whose length changes when it conducts current
- Smart springs (PAC SW3) £1.78 - provides a useful pulling force when acted on by current

Thermocolour sheet (IT9 001) £2.23 - temperature indication

Polymorph (PL1 004) £8.90 - a new polymer for use in model making or prototyping

Smart images (SM1 004) £5.20 - thin film with holographic images

Smart grease (SM1 003) £1.39 - for making a constant torque motor

and apparatus:

Motor Kit (MOT 001) £10.91 - self assembly dc motor

Energy Exchange (SEP 004) £67.50 - energy conversion demonstrations

Microcentrifuge (CEN 006) £60 - up to 13,000 rpm off 12 V

Engineered Bioreactor (BIO 001) £58.24 - scaled down version of an industrial process

White phosphorus

Despite many enquiries, we have failed to find a source of supply of white phosphorus. It would seem to be unavailable in the quantities required by schools.

Leybold Didactic

This leading designer and maker of physics apparatus have reopened a UK sales office. Please contact the company to obtain a catalogue.



Bloody Cranesbill (Geranium sanguineum) an example of coastal flora at Aberlady Bay; from the Plant Life of Edinburgh and the Lothians, one of the new Flora described on Page 14 (Photograph by C. E. Jeffree).

PASCO - see Instruments Direct

Revolution Education Ltd, 4 Old Dairy Business Centre, Melcombe Road, Bath, BA2 3LR.
T: 01225 340563; F: 01225 340564
E: info@rev-ed.co.uk

Scientific and Chemical, Carlton House, Livingstone Road, Bilston, West Midlands, WV14 0QZ. T: 01902 402402; F: 01902 402343; W: www.scichem.co.uk

Science Enhancement Programme (SEP), Allington House (1st Floor), 150 Victoria Street, London, SW1E 5AE. T: 020 7410 7129, F: 020 7410 0332, E: sep@gtep.co.uk

Summerfield Books, Main Street, Brough, Cumbria, CA17 4AX. T: 017683 41577; E: bsbipubs@beeb.net

Unilab - see Philip Harris

Vernier - see Comcal Scotland Ltd.

Addresses

ASE Booksales, College Lane, Hatfield, Hertfordshire, AL10 9AA. T: 01707 283000, F: 01707 266532, W: www.ase.org.uk

Ascol, PO Box 6745, Beeston, Nottingham, NG9 6QN. Tel: 0115 925 6049, F: 0115 925 4511, E: sales@ascol.co.uk

Botanical Society of Scotland, c/o Royal Botanic Garden, Inverleith Row, Edinburgh, EH3 5LR.

Carolina - see Instruments Direct

Comcal Scotland Ltd., 11 Bath Street, Glasgow, G2 1HY. T: 0141 332 8527, F: 0141 332 8527, E: sales@comcal.net

DCP Microdevelopments Limited, Bryon Court, Bow Street, Great Ellingham, Norfolk, NR17 1JB. T: 01953 457800, F: 01953 457888, E: info@dcpmicro.com

Didactic Systems Ltd. (Jennie Oakley), Coombe Lodge, Blagdon, BS40 7RG. T: 01761 463659, F: 01761 463641, E: joakley@leybold-didactic.co.uk

djb microtech, Delfie House, 1 Delfie Drive, Greenock, PA16 9EN. T/F: 01475 786540, W: www.djb.co.uk

Experience of Experimenting (Malin Starrett), Unit A28, Valley Business Centre, 67 Church Road, Newtownabbey, Co. Antrim, BT36 7LS. T: 028 90552721

Frederiksen - see Nicholl Education.

Griffin & George, Bishop Meadow Road, Loughborough, Leicestershire, LE11 5RG. T: 01509 233344, F: 01509 231893, E: griffin@fisher.co.uk

Philip Harris Education:

E6 North Caldeen Road, Calder Street, Coatbridge, Lanarkshire, ML5 4EF. T: 01236 437716, F: 01236 435183.

Findel House, Excelsior Road, Ashby Business Park, Ashby-de-la-Zouch, Leicestershire, LE65 1NG. T (sales): 0845 120 4520, T (repairs): 01530 418111, F: 01530 419 492, W: www.philipharris.co.uk/education

HSE Books, PO Box 1999, Sudbury, Suffolk, CO10 2WA. T: 01787 881165, F: 01787 313995, W: www.hsebooks.co.uk

Institute of Biology (Scottish Branch) - Peter Anderson, Fife Council, Auchterderran Centre, Woodend Road, Cardenden, Fife, KY5 0NE. T: 01592 414676, F: 01592 414641, E: petera@itasdarc.demon.co.uk

Instruments Direct Limited, Unit 14, Worton Road, Isleworth, Middlesex, TW7 6ER. T: 0208 560 5678, F: 0208 232 8669, W: www.InstrumentsDirect.co.uk/pasco

Leybold - see Didactic Systems

Middlesex University, Teaching Resources Ltd., Unit 10, The 10 Centre, Lea Road, Waltham Cross, Herts, EN9 1AS. T: 01992 716052, F: 01992 719474, W: www.mutr.co.uk

Nicholl Education Limited, 4 Westleigh Hall, Wakefield Road, Denby Dale, Huddersfield, HD8 8QJ. T: 01484 865994, F: 01484 860008, E: sales@nicholl.co.uk

