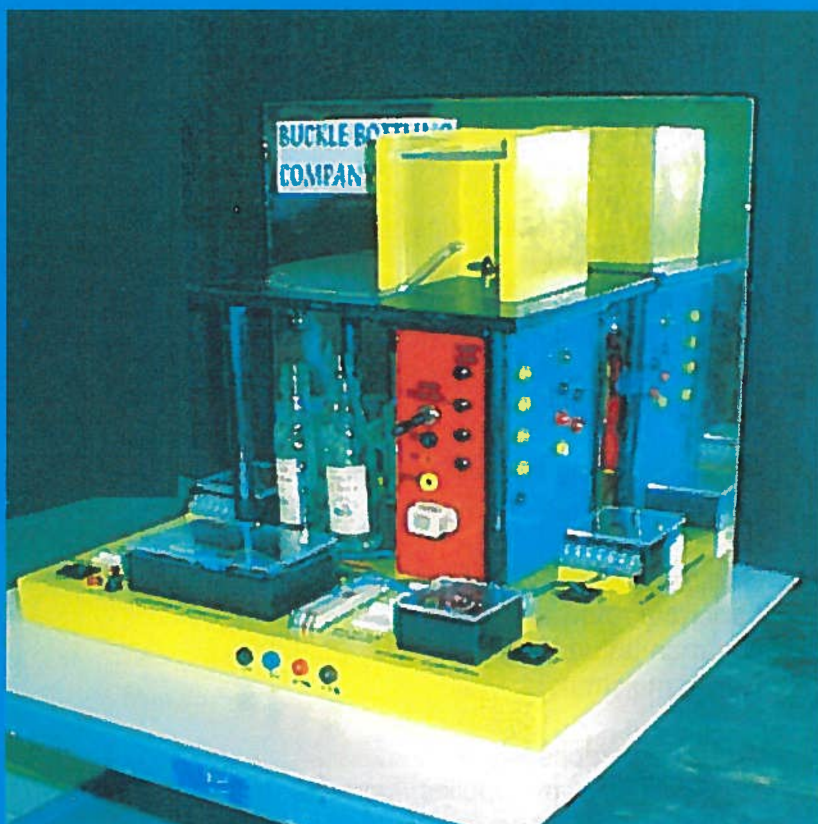
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE



Science & Technology Bulletin

For: Teachers and Technicians in Technical Subjects and the Sciences

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Tae a moose

Wee sleekit curve o' plastic grei
Niver far mun yer stray.
Panic's aa mine, bamboozled by the fray
O heich technologie.
A wad be laith tae tak yon computer way
'twasnae for the family.

Ma awfy sorry runklie's hauns
Ar nae sae gleg as thae o' bairns,
Ane day nae doot they'll get their fairins
Sic ony ither.
But noo advice gets monie airins
Frae chiel tae elder.

A doot na whiles it haes its uses,
A plus tae mony modern hooses,
Screivins, posters - onything yer choose
'S a sma request.
Tae oor PC, an printer douce
A wee bit meenit's test.

Sae, moose in haun, we mak oor clicks,
We skite aboot oor screen's wee pix,
Learning aye aa the latest tricks.
We're icon-wyce.
Labels, italics - whate'er the mix -
Aa done gae quick - aathing tae size.

Tae open menus, point, command,
Confidence graws on ivery haun,
We're shair tae get whate'er we planned.
Aye! We hae it aa saved
'Til "CRASH" - oor rock aa turned tae sand.
'S no whit we craved.

An aa the days passed at aa thae classes,
Wid better be spent in tuiming tassies,
Nae getherin leir that anely fashes,
A gytelik fouter.
Gie us spreadsheets wi pliant lassies,
Nae a computer.

Moosie, we twa ar nae alane,
Tae cry formatting sic a bane,
The best laid schemes o' the micro-men,
Gan aft agley
An leave them nocht but grief and pain
For promised joy.

Sae moosie, tethere'd by yon wirey tail,
Tae gang anely whaur we wale,
Unplug yersel and mak for the grail
O libertie!
A mat's nae place - 's ower sma' a scale
For mice - or ony wha wad be free.

INTRODUCTION

Screivins in the leid

We had already stumbled on the updated variant of the piece on page one - it was adorning the SSERC staff noticeboard - when we got our copy of *Porty Blethers* - a magazine in Scots from Portobello High School. This was quickly followed by *Lallans* the periodical of the Scots Language Society (Leid Associe). The Society also sent us a Newsletter with a reminder that this year marks the centenary of the birth of the kenspeckle Willie Soutar a writer (*screiver*) in the Scots tongue (*the leid*). Our publishing "Tae a moose" is a mere proverbial in the watter. We may yet summon up the courage (and the necessary vocabulary) to publish a full scientific or techno logical article in the Scots. Then there is the tricky matter of the Gaelic. Any volunteers?

Questionnaires - thanks!

We are very grateful to all of those readers who have already taken the trouble to complete and return a copy of our evaluation questionnaire. At the time of writing we have only just started the analysis. Even without the detailed results of that, some of our own suspicions about aspects of the Bulletin or 5-14 News already have been confirmed. The more obvious areas for improvement include those such as occasional imbalance in subject coverage or a relative neglect in some issues of certain age ranges or of finer curricular detail. With the help of the Steering Group and others, we shall look at these matters over the next few months and gradually introduce changes. These, trustfully, will bring some improvement and a wider satisfaction with some aspects of the STS service and its publications.

One apparently insoluble problem is that of humour in the Bulletin (or the lack of it). Some readers report that they sometimes find the introductory sections irksomely "jolly" and another gently complained that they would like to ken who wrote the opinionative bits so that they would know whether or not to pay them any attention! The same respondent commented that they didn't always get the "in-jokes". The idea that anyone in SSERC could even in any remote sense be "in" I find, of itself, amusing. To offset the disapproval, we have had as many comments along the lines of "very much appreciate the humour of the editor's bits" through "Just keep giving out the tablets" to a "Long Live the Editorial!" (sycophantic moi?).

We really do try to avoid just making wisecracks, *mere callisthenics with words* as Dorothy Parker put it - seeking instead to write with wit, which - as Ms Parker observed also - seems usually to carry with it some ring of the truth.

Equipment matters

At one time, the activities of SSERC were highly concentrated around science and technology education equipment. We tested it, reported on it, listed it against specific syllabuses, costed it, and taught teachers or technicians how to fix it, or to use it properly and safely. Then the wheels fell off. School science departments in particular began to have less and less in real (or any) terms to spend. There thus seemed little sense in going on with so much testing, evaluation and reporting on equipment. It was also the bit of the service for which no-one, at least on the consumer side of the equation, seemed particularly keen to pay. But then, why have only bread and butter when you can have the full IT?

We are not agin investment in information technology. Indeed SSERC could never have got as close as we do to meeting increasing demands on the service without IT. We are nonetheless currently concerned that yet another round of investment may soon be over with little or no capital expenditure on basic science and technology kit. These are after all practical subjects. It is necessary now and then for pupils and students to engage with equipment and real materials. There is even an argument that without the practical subjects, team sports and socialisation - then who needs a school at all? Yet some teachers are still having to use basic items such as power supplies, oscilloscopes or microscopes which were bought in the seventies or possibly the late sixties. IT (now ICT) specialists may start moaning when computing equipment passes its third birthday. If they were confined to teaching with thirty - not three - year old computing technology, then some pupils might still know the delights and ancient craft skills of the hand cranked, mechanical calculator.

There is also the matter of sensible levels of revenue expenditure on basics and consumables. A Royal Society Report [1], published last Autumn, sheds some useful light on these matters but unfortunately is confined largely to the 11-16 age range and the English and Welsh National Curriculum. Nonetheless it provides a useful starting point for an exercise in which the costs of setting up and running various science based courses might be estimated. Decision making on such issues might then have a more objective and rational basis. We can never afford to be in a position where we are thirled solely to some other parties' technology. The key to understanding technology, controlling it or fixing it when it's broken, is to retain the necessary practical skills and underpinning knowledge in our own population. In their heads, school science and technology teachers hold many of the keys to learning. It is possibly well past the time some had newer tools with which to teach. To that end, over the Summer we shall be working with others on a specific Scottish version of the Royal Society report.

1. *Science teaching resources : 11-16 year olds*, A report by a working group of the education committee of the Royal Society. (see also: *Letter from the Chair* - April Scottish Science Issues, ASE Scotland).

NEWS AND COMMENT

New biotechnology initiative

We are very pleased to announce the beginning of a new phase in the lives of both the SAPS (Science and Plants for Schools) Project and the Scottish Biotechnology Education Project. As many Scottish teachers will know, SAPS Scotland has been semi-dormant for a while and Marjorie Smith's part time secondment to the Scottish Biotechnology Education Project was due to end in July of this year. A way has now been found to ensure that the good practice exemplified in both projects will continue to be both developed and disseminated.

Eschewing any of the obvious puns on sap(s) the joint rebirth as a collaborative project will be more or less along the following lines: Rodger McAndrew has been reseconded to SAPS for a further two years with accommodation kindly provided by the Edinburgh University Department of Cell and Molecular Biology. It is also very likely that Marjorie Smith's work will not now come to an end in July but rather that there will be a smooth transition into the new, collaborative project. This new joint activity is to be known as:

The SAPS Biotechnology Scotland Project.

As with the earlier projects, the initiative will be national in scope; not confining itself to Edinburgh nor even the Central Belt. The emphasis will continue to fall on the development of innovative practical work to support the learning and teaching of plant science and biotechnology in schools and colleges. Dissemination will again be via staff development programmes using hands-on practical workshops. Initially the priority area will be support for the Higher Still Development programme. Thereafter other work may follow, on materials for S3/S4 and then for the 5-14 Environmental Studies curriculum. The project team will seek to collaborate more widely and will continue links with agencies such as NCBE, ASE, the Institute of Biology and SSERC as well as seeking to forge new relationships with other relevant parties.

Support for this initiative, either cash or in-kind, has come from the SAPS Trustees, Unilever, SOEID and the University of Edinburgh. It is a development we are particularly happy to see and SSERC has been pleased to accept an invitation to join the Steering Group, the full membership of which, currently, is :

Professor David Finnegan (Cell and Molecular Biology, Edinburgh University); Alan George (Unilever); Dr Jim Hay (Quest International); Professor David Ingram (Chairman : currently Regius Keeper, The Royal Botanic Gardens); Dr Jack Jackson, HMI, (SOEID); Rodger McAndrew (seconded from Queensferry High School); Richard Price (SAPS); John Richardson (Executive Director, SSERC); Marjorie Smith (Dollar Academy, currently Scottish Biotechnology Education Project) and Jim Stafford (Higher Still Development Officer for biology).

Phrases for appraisers

These we promised, foolishly, as a follow-up for the "CV tips" in the last issue. They've been floating about the ether for some time. Please don't aim non-PC accusations at us therefore. All are claimed to be from genuine staff appraisals or managers' efficiency reports :

The staff would follow him anywhere - but only out of curiosity.

She has carried out each and every one of her various duties to her own entire satisfaction. Since my last report has reached rock bottom - now digging.

Works well under constant supervision and when cornered - like a rat in trap.

Gates down, lights flashing - trains never come.

Sets the lowest personal standards and consistently fails to achieve them. Sneaked into the gene pool when the lifeguards weren't watching?

Delusions of adequacy and a room temperature IQ.

Has the wisdom of youth with all the energy of old age.

Has got the full six-pack - just lacks the plastic thingy to hold it together.

Dense? Light probably bends round him.

Wheel's turning - hamster's dead

* * *

Diary dates

SSERC's Annual Science, Technology and Safety Conference (open to the nominated delegates of member Councils) has been provisionally arranged for the morning of Friday, 23rd October 1998. As in previous years the Annual General Meeting of SSERC Limited will follow in the afternoon of the same day. The 1998 Annual Meeting and Exhibition of the *Technology Teachers' Association* (TTA) will be held on Saturday 31st October 1998 in George Heriot's School, Edinburgh and *ASE Scotland's* next Annual Meeting will be held in St Machar Academy, Aberdeen (accommodation in The Patio Hotel) on 5th to 7th March 1999.

No comment

(a) There is nothing to say that a local Crematorium would be non-viable. (b) Concern cemetery used as dumping ground.
Recent issues of (a) the East Lothian Courier and (b) The Kerryman (honest!) respectively.

Beware Geeks even when they come bearing GIFS
Nerdo-Anorak Proverb (and possible in-joke).

Actual Reality Scotland Ltd: Company formed as a joint venture by West of Scotland Councils to run Outdoor Education Centres.

* * *

SAFETY NOTES

Micro-organisms for investigations in schools and colleges: revised listings

In May 1997, a safety conference was convened by the Association for Science Education (ASE). A number of organisations were represented, including the ASE, CLEAPSS, SSERC, HSE, MISAC (Microbiology in Schools Advisory Committee), Society for Applied Bacteriology, Society for General Microbiology, NCBE (National Centre for Biotechnology Education), SAPS (Science & Plants in Schools), the Wellcome Centre and the educational suppliers Philip Harris and Blades Biological. The principal aims of the conference were to consider clarification of guidance on the use of micro-organisms and biotechnology in the DfEE publication *Safety in Science Education* and to evaluate the list of micro-organisms considered suitable for use in schools and colleges following changes in hazard categorisation of certain microorganisms by the Advisory Committee on Dangerous Pathogens [1]. One of the outcomes of the conference is a revision of this list.

The accompanying tables give selected micro-organisms which present minimum risk given good practice. These tables supersede the existing lists in SSERC *Bulletins*; the CLEAPSS *Laboratory Handbook*; *Microbiology: an HMI guide* for schools and further education 1990 (now out of print), *Topics in Safety* 1988 and *Safety in Science Education* 1996. Should each Scottish Authority also adopt them they would also then supersede the lists in the Strathclyde Code [See Notes].

As well as naming suitable organisms, the new lists give points of educational use or interest and comment on the ease with which organisms can be cultured and maintained. As before the lists of microorganisms are not definitive; other organisms may be used if competent advice is obtained and relevant risks assessed.

It should be noted that strains of microorganisms can differ physiologically and therefore may not give expected results. Where possible, fungi that produce large numbers of air-borne spores should be handled before sporulation occurs, so that the spread of spores into the air and possible risks of allergy or the triggering of asthmatic attacks are minimised. This is particularly important for some species, eg those of *Aspergillus* and *Penicillium*, which produce very large numbers of easily dispersed spores.

It should be noted also that certain species of these two fungi, previously listed as unsuitable for use in schools, are now not thought to present such a serious risk to health, given good practice in culture and handling.

Selected microorganisms

Bacterium	Educational use/interest/suitability	Ease of use/maintenance
Acetobacter aceti	Of economic importance in causing spoilage in beers and wines. Oxidises ethanol to ethanoic (acetic) acid and ultimately to carbon dioxide and water.	Needs special medium and very frequent subculturing to maintain viability.
Agrobacterium tumefaciens	Causes crown galls in plants; used as a DNA vector in the genetic modification of organisms.	Grows on nutrient agar, but requires 2-3 days incubation.
Alcaligenes eutrophus	In the absence of nitrogen, it produces intracellular granules of poly-B-hydroxybutyrate (PHB) used in the production of biodegradable plastics.	Grows on nutrient agar.
Azotobacter vinelandii	A free-living nitrogen fixer, producing a fluorescent, water-soluble pigment.	Grows on a nitrogen-free medium.
Bacillus megaterium	Has very large cells; produces lipase, protease and also PHB (see Alcaligenes); Gram-positive staining.	Grows on nutrient agar.
Bacillus stearothermophilus	Thermophilic species which grows at 65 deg.C; produces lipase and protease. Also used to test the efficacy of autoclaves.	Grows on nutrient agar.
Bacillus subtilis(!)	General-purpose, Gram-positive bacterium. Produces amylase, lipase and protease.	Grows on nutrient agar.
Cellulomonas	Produces extra-cellular cellulase.	Grows on nutrient agar but also used with agar containing carboxymethylcellulose.
Chromatium species	A photosynthetic, anaerobic bacterium.	Requires special medium / light for good growth.

(!) - Some strains have been associated with health hazards. Reputable suppliers should ensure that safe strains are provided.

Bacterium	Educational use/interest/suitability	Ease of use/maintenance
Erwinia carotovora (= E. atroseptica)	Produces pectinase which causes rotting in fruit and vegetables. Useful for studies of Kochs postulates.	Grows on nutrient agar.
Escherichia coli (!)	K12 strain: general-purpose, Gram-negative bacterium. B strain: susceptible to T4 bacteriophage.	Grows on nutrient agar.
*Janthinobacterium (=Chromobacterium) lividum**	Produces violet colonies. Grows best at 20 deg.C.	Needs frequent subculture; will grow on nutrient agar but special medium recommended.
Lactobacillus species	Ferment glucose and lactose, producing lactic acid; *L. bulgaricus* is used in the production of yoghurt.	Requires special medium and frequent subculturing to maintain viability.
Leuconostoc mesenteroides	Converts sucrose to dextran: used as a blood plasma substitute.	Requires special medium as for *Lactobacillus.*
Methylophilus methylotrophus	Requires methanol as energy source; was used for the production of Pruteen single-cell protein.	Requires special medium containing methanol.
Micrococcus luteus (= Sarcina lutea)	Produces yellow colonies; useful in the isolation of the bacterium from impure cultures. Also used to simulate the effects of disinfectants, mouthwashes and toothpastes on more harmful organisms.	Grows on nutrient agar.
Photobacterium phosphoreum	Actively-growing, aerated cultures show bioluminesc- -ence; grows in saline conditions.	Requires a medium containing sodium chloride.
Pseudomonas fluorescens	Produces a fluorescent pigment in the medium.	Grows on nutrient agar.
Rhizobium leguminosarum	A symbiotic, nitrogen fixer; stimulates the formation of nodules on the roots of legumes but special conditions are needed for N-fixation in culture.	Grows on yeast malt agar; some authorities recommend buffering with chalk to maintain viability.
Rhodopseudomonas palustris	A photosynthetic, anaerobic, red bacterium. Also grows aerobically in the dark.	Requires light and a special medium, growing atypically on nutrient agar.
Spirillum serpens	Of morphological interest.	May grow on nutrient agar but requires very frequent subculturing to maintain viability.
*Staphylococcus albus (epidermidis)***	A general-purpose, Gram-positive bacterium, producing white colonies.	Grows on nutrient agar.
Streptococcus (= Enterococcus) faecalis	Of morphological interest, forming pairs or chains of cocci.	Nutrient agar with added glucose can be used but grows better on special medium, as for *Lactobacillus*
Streptococcus (= Lactococcus) lactis	Of morphological interest, forming pairs or chains of cocci. Commonly involved in the souring of milk; also used as a starter culture for dairy products.	Can grow on nutrient agar with added glucose; some authorities recommend buffering with chalk to maintain viability.
Streptococcus thermophilus	Ferments glucose and lactose, producing lactic acid; used in the production of yoghurt. Grows at 50 deg.C.	Can grow on nutrient agar with added glucose; some authorities recommend frequent subculturing to maintain viability.
Streptomyces griseus	Responsible for the earthy odour of soil. Grows to form a fungus-like, branching mycelium with aerial hyphae bearing conidia. Produces streptomycin.	Grows on nutrient or glucose nutrient agar but better on special medium which enhances formation of conidia.
Thiobacillus ferrooxidans	Involved in the bacterial leaching of sulphur-containing coal. Oxidises iron(II) and sulphur. Demonstrates bacterial leaching of coal samples containing pyritic sulphur.	Requires special medium.
Vibrio natriegens (= Beneckea natriegens)	A halophile, giving very rapid growth. Prone, however, to thermal shock with a sudden drop in temperature.	Requires medium containing sodium chloride.
Vibrio species (!)	Of morphological interest, more typical *Vibrio* shape than *V. natriegens.* Ensure a safe species is used.	Grows on nutrient agar.

(!) - Some strains have been associated with health hazards. Reputable suppliers should ensure that safe strains are provided.
* - Can be chosen for investigations that once required the use of *Chromobacterium violaceum* or *Serratia marcescens.*
** - This organism has been known to infect debilitated individuals and those taking immuno-suppressive drugs.

Fungus	Educational use/Interest/suitability	Ease of use/maintenance
Agaricus bisporus	Edible mushroom; useful for a variety of investigations on factors affecting growth.	Grows on compost containing well-rotten horse manure; available as growing kits.
Armillaria mellea	The honey fungus; causes decay of timber and tree stumps. Produces rhizomorphs.	Grows very well on malt agar. Some authorities recommend carrot agar.
*Aspergillus nidulans***	For studies of nutritional mutants. Produces abundant, easily-dispersed spores - may become a major laboratory contaminant!	Grows on Czapek Dox yeast agar. Special media required for studying nutritional mutants.
*Aspergillus niger***	Useful for studies of the influence of magnesium on growth and the development of spore colour. Used commercially for the production of citric acid. Produces abundant, easily-dispersed spores - may become a major laboratory contaminant!	Requires special sporulation medium for investigations.
*Aspergillus oryzae***	Produces a potent amylase; useful for studies of starch digestion. Also produces protease. Used by the Japanese in the production of rice wine (saki).	Grows on malt agar; add starch (or protein) for investigations.
Botrytis cinerea	Causes rotting in fruits, particularly strawberries. Useful for studies of Kochs postulates with fruit, vegetables and *Pelargonium sp.* Important in the production of some dessert wines (noble rot).	Can be grown on malt agar or agar with oatmeal.
Botrytis fabae	Causes disease in bean plants.	Requires agar with oatmeal.
Chaetomium globosum	Useful for studies of cellulase production; thrives on paper.	Can be grown on V8 medium but survives well just on double thickness wall paper, coated with a flour paste.
Coprinus lagopus	For studies of fungal genetics.	Grows on horse dung.
Eurotium (= Aspergillus) repens	Produces yellow cleistocarps (cleistothecia) embedded in the medium and green conidial heads in the same culture.	Requires special medium.
Fusarium graminearum	Causes red rust on wheat; used in the manufacture of Quorn mycoprotein.	Can be grown on V8 medium.
Fusarium oxysporum	A pathogen of many plants. Produces sickle-cell shaped spores, a red pigment and pectinase.	Grows well on several media including malt, potato dextrose and Czapek Dox yeast agar.
Fusarium solani	Digests cellulose; macroconidia have a sickle shape.	Grows on potato dextrose agar.
Helminthosporium avenae	A pathogen of oats.	May not grow easily in laboratory cultures.
Kluyveromyces lactis	A yeast, isolated from cheese and creamery products. Ferments lactose and used to convert dairy products to lactose-free forms. Genetically-modified strains are used to produce chymosin (rennet).	Grows on malt agar or glucose nutrient agar.
Leptosphaeria maculans	For studies of disease in *Brassica* plants.	Requires cornmeal agar or prune yeast lactose agar to promote sporulation in older cultures.
Monilinia (= Sclerotinia) fructigena	For studies of brown rot in apples. Useful for studies of Kochs postulates.	Grows on malt agar or potato dextrose agar.
Mucor genevensis	For studies of sexual reproduction in a homothallic strain of fungus.	Grows on malt agar.
Mucor hiemalis	For studies of sexual reproduction between hetero-thallic + and - strains and zygospore production.	Grows on malt agar.
Mucor mucedo	Common black pin mould on bread. For sporangia (asexual), mating types and amylase production.	Grows on malt agar.
Myrothecium verucaria	For studies of cellulose decomposition but *Chaetomium globosum* is preferred.	Grows on malt agar.

** - Possible risk of allergy/asthma if large numbers of spores are inhaled.

Fungus	Educational use/interest/suitability	Ease of use/maintenance
*Neurospora crassa***	Red bread mould. Produces different coloured ascospores. Can be used in studies of genetics. Beware - readily becomes a major laboratory contaminant!	Grows on malt agar.
*Penicillium chrysogenum***	Produces penicillin; useful for comparative growth inhibition studies in liquid media or when inoculated onto agar plates seeded with Gram-positive and negative bacteria. Produces yellow pigment.	Grows on malt agar, though some authorities indicate that it thrives better on liquid media.
*Penicillium expansum***	Does not produce penicillin; causes disease in apples. Useful for studies of Kochs postulates.	Grows on malt agar.
*Penicillium notatum***	Produces penicillin; useful for comparative growth inhibition studies in liquid media or when inoculated onto agar plates seeded with Gram-positive and negative bacteria.	Grows on malt agar.
*Penicillium roqueforti***	Does not produce penicillin; the familiar mould of blue-veined cheese.	Grows on malt agar.
*Penicillium wortmanii***	Produce wortmin rather than penicillin.	Grows on malt agar.
Phaffia rhodozyma	A fermenting red yeast. Used to colour the food supplied to fish-farmed salmon.	Grows on yeast malt agar.
Phycomyces blakesleanus	Produces very long sporangiophores which are strongly phototropic.	Grows on malt agar.
Physalospora obtusa	An ascomycete fungus that grows on apple. Thought to produce pectinase.	Grows on potato dextrose agar.
Phytophthora infestans (+)	Causes potato blight. Produces motile zoospores.	Can be grown on V8 medium.
Plasmodiophora brassicae	For studies of disease in *Brassica* plants, particularly club root. Useful for studies of Kochs postulates.	May not grow easily in culture.
Pleurotus ostreatus	Edible oyster cap mushroom.	Can be grown on rolls of toilet paper! Also grown on logs or between log slices.
Pythium de baryanum (+)	Causes damping off of seedlings; cress is best to use.	Grows on cornmeal agar.
Rhizopus oligosporus	Used in the fermentation of soya beans to make 'tempe', a meat-substitute food in Indonesia.	Grows on potato dextrose agar, Czapek Dox yeast agar and other fungal media.
Rhizopus sexualis	Produces rhizoids and zygospores. Useful for studies of the linear growth of fungi.	Grows on potato dextrose agar and other fungal media.
Rhizopus stolonifer	Produces rhizoids. Produces lipase.	Grows on potato dextrose agar, potato carrot agar, Czapek Dox yeast agar and other fungal media.
Rhytisma acerinum	An indicator of air pollution: less common in industrial areas. On sycamore leaves, it forms tar spot lesions, the number or diameter of which can be compared at different sites.	Difficult to maintain but laboratory cultures are not likely to be needed.
Saccharomyces cerevisiae	Valuable for work in baking and brewing, showing budding, for spontaneous mutation and mutation-induction experiments, and for gene complementation using adenine- and histidine-requiring strains.	Grows on malt agar or glucose nutrient agar.
Saccharomyces diastaticus	Able to grow on starch by producing glucoamylase.	Grows on malt agar or nutrient agar + 1% starch.
Saccharomyces ellipsoideus	Used in fermentations to produce wine; can tolerate relatively high concentrations of ethanol.	Grows on malt agar.
Saprolegnia litoralis (+)	Parasitic on animals. Produces zoospores. Good illustration of asexual and sexual stages.	Culture by baiting pond water with hemp seeds.

** - Possible risk of allergy/asthma if large numbers of spores are inhaled.
(+) - Now classed as a protoctist, so may not be found in the lists of fungi from suppliers.

Fungus	Educational use/interest/suitability	Ease of use/maintenance
Schizosaccharomyces pombe	Large cells, dividing by binary fission. Good for studies of population growth, using a haemocytometer for cell counts. Prone to thermal shock.	Grows on malt agar. For studies of population growth, a malt extract broth can be used.
Sordaria brevicollis	For studies of fungal genetics, including inheritance of spore colour and crossing over in meiosis.	Requires special medium for crosses between strains.
Sordaria fimicola	For studies of fungal genetics, including inheritance of spore colour and crossing over in meiosis.	Grows on cornmeal, malt and other agars but may not transfer readily from one medium to another. White-spore strain may not always grow normally on standard cornmeal agar.
Sporobolomyces sp.	Found on leaf surfaces. Spores are ejected forcibly into the air from mother cells.	Grows on malt, yeast malt and glucose nutrient agar but laboratory cultures may not be needed.
Trichoderma reesei	Commercial production of cellulase.	Grows on malt agar.

Viruses

These are not frequently used in schools and colleges but a selected list of those which might be considered is given below.

Bacteriophage (T type) (host E. coli)
Cucumber Mosaic Virus
Potato Virus Y (Not the virulent strain)
Turnip Mosaic Virus
Potato Virus X
Tobacco Mosaic Virus

Algae, protozoa (including slime moulds) and lichens

Though some protozoa are known to be pathogenic, the species quoted for experimental work in recent science projects and those obtained from schools' suppliers or derived from hay infusions, together with species of algae and lichens, are acceptable for use in schools.

Unsuitable microorganisms

A number of microorganisms have in the past been suggested for use in schools or general biological courses in FE, but are no longer considered suitable. These are listed below. Some fungi previously considered unsuitable have been reinstated in the list of selected organisms now that it is thought that they do not present a major risk, given good practice.

Bacteria

Chromobacterium violaceum
Clostridium perfringens (welchii)
Pseudomonas aeruginosa
Pseudomonas solanacearum¤
Pseudomonas tabaci¤
Serratia marcescens
Xanthomonas phaseoli¤

Fungi

Rhizomucor (Mucor) pusillus

¤ - Not because of any threat to human health but because of possibilities of escape and infection of economically important crop plants.

Additional Notes:

1. The new lists of microorganisms will also be available from other sources including ASE, CLEAPSS, MISAC and NCBE.
2. The Higher Still Development Officer for biology courses and relevant personnel at SOEID have been kept informed on progress in this matter. At some point it may be necessary to convene a cross authority working group to revise the *Strathclyde Code of Practice* to include the new lists. Meantime there is nothing to stop any individual Council adopting or adapting these lists, for example as part of their control measures under COSHH.

Acknowledgements and reference

SSERC wishes to thank: ASE for convening the conference; colleagues at CLEAPSS (John Tranter especially) for acting so effectively as secretariat afterwards - drafting and redrafting lists to accommodate the microbiological preferences, affections, or even affectations, of everyone making comments - and, lastly by no means proverbially, we are grateful to NCBE/MISAC and to Dr John Grainger for bringing his expertise to bear, helpfully as always, on any particularly tricky problems.

1. *Categorisation of biological agents according to hazard and categories of containment*, 4th edition, 1995, Advisory Committee on Dangerous Pathogens, HSE Books, ISBN 0717610381.

EQUIPMENT NOTES

Harris System SM

Comprising of a large range of *SensorMeters*, portable datalogger and software, the system may be used for measurement, data capture and analysis. This review looks at the Temperature and Radioactive Count Rate sensors and how System SM performs within those contexts.

We had intended to review System SM within the context of three sensors, the Distance sensor (E30160/2), Temperature sensor (E30660/0) and Radioactive Count Rate (E30500/0) sensor. The Distance sensor was found to perform poorly. Our findings have been sent to Harris for comment and at the time of writing this article we still await their response. In fairness to them we feel unable to publish our findings in the Bulletin because the sensor we had reviewed has just been superseded by another version. Therefore this part review of SM takes a detailed look at just two sensors. A narrow scope, but one from which we can begin to form a fair judgement of the system. We should be able to report on the pH and conductivity functions in the next issue.

The system is illustrated schematically overleaf (Fig. 1). It comprises a probe, *SensorMeter*, data-logger and computer. The *SensorMeter* with probe can be used either on its own as a stand-alone instrument, giving readings in SI units shown on its liquid crystal display, or in conjunction with the *DL plus* datalogger. The data-logger can be used with or without a computer. Without the computer, it may be used to store readings and display these either in digital or graphical form. With the computer, data may be processed and analysed with software called *Datadisc PRO*.

System SM SensorMeters

Air pressure (atmospheric, 900 to 1100 mBar)
Conductivity (6 ranges : 0.01 to 100 S m^{-1})
Current (4 bipolar d.c. ranges, ±10 A max)
Low current (4 bipolar d.c. ranges, ±0.5 to 1000 mA)
Distance (also speed, acceleration, range : 0.4 to 10 m)
Relative humidity (0 to 100%)
Infrared irradiance (3 ranges : 2 to 800 W m^{2})
Light (5 ranges : 1 to 100 k lux, also log range)
Magnetic flux (2 bipolar ranges : ±0.1 to ±100 mT)
Dissolved oxygen (measures percentage saturation in aqueous solutions or air)
pH (measures pH, e.m.f. of electrode, temperature)
Position (measures small displacements from 0.1 to 60 mm)
Potential difference (4 bipolar ranges : ±0.01 to ±20 V)
Radioactive count rate (3 ranges : 0.2 to 1000 counts s^{-1})
Pressure (to measure differential pressure relative to absolute, or breathing rate with stethograph, 4 bipolar ranges : ±10 Pa to ± 50 kPa)
Sound (50 to 110 dB)
Temperature (3 ranges : 0 to 110 °C, -20 to 50 °C, any 10 ° span between -20 and 110 °C)
High temperature (3 ranges : -20 to 1000 °C)
Temperature difference (measures temperature difference between a pair of thermocouple points, 4 spans : 100, 40, 20 and 10 °C)
Ultraviolet (standard probe detects UVA and UVB, additional probe detects UVB, 3 ranges : 0.01 to 100 W m^{-2})

Specifications

4 analogue input channels, 5 pin DIN connectors
10-bit ADC conversion
Maximum recording speed of 16 kHz
Membrane keypad operation
LCD display, 64 x 128 pixel graphics
Memory : DL plus 32 : 32kB RAM, 20 data files max
DL plus 128 : 128kB RAM, 100 data files max
File formats : TAB, CSV, SID
Computer compatibility : Acorn Archimedes, IBM compatibles, Apple Macintosh, BBC, Nimbus (but not all models compatible, consult Harris)
RS232 compatible serial communication
Optical isolation between DL plus and computer
Power : DL plus 32 : 8 AA cells
DL plus 128 : 4 AA cells / Mains adaptor
Lithium battery memory backup
Auto shutdown after 90 s inactivity
Battery operation for logging remote from computer

Software :
Datadisc PRO for Windows
also for MS-DOS, Macintosh, RISC-OS, etc.
Datadisc Explore (9 to 13 age range)
Datamass PRO (reads data from balance, RS232 O/P)
System SM Timing Package (mechanics experiments)

Several kinds of computer platform may be used. However this issue is complex. We understand that *Datadisc PRO* does not run on the Power Macintosh PC 4400 series machines. Therefore you should ask Philip Harris for information about compatibility with specific computer types while considering making a purchase.

The range of sensors is given in the box above. They vary in price from £105 to £193, excepting the Radioactive Count Rate *SensorMeter*, which costs £285 because of the high price of its Geiger probe. As stand-alone instruments with the enhanced facility of an electrical output, some are reasonably priced - for instance the Relative Humidity meter (£138), Infrared meter (£170), Light meter (£110), Oxygen meter (£110) and pH meter (£149). However others are relatively expensive - Current (£105), Low Current (£105), Potential Difference (£110) and Temperature (£110). Lower priced instruments are available for these functions.

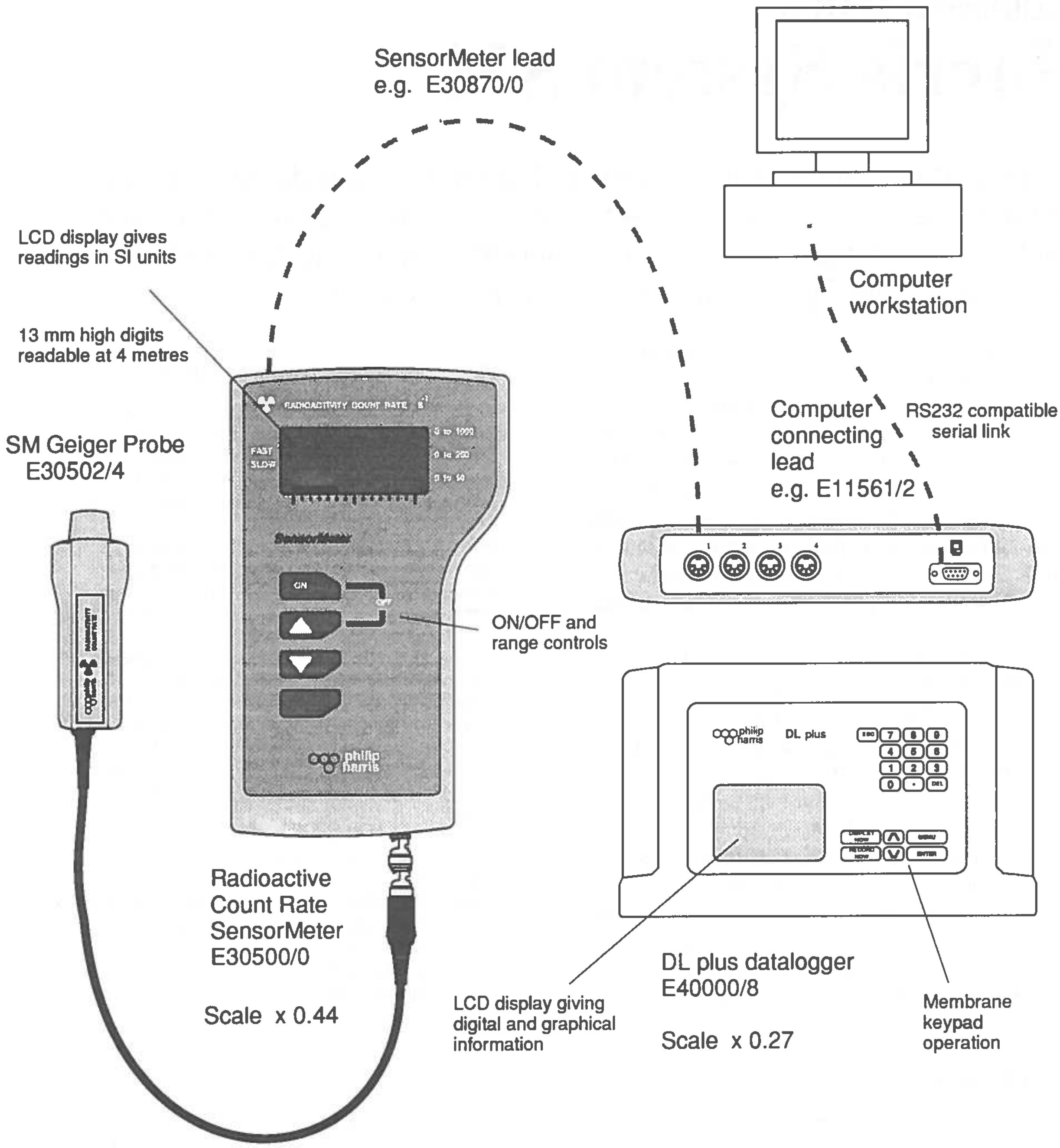


Figure 1 Schematic diagram of typical SM system showing probe, *SensorMeter*, datalogger and computer.

Rival datalogging systems cost less because they omit the *SensorMeter* stage. The direct reading instrument is unquestionably useful because in many applications either a single, or small number of, readings is all that is required. Had the system been designed with a single *SensorMeter* however, which had the capability to recognise any sensor probe to which it had been connected, then there should, potentially, be a great reduction in cost. The system, as it stands, is therefore relatively - and possibly needlessly - expensive.

Considering the technical specification of the *DL plus* datalogger, the provision of four analogue channels is generously adequate, but the lack of digital inputs is strange because some types of sensor, such as the light gate, send out digital signals.

The analogue to digital converter, being 10-bit, resolves signals to 1 part in 1024 of full scale. If the input is bipolar, the resolution reduces to 1 part in 512, or 0.2% of full scale. The uncertainty has not been specified by Harris. Presuming the ADC to be an industry standard chip, then the uncertainty in a reading may be about 0.4% of full scale for monopolar signals, or 0.8% of full scale for bipolar signals. Errors inherent in the sensors would augment these uncertainties.

The highest sampling rate is 16 kHz. Thus the maximum waveform frequency which can be detected is about 6 kHz. This encompasses most of the human range of hearing.

The performance of the ADC in the *DL plus* is thus satisfactory overall, but other products do better.

Data capture

The *DL plus* is prepared for capturing data by making a small number of key presses on its membrane keypad. The LCD display fails to cue the first step and the user has to select from one of four instructions on the keypad to prompt a response. After this first keypress, where necessary, cues are indicated on the display. Although initially confusing for a minute or so, the process is simple and does not take long to master.

Sensors connected to *DL plus* are recognised automatically. Data capture is both started and stopped by keypresses, or by a rising or falling input, or by the time. Readings can be read directly from the display, or crude graphs looked at. A datafile can be given a name by keying in alphanumeric data from the keypad into the datalogger, but this is tedious because of the restricted character set. Using the default filename is simpler.

Datadisc PRO was easy to install first time round into a computer (Toshiba Notebook, 120 MHz, running Windows 95). However finding that its curve-fitting facility was inoperative, we obtained a second version from Harris. In order to install this, some Microsoft files had to be edited, which made the second installation rather awkward.

Datadisc PRO is fairly straightforward to operate and can be used without tuition. Having the standard Windows system of pull-down menus and plenty of on-screen help, newcomers should generally be able to utilize most of its functions without too much difficulty.

Data is easily transferred from *DL plus* into the computer with *Datadisc PRO*. Graphs can be edited allowing you to select the part of interest and reject the rest. Quantities are displayed in SI units. There is insufficient contrast to discern clearly some characters or graphical features on the notebook's LCD display. Graphical data can be presented as a series of points, or interconnecting lines.

There is a curve smoothing facility and mathematical operations facility. With the latter, it would be possible to apply or remove an offset, or rescale, integrate, or differentiate. After a mathematical operation has been applied, the axis is automatically rescaled with the appropriate SI unit. For instance if a distance-time graph is differentiated with respect to time, the *y*-axis would be rescaled in $m\ s^{-1}$.

Generally *Datadisc PRO* is powerful in effect, but simple to operate. It does not however have all of the flexibilty one might expect. For example, tabulated data sets are automatically rounded off, whereas graphical data are not. This is fair enough for a first inspection, but a facility to access data to a greater precision than that provided should be available. A specific example of the system's inflexibility is discussed under the review of the Radioactivity Count Rate sensor.

Temperature *SensorMeter*

There are three temperature *SensorMeters* in the SM range : one for reading to 1000 °C with its Type K thermocouple, one for measuring temperature differences of up to 50 °C with a pair of point thermocouple sensors, and one for general laboratory use between -20 °C and +110 °C. It is the last of these that we have tested (E30660/0) - in fact we have tested two samples of the product.

The *SensorMeter* has the standard hand-held instrument case as in Figure 1, to which is attached a 295 mm stainless steel probe. The sensor type is not specified. Both sensors complied with the ±2% display accuracy specification, but do not comply with ±0.4% computer output accuracy. One of the sensors had a systematic error of between 0.3 °C to 0.5 °C; the other of between 0.7 °C and 1.2 °C, depending on which part of the scale was in use. In other words, each had a slight non-linearity. All in all, and for this sort of product, these performances are quite fair.

The probe is 295 mm long. We were concerned that this extreme length might cause problems. In fact it doesn't to any great extent. Only a small proportion of the probe needs to be immersed in a liquid to register true. If only 40 mm is under the surface, the reading is low by about 0.2 °C, which in most experiments would not be significant. Relating this to beakers of fluid, the probe can be used with confidence in samples as small as 200 cm^3 liquid in a 250 cm^3 capacity beaker. With lower volumes of fluid, the meter might read low or high.

We were concerned that heat might be conducted through the probe to the point of suspension. This effect was investigated and found to be negligible. The upper part of the probe can be held in any position without affecting measurements.

Because the mass of the probe is 24 g, it has a water equivalent of 2.4 g. Thus if put into 200 cm^3 water, the thermal capacity is altered by a little over 1% - a case of the measuring process affecting the system under observation. Usually this would be insignificant.

Finally we considered the probe's response time. Here we found that it takes about 20 s to reach 90% of its final value if immersed in water and 45 s to equilibrate. This is relatively slow for an electronic sensor and very slow compared with a mercury in glass thermometer.

The *SensorMeter* is battery operated, but may also be supplied from a mains adaptor (E30850/5) which can power up to four *SensorMeters* at the same time through a junction box (E30863/3).

Summarizing these findings, the Temperature *SensorMeter* performs quite well. However at £110 it is forty five times more expensive than a mercury in glass instrument providing an equivalent accuracy, and nearly four times dearer than Data Harvest's Temperature Sensor (6106 @ £29).

Radioactivity Count Rate *SensorMeter*

The Radioactive Count Rate *SensorMeter* (E30500/0) is a handheld portable meter connecting via a 1.5 m flexible lead to the System SM Geiger Probe (E30502/4), which may also be hand held. There is a signal outlet for transmitting data to a datalogger (e.g. *DL plus 32*). The count rate is displayed as 13 mm high digits on an LCD display on the *SensorMeter*. Because of the type and size of display, the instrument is really designed for individual usage, which would not be appropriate at Standard Grade, nor possibly even Higher Grade. Experimental work in this subject where classes include pupils under the age of 16, must be by teacher demonstration. If used for such demonstration, the digits are reasonably readable at four metres, but there is no means of setting up the *SensorMeter* to face an audience. Thus the *SensorMeter*, on its own, is inappropriate for teacher demonstrations.

The *SensorMeter* records count rate. The display period can be switched between 0.33 s and 3.3 s. The shorter display period is sufficient to register mentally. The longer is sufficient to be recorded in writing. It has three ranges. The resolution on the most sensitive range is 1% of full scale (50 counts s^{-1}), or 0.5 counts s^{-1}. If set to record the count rate from background radiation, most of the readings are 0 counts s^{-1}. There is an occasional blip to either 0.4, 0.8, or 1.2 counts s^{-1}. These increments reflect its nominal resolution of 0.5 counts s^{-1}.

Why was the instrument designed to read count rate rather than count? One of the basic learning experiences which is missed is an indication of counting. Counts mean integer values. Each count signifies a radioactive emission. The *SensorMeter* misses the easily assimilated and fundamental concept of counting these emissions. Ideally it should be able to measure both count and count rate. Given only one of these functions, the wrong one has been selected.

The GM tube is sensitive to alpha radiation from Am-241, but insensitive to gamma radiation from this source. Therefore, arguably, the performance of the System SM Geiger Probe (E30502/4) is preferable to the GM tube traditionally used by schools (Philips, ZP1481). The latter is relatively insensitive to alpha radiation, but quite sensitive to the low energy gamma radiation emitted by Am-241.

The GM probe is also suitably efficient at detecting beta radiation from an Sr-90 source and gamma radiation from a Co-60 source.

Standard experiments to which it may be used without the datalogging facility include :

- attenuation by air, or tissue paper on alpha radiation;
- attenuation by paper, perspex, or aluminium on beta radiation;
- attenuation by lead on gamma radiation and the determination of half-value thickness of lead for radiation from a Co-60 source.

Standard experiments for which the *SensorMeter* is relatively useless comprise all those where the count rate is very low. These include the measurement of background count rate, and the demonstration of the presence of radon in the atmosphere by testing for radioactivity on a sample of tissue paper through which air has been drawn for several minutes.

If the *SensorMeter* is connected to a *DL plus 32* datalogger, which itself is connected to a computer running *Datadisc PRO*, the system can log count rate versus time, displaying the count rate as a series of small crosses or squares. Thus if the probe was positioned at a fixed set distance from a standard source, you can readily show the random nature of radioactive emission as a series of marks scattered about some mean value with respect to time.

Nonetheless, we were disappointed that the software could apparently only handle the data as collected by the *SensorMeter* and data logger, which is organised as the count rate over a 1 s period. It would have been useful also to measure the count rate over longer periods so as to record the variation of background radiation with time. However this was not possible. This is the example of the inflexibility of *Datadisc PRO* we referred to earlier. Even *VELA*, God bless its aged soul, was sufficiently versatile to sample over almost any period asked for!

To illustrate this point. In the example of the count rate from background radiation (Fig. 2) most of the readings are 0.0 s^{-1}. But by plotting the integral against time, the total count over the 10 min logging period was found to be 71. Dividing this value by 600 gives the average for background to be 0.12 counts s^{-1}. It is a beautiful illustration of integration, but as a way of getting a value for background count rate it may well be too complex for the child of average attainment. The procedure with standard equipment of taking the count over a 100 s period is simpler.

In summary, the Harris System SM Ratemeter is adequate for most of the standard experiments with sealed sources, but not as a demonstration meter. The GM probe is adequately sensitive to the typical energies of alpha, beta and gamma radiation from sealed sources of the approved types for schools.

Description	Order code	Price (£)
Radioactive Count Rate *SensorMeter*	E30500/0	170.00
System SM Geiger Probe	E30502/4	115.76
SensorMeter lead	E30870/0	2.75
DL plus 32 datalogger	E40000/8	399.00
Computer connecting lead	see catalogue	15.00 or 20.00
Datadisc PRO (single user)	E49980/3	125.00
	Total	827.51
Scaler (Digicounter)	Y77680/7	457.54
GM tube ZP1481	Q88500/0	134.33
GM tube holder with cable	Q88510/3	116.55
	Total	708.42

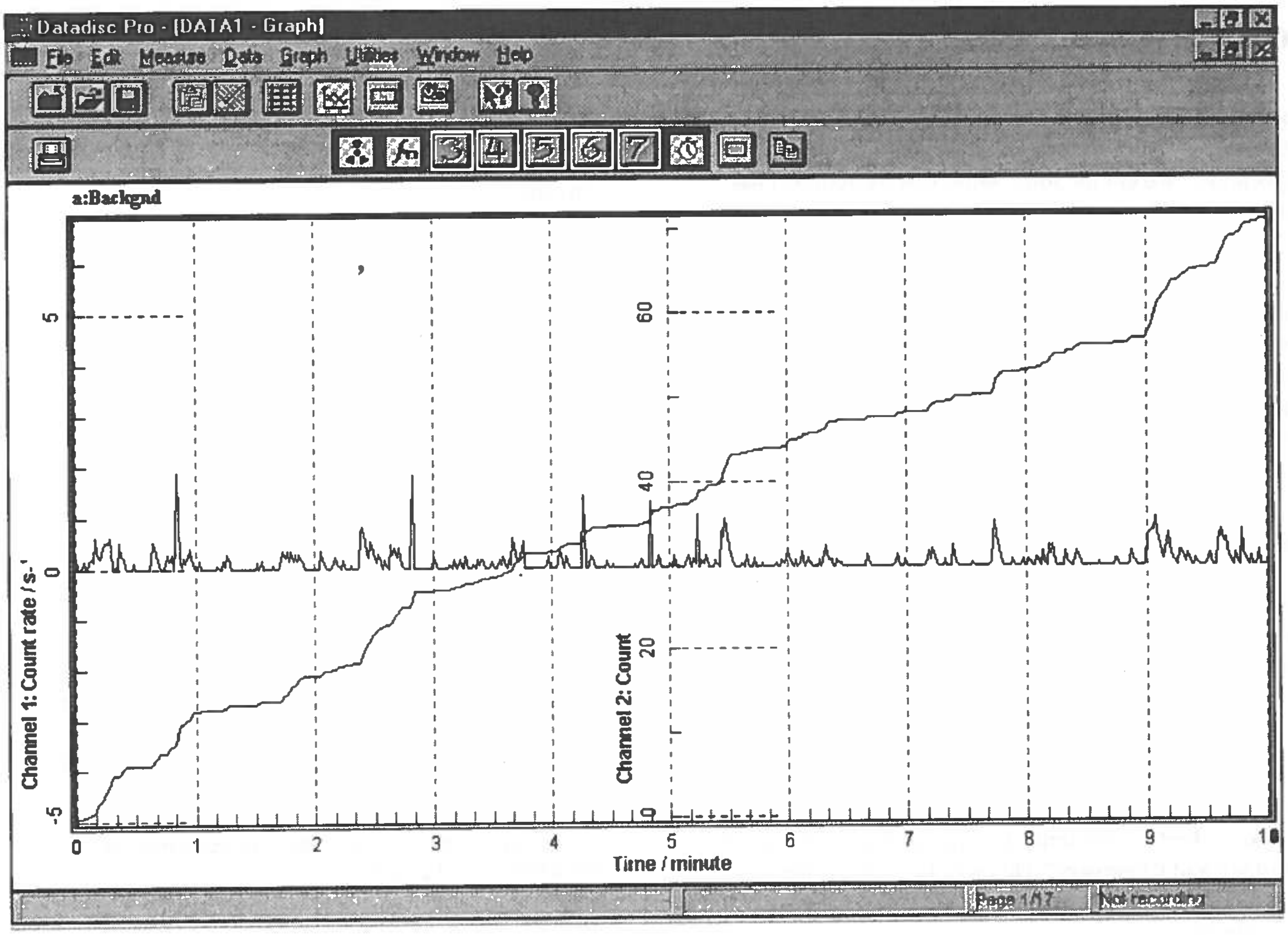


Figure 2 Graphs produced by *Datadisc PRO*. Channel 1 gives the actual output of the *SensorMeter* as a count rate versus time. Channel 2 has been derived as the integral of Channel 1 against time.

The image has been enhanced by converting grey tones into black.

Its specification though is frustratingly inflexible in not counting over long periods of time. Thus it does not allow an experimenter to monitor satisfactorily low level radiation from background, nor readily to experiment with radon.

The SM Ratemeter can be linked to a computer through a *DL plus* datalogger. Its positive features mainly relate to the facility to plot count rate versus time. By monitoring count rate from a sealed source at a fixed distance, the randomness of count rate is beautifully shown. Similarly both the randomness of disintegrations, and radioactive decay are effectively shown when monitoring the radiation from a protactinium generator (see following article). The facility to analyse data mathematically - whether in *Datadisc PRO*, or after transferral to other software - is also useful, but beyond the scope of current Standard Grade and Higher Grade syllabuses. Other positive features which should not be discounted arise from being able to process data in a computer environment. For instance graphs can be superposed, printed out, or shipped to worksheets or lab reports.

The cost of the System SM Radioactive Count Rate package (see list, opposite left) is not significantly more than that of traditional, standard apparatus - ignoring the cost of the computer. Note that each system has such other facilities they do not otherwise directly correspond.

General points

The connecting leads between a probe, *SensorMeter*, datalogger and computer are reasonably obvious to handle and fit together (Fig. 1).

The *SensorMeter* is powered by a 9 V PP3 battery. A manganese alkaline battery is specified to provide 60 h constant use.

The *DL plus 32* datalogger is powered by two batteries each of four 1.5 V AA alkaline cells. One of these batteries lasts for a long period. We find this to be the case. The current drawn from the other battery varies between 10 mA and 40 mA depending on the datalogger's mode of operation. These batteries have a capacity of 2700 mAh. Because those parts of the system that draw a significant current shut down automatically after a short period of inactivity - about 115 s - to conserve power, batteries should last for a reasonably long period.

Overall summary

System SM is satisfactory overall but good only in parts. Whereas other dataloggers seem to have been designed by science equipment experts and subject specialists, we get the impression that System SM has seen other influences.

It is generally the case that the design team for school equipment knows the subject inside-out. By paying attention to finer details, they would try to ensure that, if possible, the product's scope includes all of the standard activities to which such equipment might reasonably be put. Almost above all, we would expect any micro-processor based instrument to be versatile.

Consider some features of the Radioactivity Count Rate *SensorMeter*. It cannot be used by children with radioactive sources because of the regulations, yet has not been designed for teacher demonstration. It does not measure count; cannot measure background except by indirect means nor easily show that radon is a major constituent of air.

Did any physics teachers help to design it?

System SM is brilliant in concept, many of its features are superb, but it has too many flaws to be an outright winner. We therefore award it a *B* assessment for Physics. Perhaps it merits a marginal *A* assessment for Biology and Chemistry? This will become clearer once our evaluation of the pH and conductivity sensors is completed.

Assessment :

A Most suitable for use in Scottish schools and non-advanced FE

B Satisfactory for use in above.

C Unsatisfactory.

Summary : Harris System SM

- The whole package is easy to use; it performs well in part and can be configured to suit many experiments.
- The system includes a wide range of direct reading sensors for Biology, Chemistry, Environmental Science and Physics.
- The SM System with a datalogger and direct reading sensors is unique.
- Of the sensors tested, the Distance *SensorMeter* (now superseded) performs poorly, the Temperature *SensorMeter* performs fairly well, and the Radioactivity Count Rate *SensorMeter* performs well in part, but fails to measure background, and in our opinion measures the wrong physical quantity.
- The SM System is not directly compatible with other basic apparatus. Note that there is really no point in providing IT equipment without also providing good quality, basic equipment - it would be like offering butter without bread.
- The *DL plus* datalogger has a reasonably good technical specification, with which its technical performance complies.
- It has a remote logging facility.
- Readings are given in SI units.
- The *DL plus* recognises the type of *SensorMeter* attached to it.
- The computer software *Datadisc PRO* is powerful in effect and simple to operate. It is one of the system's main assets. However we have some niggling reservations.
- Tuition may not be required for persons acquainted with a Window's operating system.
- There are useful functions to aid analysis such as the curve smoother, mathematical operator, curve fitter, error bars and statistical functions.
- There is excellent on-screen support.
- *Datadisc PRO* runs on different platforms - PC Windows, PC MS DOS, Macintosh, RISC OS - but check with Harris because it does not run on some computer types.
- The technical specification of the system is satisfactory for all sciences, including Physics.

TECHNICAL NOTES

Analysing graphs

With many data capture systems, there is a mathematical modelling facility letting you fit a standard curve to a set of data. An example is discussed.

The data opposite (Fig. 1) shows the radioactive decay of the nuclide Pa-234. It was obtained with a Harris Protactinium Generator and Harris Radioactivity Count Rate *SensorMeter* and *DL plus 32* datalogger. The graph was obtained with *Datadisc PRO*.

Following the usual procedure, the generator was shaken for about 5 s and placed, inverted, beneath the Geiger tube. For an initial period of a minute or so (not shown) the count rate rises, indicating the separation by density of the two fluids within the generator. After that the count rate begins to fall, signifying that the Geiger tube is detecting radiation more or less exclusively from the Pa-234 nuclide. There will also be small contributions from background and from the uranyl nitrate held in solution in the bottom half of the generator.

The count rate was taken for a 10 minute period , being recorded in the *DL plus*. The file was then transferred to *Datadisc PRO* and displayed as a graph. The first minute was edited out to produce the version illustrated (Fig. 1). A curve of the form :

$$A = A_0 \exp(-\lambda t)$$

was fitted through the points. This is the curve shown in Figure 1.

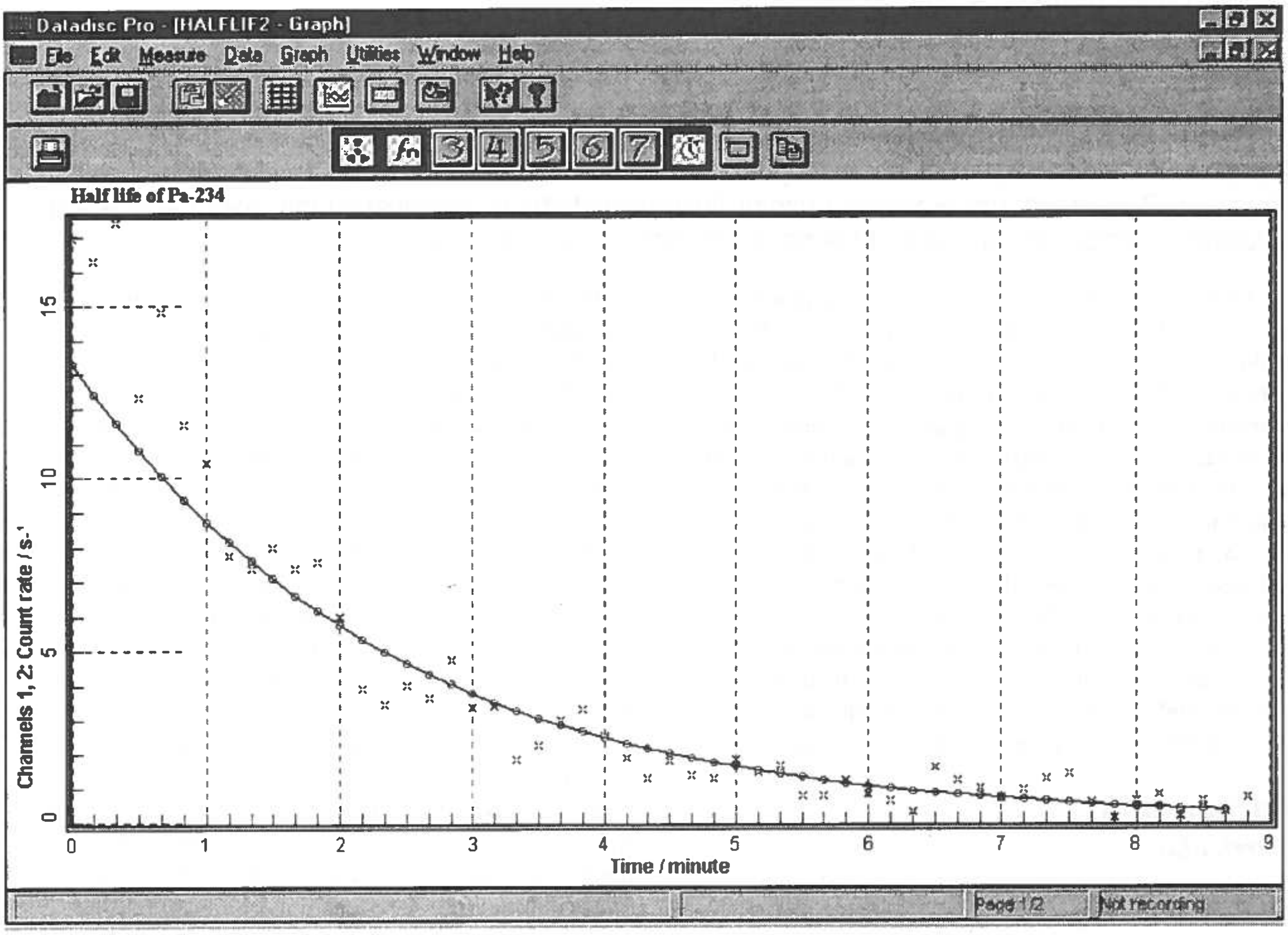


Figure 1 Graph produced by *Datadisc PRO.* Channel 1 gives the actual output of the *SensorMeter* as a count rate versus time. Channel 2 has been derived as the curve best fitting the data. Note that it lies below all of the data collected before 1 min.

The image has been enhanced by converting grey tones into black.

The value of λ generated by this analysis is 0.00702, which gives a half-life T of 98 s using the relationship :

$$T = 0.69 \div \lambda$$

However this value is far too high. The half-life value for Pa-234 given in the Radiochemical Manual is 71 s. There are two obvious alterations to consider making. Firstly there is background to subtract from the data. Background had previously been found to be 0.12 counts s^{-1}. Taking the contribution from uranyl nitrate to be about this also, we subtracted 0.24 counts s^{-1} from all the data. Secondly, because the derived curve lay below all the data plotted in the first minute of actual logging (Fig. 1), it would seem that the tail end of the data was exerting too strong an influence on the curve. We therefore edited out all the data between 5 min and 9 min and redrew the curve for the remaining data (from 0 min to 5 min). This gives a half-life of 72 s, in agreement with the accepted value.

Summarizing the steps we took :

1. Subtract the count rate due to contributions from background and uranyl nitrate.
2. Delete any data logged whilst liquids in generator were separating. (i.e. 0 min becomes point when separation complete).
3. Delete data after 5 min, by which time four half-lives have elapsed.
4. Plot exponential function through modified data.

The exercise shows that the user of mathematical facilities needs to apply judgement. The analysis is not automatic, but has to be done carefully.

We also question whether automated data capture and analysis by software is always helpful. If readings were taken off a scaler every 10 s and jotted down, then pupils would get practice in graphing the data, fitting a best curve through the points and finding a value for half-life. As such, it is a worthwhile exercise. Unlike the automated curve in Figure 1, it is probable that the curve drawn by eye would go through the first minute's data, providing the pupil with a value for half-life close to 71 s.

Automated data capture and graphical analysis are impressive and worth doing for their own sake. But manual labour is also worthwhile, and may well lead more directly to a good result.

Antibody-antigen interaction

A protocol included as part of kit developed at the Scottish Antibody Production Unit (SAPU) is described. The procedure provides a useful illustrative students' practical on the role of antigens in inducing antibody production and the nature of antibody/antigen reactions.

The protocol to be described is based on instructions provided with a Schools Kit for the Higher Grade Human Biology course. This kit is available directly from SAPU and costs £35 nett (ie plus carriage and VAT). It contains materials and instructions for a practical exercise allowing the visualisation of antibody/antigen interactions. SSERC have modified the procedures slightly. This was done in consultation with staff at the Scottish Antibody Production Unit (SAPU) who designed and produced the kit, and with colleagues who have used the earlier versions (see *Acknowledgements*). The rest of this page provides more detail for teachers and technicians. The facing and subsequent pages are intended for the use of students or as a basis for student materials of your own. Appended are : technical information, recipes, and acknowledgements.

Background

Curricular

A number of basic immunological principles are included in current Scottish Biology and Human Biology courses. Not surprisingly similar material is to be found in the Arrangements for Higher Still (for example see *Cell Function and Inheritance : cellular response in defence* in Higher Human Biology or the parallel entry under *Cell Biology* for the Biology Course).

Under such entries it would seem that none of the Learning Activities suggested specifically mention student practicals or investigations. This may have been because kits formerly available for practical work in immunology, for a variety of reasons, have been withdrawn from the market. The availability of the SAPU kit is thus both apposite and timely. The unit has now also produced a kit for an ELISA protocol on which we hope to report in some future issue. NCBE has also developed, or has access to, some relevant protocols and these too shall be reviewed in due course. Finally, we understand that SAPS (Science and Plants for Schools) at Homerton College are currently working on an ELISA protocol.

Theoretical

Antibodies are special proteins produced by the types of white blood cells known as lymphocytes. Antibody formation is triggered by the presence in the body of foreign materials known as antigens. Typically, *antigens* are complicated molecules such as proteins or sometimes carbohydrates. For example, a protein coat surrounding a viral particle would be likely to have an antigenic action and trigger the production of antibodies. Similarly the sera or other body fluids of one animal will contain many types of molecule which would be 'alien' to another, even of the same species, and thus have an antigenic action.

This is obviously of great importance in organ transplant technologies as well as in familiar blood transfusion, serum transfer or infection prevention and control by vaccination or immunisation techniques. One way in which antibodies act is by binding to the antigen at a specifically shaped receptor or binding site, the two molecules becoming locked together. This prevents the antigen exerting any further harmful effect for example by interfering in the normal metabolism of the organism it has entered. The increased size or changed shape of the resulting antibody/antigen combination under certain conditions can lead to its precipitation. This can be easily shown *in vitro* especially if the antibody and antigen are present in near equivalent proportion. This is one of the basic principles behind the visualisation technique used in the SAPU human biology kit.

Some antibodies are secreted as free molecules (by B type lymphocytes) into the blood serum or lymphatic fluid. Others may remain bound to the cells which produce them (T lymphocytes or T cells) and are thus carried to sites of infections or other immuno-challenges by the cells which made them. Following the initial response to antigens, and their eventual removal from the system, a few B and T cells remain in the body as so-called *memory cells*. Should a previously met antigen be re-encountered the production of antibodies against it is then more rapid and on a much greater scale. This is the basis of a *naturally acquired, active immunity*.

If a mammal is deliberately injected with antigens (or non-virulent sources thereof, such as a heat treated or otherwise debilitated bacterium or virus) antibodies will be formed in its sera. Such a mammal would then have an *artificially acquired active immunity (*ie it is said to have been *immunised).* Its blood is also a potential source of antibodies. These may be extracted and injected into another species to give *artificial passive immunity.* Antibodies can also have value for other clinical uses or in research.

Antibodies usually are highly specific. Each of the thousands of types of mammalian lymphocytes may only recognise and respond to one type of antigen. It might be thought then, that the preparation of vaccines etc from treated blood sera should be simple. Unfortunately, and as usual, in practice it is not quite so straightforward. When one mammalian species is exposed to a particular type of antigen from another species it may produce antibodies to that protein type not only from the species to which it has been exposed but possibly from others to which it was not so exposed. This is called *cross reaction* and is the second basic principle illustrated by activities in the kit.

Introduction and background

ANTIBODIES are special proteins produced by white blood cells called lymphocytes. They may be secreted into the plasma by *B type lymphocytes*[1] or attached to the surfaces of *T type cells*[2].
In either case the antibody molecule has specially shaped regions (receptor sites) which fit onto and bind with foreign proteins or carbohydrate molecules - ANTIGENS - which might cause infection or allergies or otherwise interfere with normal cell chemistry etc. By binding with foreign substances like this, (or in acting in other ways) antibodies can render them harmless. (See Figure 1. For a more detailed explanation refer to your teacher or to texts eg Torrance or Clegg & McKean).

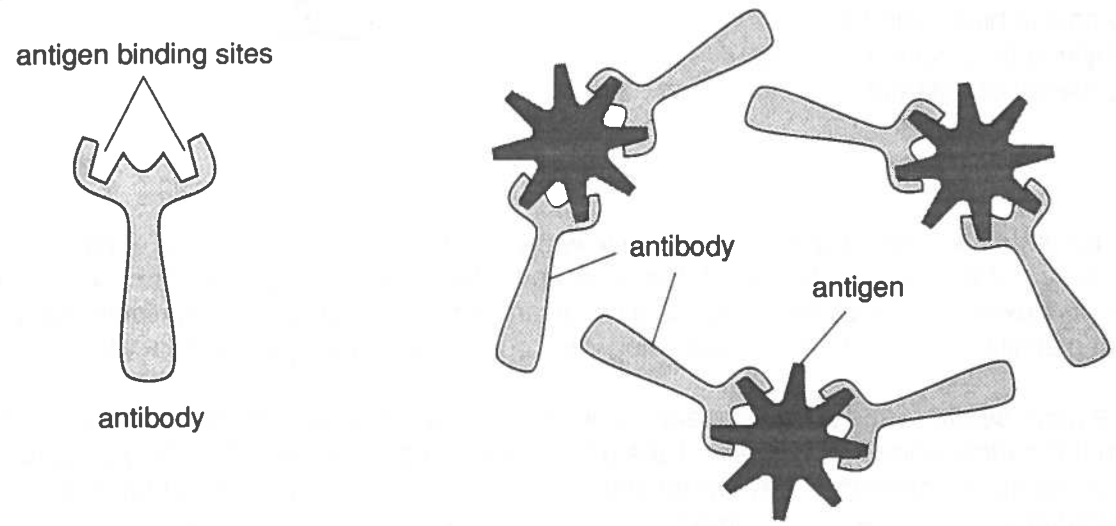


Figure 1 Schematic diagram illustrating the receptor sites on 'Y"-shaped antibody molecules and binding to antigens.

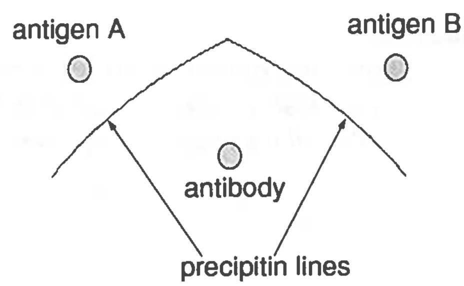


Figure 2 Formation of precipitin lines in a gel

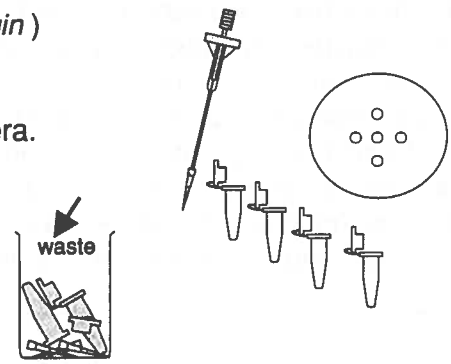
Antibody production in the blood of mammals can also be stimulated by deliberately introducing antigens, by injection or similar means. The antibodies so produced can be extracted and purified for use in vaccines etc. It is also possible to use sera (blood fractions without red cells) which have been exposed to antigens to demonstrate the interaction of an antibody with its antigen. This is one of the procedures which you can carry out with the SAPU Human Biology Kit. The idea is to place the antibody and the source of antigen into wells (holes) in an agar plate. Each can then diffuse outward.
Providing that both are in roughly equal proportions when they meet, they will cross-link to form even larger molecules. The result is that the complex which forms ceases to move through the medium, precipitating instead as a solid. It then appears as a visible line (a precipitin line) in the gel. For example, in Figure 2 precipitin lines have formed between an antibody and two antigens - A and B. Note that in this case the lines fuse, suggesting that the antibody precipitates both. The antigens are therefore the same - ie there is complete identity.

In the activities which follow you will use serum from a donkey which has previously been exposed to a blood protein - a type of immunoglobulin called IgG - from sheep and goat. This is then exposed to antigens in sera from various species. The reaction between the donkey antibody and the relevant antigen can be observed directly by allowing it to proceed in a gel. To further illustrate, and hopefully clarify, the processes of antibody production and interaction; donkey sera itself is included. There is also a fourth serum to which the donkey has NOT been previously exposed.

Footnotes : [1] B-type lymphocytes - *bone* marrow derived [2]. T type lymphocytes - originally *thymus* derived.

Collect

A plastic Petri dish with 2% agar agar (with a trace of *Nipagin*)
Pasteur pipettes or micropipettor and tips
5-hole template (for removing gel to form wells)
Four Eppendorf tubes - donkey, sheep, goat and bovine sera.
Beakers and a 'discard' jar (with disinfectant for some items of used equipment)
2% Harris lab disinfectant (clear phenolic) or equivalent
0.9% saline solution
Optional
Coomassie blue stain OR
methylene blue stain (alcoholic)
Two pieces of polaroid



Method

1. Using the template (see Figure 3) take out five wells with the wide end of a glass Pasteur pipette (taking care not to stab your hand with the other end!). Remove the plugs with the fine end of a pipette and lower (not drop) them into the disinfectant in the discard jar. (Alternatively use a cork borer of a similar size, flaming it and allowing it to cool between taking out each well).

2. Use the micropipettor (and a fresh tip each time) to dispense 30 µl of each of the sera into the wells in the pattern shown in Figure 4. Take pains not to overfill the wells. Carefully discard each used tip into the disinfectant. They will be sterilised later for reuse. [If you do not have a micropipettor you can use two or three small drops from a fine Pasteur pipette].

3. Replace the lid on the completed plate and leave it undisturbed at least overnight.

Results

Sketch the pattern of lines which have appeared.
(If you wish to stain the plate and dry it to preserve your results for a while, then follow the additional instructions opposite).

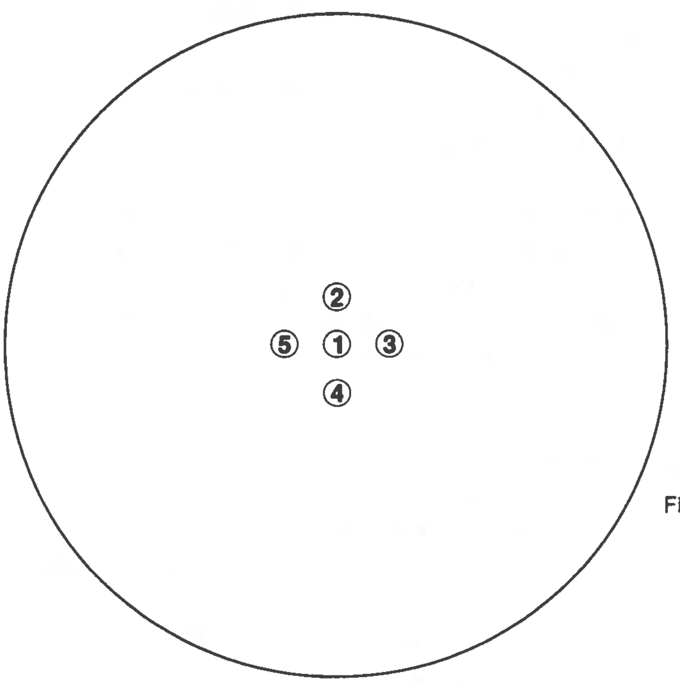


Figure 3 Template (actual size) for a 90 mm diameter Petri dish.

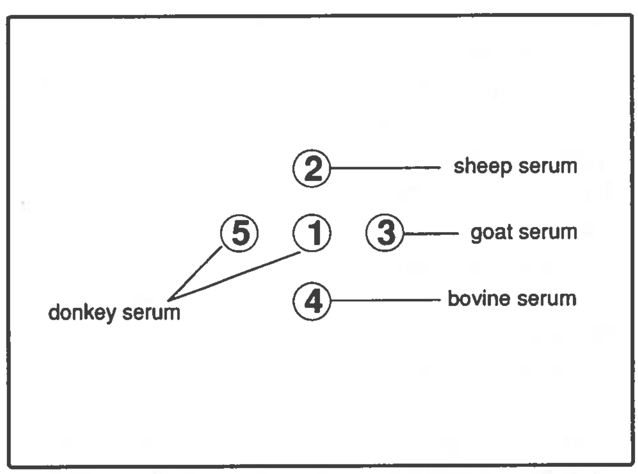


Figure 4 Centre of template approximately twice the actual size and showing the suggested pattern of loading the various sera into the wells cut in the agar gel. Approximately 30 µl of each of the sera is loaded into each of the different wells as shown. The donkey serum in both wells 1 and 5 carries the antibody IgG produced in response to exposure to immunoglobulins from sheep and goat.

Questions and further ideas

1. *How do you account for the lines : what are they and how have they formed? Why is there no line between wells 1 and 5? What is the name for this lack of reaction?*
2. *The donkey had not been previously exposed to bovine material (ie from cattle). How do you account for the line between wells 1 and 4 (this is called a Cross Reaction)?*
3. *What do you think the above observation (question 2) might mean for vaccine development or for the production of antibodies for clinical or other uses? What are "monoclonal" antibodies?*
4. *What patterns do you think might emerge with pairs or other groupings of these sera? Design and carry out further investigations to test your hypotheses.*

Drying and mounting gel plates

1. Flood the gel plate (still in the Petri dish) with 0.9% w:v saline solution and leave overnight to leach out unreacted proteins.
2. Pour off the saline solution and place two or three 90 mm diameter filter paper discs on the top surface of the gel. Put a 100 g mass on top of the papers to minimise crinkling of the gel.
3. Gently dry out the gel further in an incubator or similar at about 25°C until it shrinks away from the sides of the Petri dish. With a broad bladed spatula (eg a *Chattaway* type) carefully remove the plate from the dish. Place it between two pieces of plastic film (eg Parafilm or a piece of Copy Pocket) and mount it or file it in your lab book.

Appendix : technical details etc

The Human Biology Kit is available from SAPU at the address listed on the inside rear cover of this issue. A kit contains more of each of the sera than needed for one class. They may however be stored frozen. We dispensed them in suitable volumes (100 µl to 200 µl of each serum in each tube) into freezer batches of labelled Eppendorf tubes. To do so we used a micropipettor (eg SSERC Item 849 see page 32).

Recipes : *Agar plates* - a 2% w:v gel prepared and poured as usual but with the following modification.

Add 1 g of Nipagin (mould suppressant used for Drosophila media) to 50 cm^3 of water with a few drops of industrial methylated spirit (IMS) warm and stir to dissolve; add the resulting solution to 450 cm^3 of distilled or deionised water with 10 g of agar-agar thereafter proceed as usual to autoclave and then aseptically pour the plates.

The nipagin is needed to suppress mould growth if students are to dry the plates and keep them in their lab practical files. In our trials, it definitely stopped mould growth but did not seem to interfere in any way with precipitin line formation.

Pipettes : If you have an NCBE/SAPS DNA kit then the simple micropipettors and tips supplied therein are useful also for dispensing sera into wells in this present protocol. Else use a Pasteur pipette and guesstimate 30 µl as one or two small drops. (See above also for batching sera).

Staining : It has been suggested that the precipitin lines may be more obvious when the plates are stained (after treatment with saline and before drying). Various stains have been trialled at SSERC including : amido black (naphthol blue-black), alcoholic methylene blue or the coomassie blue used for staining DNA fragments (in recent NCBE/SAPS kits). In our view, none made any significant difference to the contrast between the lines and the plate, especially when the gel was back-lit. Staining thus seems an unnecessary extra step. It may also confuse students since with some stains a distinct four lobe pattern is formed. This is not connected in any way with the investigation but is merely a product of lateral diffusion of the stain via the sides of the wells. It thus may introduce unwanted 'noise'. We did discover that the precipitated protein complexes are weakly birefringent (ie doubly refracting). The lines thus may be more obvious when the plate is placed between polaroid filters.

Safety : There are no significant, uncontrolled risks provided that the precautionary measure given in the kit notes are taken.

Acknowledgements : Firstly to Marjorie Hamilton, Technical Officer at SSERC, for all her bench work and the drafts of this article. SSERC is also extremely grateful to the Scottish Antibody Production Unit for co-operation in its preparation. In particular we would thank Dr Laura Bence for her patient explanations and repeated, good humoured, assistance. Thanks are also due to colleagues at The Lab at Strathclyde University Jordanhill Campus and at Hamilton Grammar School. The former brought the SAPU kit to our attention and the latter shared their experience of using the kit with students.

EQUIPMENT NOTES

Laboratory power supply

The Irwin Central Power Source has been designed to supply a whole laboratory with a low voltage supply.

On this page and the next are given a description and technical assessment of this apparatus. Thereafter, in a related note, some wider educational and technical issues are discussed.

Performance :

1. *Operation :* The apparatus has been found to work reliably and effectively. It complies with its specification of delivering 30 A d.c. at 15 V continuously.
2. *DC smoothing :* The DC supply is very effectively smoothed. At maximum loading, drawing a current of 30 A, the output supply voltage of 8.8 V d.c. r.m.s. has an a.c. ripple of 0.55 V a.c. r.m.s. This is unusually small for school power supplies. One benefit is that d.c. reading voltmeters and ammeters used by pupils on the d.c. supply will not give erroneous values caused by excessive a.c. ripple.
3. *Load line :* The supply voltage falls with load from 12.1 V at 0 A to 8.8 V at 30 A. Relative to other laboratory power supplies, this reduction in voltage with current is quite small, and better than most. However it may still cause difficulties. For instance if 10 rayboxes were to be supplied, each 12 V, 24 W, then as they are connected one by one, the lamps become far too dim without some readjustment of the supply voltage. Or if the supply is readjusted to give 12 V at 20 A (for 10 lamps), then as the rayboxes are disconnected one by one the final lamp to be disconnected would be running at 14 V. This will certainly reduce the life of the lamp, if not fuse it there and then. The teacher operating the supply has to be wise to this effect and respond to minimize the difficulty.
4. *Overcurrent cut-outs :* If the supply was gradually loaded up, the cut-out operated reliably at about 36 A at maximum trip setting.

   If the supply was left to run at 35 A continuously on maximum trip setting, then the cut-out usually operated within an hour. Pressing the reset would switch on the supply again.

   Operation of the cut-out at other trip setting levels was tested and found to be reliable.

   If the supply was badly overloaded, such as by a short circuit across the outlet, the cut-out always acted instantly.

   If the supply outlet was shortcircuited while the supply was off, then on attempting to power up, the main fuses on the 230 V supply blew (two 5 A fuses in series).

   We did not experience any other difficulty from overloading or shortcircuiting. The automatic trip was always effective except in the instance of trying to power up with a short across the supply outlet.
5. *Panel meters :* The ammeter reads about 5% high. The voltmeter reads about 2.5% high. The voltmeter readings are the more critical of the two. Since the voltmeter error is less than 5%, it is unlikely to cause an operational problem.
6. *Temperature rise :* The temperature rise after continuous operation for 1 h at full load (30 A at 12 V) was 13 °C maximum on the enclosure exterior. This is insignificantly low and very satisfactory.

   Disengagement of the cooling fan does not lead to danger.
7. *Poisonous and injurious gases :* Noxious gases were evolved from the apparatus during the first few hours of operation. The apparatus was then placed in a fume cupboard and run for a further 10 h. Thereafter the evolution of unpleasant odours was insignificant.

   We advise running the unit on full load continuously for 8 h in a fume cupboard on delivery to prevent fumes being released into classrooms.

Assessment

Technically the Central Power Supply is suitably well engineered and performs satisfactorily. We trust that the structural problem with the frame during transit has been addressed by better, appropriate packaging. The evolution of fumes during the initial period of running is a nuisance which can be easily controlled. The product merits an *A* assessment technically speaking.

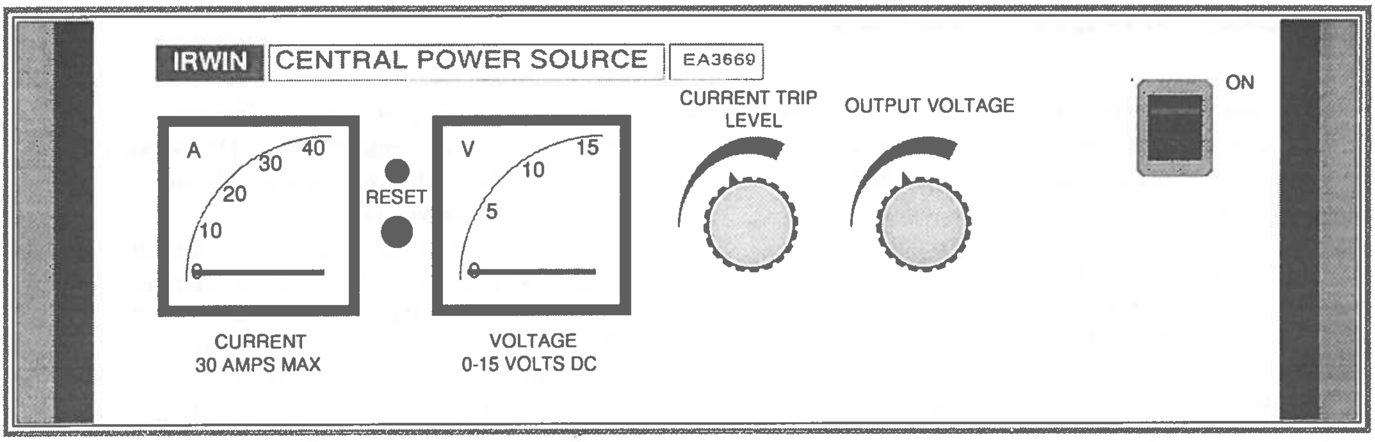
However this rating has to be tempered by our remarks overleaf on this type of power source. It is our judgement that portable units are preferable. In our view, generally a central source is inappropriate.

Assessment scale :

A Most suitable for use in Scottish schools and non-advanced FE

B Satisfactory for use in above.

C Unsatisfactory.



Function : Isolated low voltage power source for supplying sets of outlet terminals, wired in parallel, on laboratory benches.

Specification : Continuously variable outlets up to 15 V d.c. smoothed. Maximum current 35 A d.c. continuous. Outputs not referenced to earth. Functional earth socket not provided.

Circuit : The supply is taken to a variable transformer (output = 0 - 230 V), from where it goes to an isolating transformer. The maximum voltage which this can deliver is 15 V a.c. The right hand control knob on the front panel operates the variable transformer's output. The left hand control knob sets the trip current level, which is variable between 5 A and 35 A.

The isolating transformer is protected by a fuse and electromagnetic cut-out operated by an electronic circuit.

The supply is full-wave rectified DC with capacitive smoothing.

Construction : Robust composite enclosure in steel and aluminium. Built to Class 1 electrical safety standard. Complies with IEC 1010-1 on electrical safety, except that, on both the units we inspected, the frame had buckled because of impact stresses during transit. We understand that Irwin have strengthened the packaging to prevent such damage from recurring.

Anti-tamper mechanism : The front panel with the controls is covered with a lockable, hinged door, which is manufactured from tough, transparent plastic.

Enclosure : multi-part steel enclosure with internal aluminium framework and steel reinforcing. Exterior is stove enamelled in shades of mid and pale grey.

Dimensions : Width 535 mm, depth 340 mm, height 180 mm.

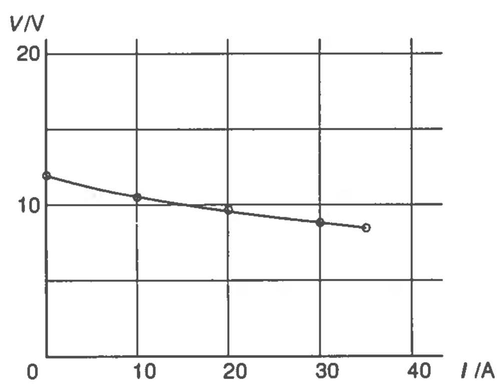
Weight 23 kg. No carrying handle, but side framework is an aid to lifting. This is not a portable instrument - transportable rather than portable.

Detachable mains cord with IEC connector.

External mains fuse on IEC chassis plug on rear panel.

Overcurrent protection : fuse and electronic trip operating an electromagnetic cut-out on primary supply. Trip current level settable up to 35 A

Outlets : heavy duty screw terminals on rear panel.



Load-line beginning at 12 V off load. Output is continuously variable from 0 V to 15 V DC.

Laboratory power supplies : portable units versus single source

In appraising the Irwin *Central Source Power Supply* we need to look beyond narrow questions of whether the unit is electrically safe and performs to specification, important though such issues are, to the wider matter of replacing lots of small, portable, power supplies with a central laboratory source. Thirty years ago the question was often put the other way round. Then the installation of a single, central source had been commonplace. The experience of many operational problems led teachers to question this type of power source. From that experience, nearly every school now relies on portable units.

The arguments for and against either type are complex and relate to educational, technical and financial issues. Here are some (expressed for and against a central unit) :

Financial : One central supply per lab costs less than lots of portable units?

PRO: Only one unit per lab needed.

Not portable, therefore unlikely to get damaged and should stay in service for a longer operational period.

School has fewer appliances to service.

ANTI: Because a central power source is not portable, every laboratory would need to be provided with one whereas portable units can be shared out amongst lots of laboratories allowing economies of scale. For instance, to equip six labs would require either seven central power sources (including one backup) or perhaps twenty portable units at a nominal cost of £100 a unit, viz.

7 x £1179	= £8253	(Central)
20 x £100	= £2000	(Portable)

There are costs of installing and maintaining transmission lines to benches to add to the amount for central sources.

Costs to be added to the portable amount include a higher rate of depreciation, and a greater number of units for testing and repair.

Generally, portable supplies cost less to provide.

Educational : If we reduce the scope for mischief-making, schools can get on with teaching, can't they?

PRO: The teacher has a very tight control over practical work because he or she sets the voltage that every pupil works at.

Pupils cannot hike up the voltage such that components are burned out.

Encourages lock-step teaching where every pupil is doing the same practical activity.

ANTI: Prevents different groups doing different experiments at the same occasion. Discourages a flexible approach to teaching methods and laboratory management.

Treats pupils as being irresponsible. Teachers who expect the worst of their pupils often find that their pupils behave badly. Might it not be better to expect the best from pupils thereby teaching them to behave responsibly.

The experience of making a silly mistake and taking the consequences from such action is in itself a useful learning experience. Setting the supply voltage to the right level and appreciating the consequences that may result in too high a value being chosen are learning experiences with which schools should provide children.

Technical : Socket outlets on every bench delivering an LT supply seems more elegant than providing lots of portable units?

PRO: Takes up very little bench space. Saves space for other activities.

Avoids the continual portering of electrical supplies. This saves time and prevents much mechanical damage to mains apparatus which would otherwise occur. Is therefore less risky.

ANTI: Full loading causes outlet voltage at the supply terminals to drop by 3 V. Therefore loads would not operate at correct power rating. This problem will be worsened by the voltage drop across transmission lines to benches which will also occur on full loading.

If the trip on the Central Power Source is set at 30 A, there could be localized overheating on the transmission lines. The lines are liable to perish by overheating unless individually protected by fuses or other overcurrent devices.

Transmission lines and bench outlets would be susceptible to damage by vandalism.

Nuisance tripping affects everyone in the lab. This would be a significant menace to the operation of programmable devices.

Electrical noise generated by one activity would be passed through the transmission lines to everyone else.

On balance, the advantage lies with portable units.

EQUIPMENT NOTE

Micro-centrifuge applications

An evaluation of a pre-production prototype of an inexpensive micro-centrifuge developed through the Technology Enhancement Programme (TEP) is briefly reported. School based, biochemical applications are suggested.

As part of TEP activities, Professor John Cave has designed, and will produce, an affordable high-speed micro-centrifuge for the educational market. SSERC agreed to examine and report on a prototype of the device. CLEAPSS, NCBE and the SAPS team at Cambridge have also, we understand, examined and commented on samples. The device is known as the SAPS/NCBE/TEP Microcentrifuge and will be marketed through NCBE. A full technical evaluation and test report on the final production model will be made by SSERC in due course.

Technical description

General : The device is cylindrical, being constructed from high density alkathene water supply pipe, of external diameter ca. 123 mm and internal 100 mm. It is approximately 180 mm high measured from the bench surface. It is closed at the base and top by aluminium sheet discs. The top disc acts as a lid and has a central black plastic, spherical knob acting as a handle. The lid is held in place by three threaded rods which also function as an interlock - see below. The base is fitted with three plastic feet. The eight-place, lightweight alloy rotor is angled and 60 mm in diameter. It takes Eppendorf or similar micro-tubes.

Electrical : The rotor is driven via a shaft by a low-voltage motor in the sealed basal compartment. There is a flexible seal of neoprene (or similar material) between the rotor chamber and the motor housing. The electrical supply to the motor may be either from its own internal battery at 6 V or via a 'jack' type socket near the base. This can be fed from an external mains to low voltage supply of an approved type at 6 to 12 V. Maximum current is 1 A.

Mechanical safety : The lid is interlocked using a simple yet elegant, time-delay bolt, mechanism. In the prototype this relies on three, part insulated, part conducting, threaded rods which pass through holes in the lid into matching holes in the wall of the body of the centrifuge. Electrical contact is made between two of these rods via the lid. The circuit is however only completed when two of the rods have been screwed fully home into the body. This means both that the motor cannot normally start until the lid is in place and that it has come fully to rest before the lid may be opened.

Unfortunately in the prototype examined it proved, given minimal scientific awareness, all too easily to circumvent the interlock. A metallic rod (such as a screwdriver shaft) or other conducting device of sufficient length could be used to short across the relevant rods. Even in the absence of the lid this completed the circuit. The motor and the rotor started up. Such subversion of this safety feature is easily prevented by attaching at least one relevant bolt permanently to the lid (ie making it a *captured* bolt). TEP are aware of this relatively minor problem. We were given to understand that in the production models all three delay bolts will be captured.

Capacity and efficacy : The eight place head will take capped Eppendorf tubes each of which should comfortably accommodate 1 cm^3 of liquid (1.5 cm^3 max.) ie 8 - 12 cm^3 in total if all eight stations are used. Despite first impressions, we found this total volume more than sufficient to meet the requirements for two common practicals (the Hill reaction and DNA extractions see below). In addition there is positive educational merit and purpose in making pupils and students of biology and chemistry more familiar and comfortable with working at the microscale.

As to efficacy and rapidity of separations : John Cave's design is as impressive as it is imaginative and innovative. The speeds of rotation achievable with such a small diameter, lightweight, angled head are remarkable. This is so even at 6 V with the internal battery.

Supply and price : The NCBE is likely to act as the educational agent and supplier for the device. The price will be relatively low - probably about £100 or less - for UK schools, with a higher price overseas and for research or Higher Education users. It is important to stress that this effectively means that schools could purchase five or more of these microcentrifuges for the price of an equivalent, more conventional, mains-powered, model. The major potential source of breakdown with any centrifuge is the motor. Spare motors will thus be made readily available, also at low cost, to schools.

Applications

In trialling the prototype we used it to carry out two operations which are needed for popular school practicals. These were: the isolation of chloroplasts prior to their resuspension to demonstrate the *Hill Reaction* and the spinning down of DNA extracted from plant material such as cress or peas prior to cutting it with endo-nuclease enzymes and separation of the fragments by electrophoresis. In both cases the microcentrifuge was more than up to the task. When it was powered at 12 V from an external supply it was possible to cut the usually recommended centrifugation times by at least half. It is likely that the isolation of other organelles, even mitochondria, will now be feasible in schools. If more detail is required please request a copy of the full report from SSERC.

EQUIPMENT NOTES

Digital multimeters

A report on inexpensive digital multimeters.

Multimeter model	Supplier	Order code	Price (£)	Special or quantity discounts		
Rapid 208	Rapid	85-0676	8.50	7.90 (5+)	7.40 (10+)	6.80 (25+)
Rapid 318	Rapid	85-0719	19.90	18.70 (5+)	17.90 (10+)	17.20 (25+)
Rapid 328	Rapid	86-0670	33.00	30.70 (5+)	28.70 (10+)	26.40 (25+)
Rapid 925	Rapid	85-0721	23.05	21.70 (5+)	19.95 (10+)	19.40 (25+)
Rapid 935	Rapid	85-0702	26.90	25.70 (5+)	24.50 (10+)	23.90 (25+)
Rapid 955	Rapid	85-0732	29.50	27.50 (5+)	25.70 (10+)	23.60 (25+)
Bosstek DT 9330	RMR Measurements	DT9330	29.00	less 10% educational discount		
M 215	Maplin	KW10L	21.69	17.29 (5+)	15.81 (10+)	
Academy PG 017	Maplin	GW24B	42.54	29.95 (5+)	26.99 (10+)	

Table 1 Multimeter suppliers, order codes and prices.

Scope

All of our sample of digital multimeters (DMM) (Table 1) are at the bottom end of the market where, because they do not cost very much, they are likely to be of interest to schools and FE colleges.

Some of the meters we recommended in 1993 [1] are still available and worth considering. Details of these can be found at the end of this report.

Because there are far more multimeters on the market than the Centre can possibly test, there may be meters you are interested in buying but which have not been tested by us. We therefore offer, within reason, and if feasible, to test any other model of meter for a school at their request.

Functions

A review of curricular requirements for science and technology courses was given in our first multimeter test report [2]. In summary, measurement of a.c. and d.c. current and voltage, and also resistance, are the main required functions. Table 2a shows which meters have these basic functions.

Provided you already have a class set of meters with all of these functions there may be a financial benefit from buying another set of meters with a restricted range of functions - perhaps missing out on a.c. current only, or both of a.c. and d.c. current.

Of the extra functions (Table 2b), continuity testing is certainly very useful. Logic level testing is of limited use in digital electronics, and does not feature in this batch. Capacitance measurement is occasionally wanted, but this function clutters up what is usually already a very crowded set of markings. And so does frequency measurement. This function is becoming more common and, we are pleased to find, more accurate.

Features

The following comments relate to data given in Tables 3a and 3b.

Key : N = no Y = yes

Common terminal : Avoid meters with a common terminal for V, mA and Ω ranges. The common terminal raises the chance of mis-use, leading to more nuisance fusing than on meters with separate mA terminals.

Fuse protection : In most circumstances, the lack of fuse protection on the 10 A or 20 A range is not a nuisance, since few laboratory power supplies can deliver currents greater than 10 A. However if a multimeter were to be used for measurements on the mains supply, or indeed on any hazardous live supply, all the current ranges should have fuse protection. Because there is a risk of mis-use of test equipment in schools, it would be good practice to buy only those meters that were fully fused on all current ranges.

Battery current : Apart from two Rapid DMMs, *208* and *328*, battery current drawn is reasonably low.

Auto power off : This feature is found on three models.

Range selection : All the autoranging meters show the appropriate SI unit on the LCD display. This is excellent. The key means :

A = autoranging M = manual switching of ranges

Markings : Markings must not be ambiguous. Any meter with a switch setting showing two different ranges or functions is given a lower assessment. The key means

A = clear; B = tolerably clear;
C = unclear, significant chance of misinterpreting

Number of digits : Six of the displays have 3½ digits, meaning that the maximum value is 1999. The other three have 3¾ digits, reading to 3260.

Multimeter model	Voltage DC	Voltage AC	Current DC	Current AC	Resistance
Rapid 208	200 mV - 600 V	200 V, 600 V	200 µA - 10 A	-	200 Ω - 2 MΩ
Rapid 318	200 mV - 1000 V	200 mV - 700 V	20 µA - 10 A	200 µA - 10 A	200 Ω - 200 MΩ
Rapid 328	200 mV - 1000 V	2 V - 700 V	2 mA - 200 mA, 20 A	20 mA, 200 mA, 20 A	200 Ω - 200 MΩ
Rapid 925	320 mV - 600 V	320 mV - 600 V	320 µA - 320 mA, 20 A	320 µA - 320 mA, 20 A	320 Ω - 32 MΩ
Rapid 935	320 mV - 600 V	320 mV - 600 V	320 µA - 320 mA, 10 A	320 µA - 320 mA, 10 A	320 Ω - 32 MΩ
Rapid 955	320 mV - 1000 V	320 mV - 1000 V	320 µA - 320 mA, 10 A	320 µA - 320 mA, 10 A	320 Ω - 32 MΩ
Bosstek DT 9330	200 mV - 1000 V	200 mV - 700 V	200 µA - 10 A	200 µA - 10 A	200 Ω - 20 MΩ
Maplin M 215	200 mV - 600 V	200 V, 600 V	200 µA - 200 mA, 10 A	-	200 Ω - 20 MΩ
Academy PG 017	200 mV - 600 V	200 mV - 600 V	2 mA - 200 mA, 10 A	2 mA - 200 mA, 10 A	200 Ω - 20 MΩ

Table 2a Multimeter functions : basic functions *V*, *I* and *R*.

Multimeter model	Capacitance	Frequency	Temperature	Diode	Continuity	h_{FE}
Rapid 208	-	-	-	Y	Y	-
Rapid 318	-	-	-	Y	Y	Y
Rapid 328	2 nF - 20 µF	20 kHz	-20 °C to +1000 °C	Y	Y	Y
Rapid 925	-	-	-	Y	Y	-
Rapid 935	-	-	-	Y	Y	-
Rapid 955	320 nF, 320 µF	32 kHz, 150 kHz	-	Y	Y	Y
Bosstek DT 9330	-	-	-	Y	Y	Y
Maplin M 215	-	-	-	Y	-	-
Academy PG 017	2 nF - 20 µF	2 kHz - 20 MHz	-	Y	Y	Y

Table 2b Multimeter functions : extra functions.

Multimeter model	Common *V* and *I* terminal	mA ranges fused	10/20 A range fused	Battery type	Battery current (mA)	Auto-power off	Range selection	Markings	Dimensions L x B x D (mm)
Rapid 208	Y	Y	N	PP3	1.7 - 5.3	N	M	B	125 x 69 x 27
Rapid 318	N	Y	Y	PP3	1.5 - 2.0	N	M	A	189 x 91 x 32
Rapid 328	N	Y	N	PP3	4.3 - 4.7	Y_NF*	M	A	189 x 91 x 32
Rapid 925	N	Y	N	PP3	0.4 - 0.9	Y	A	A	131 x 73 x 32
Rapid 935	Y	Y	Y	2 x AA	1.4 - 1.6	Y	A	A	140 x 70 x 36
Rapid 955	N	Y	Y	PP3	1.9 - 2.5	N	A	A	189 x 91 x 32
Bosstek DT 9330	N	Y	N	PP3	3	Y	M	A	174 x 87 x 38
Maplin M 215	N	Y	N	PP3	0.6 - 1.0	N	M	A	171 x 88 x 39
Academy PG 017	Y	Y	Y	PP3	1.3 - 1.6	N	M	B	151 x 70 x 38

Table 3a Multimeter features. * Y_NF : Feature specified, but not functioning, or non-existent

Multimeter model	No. of display digits	Display height (mm)	SI units shown	Hold	Fuse access	Protective holster	Enclosure colour	Robust-ness
Rapid 208	3½	12.5	N	N	M	N	Yellow	B
Rapid 318	3½	25	N	N	D	Y	Dark grey	B
Rapid 328	3½	25	N	N	D	Y	Dark grey	B
Rapid 925	3¾	12	Y	N	M	N	Yellow	B
Rapid 935	3¾	11	Y	Y	M	Y	Dark grey	B
Rapid 955	3¾	17	Y	Y	D	Y	Dark grey	B
Bosstek DT 9330	3½	21	N	N	M	N	Yellow	B
Maplin M 215	3½	20	N	N	M	N	Dark grey	B
Academy PG 017	3½	14	N	N	M	N	Dark grey	B

Table 3b Multimeter features.

Display height : A display height of 20 mm can be comfortably read at 4 metres. Instruments with 20 mm LCDs may be used in demonstration experiments.

SI units : Autoranging models have annunciator functions showing readings with SI units.

Hold : This pushbutton freezes the display. It is useful for taking a series of measurements at regular periods of a changing signal.

Fuse access : Fuses should be neither immediately accessible, which puts them at risk of being tampered with, nor difficult to replace. The key is :

E = easy access M = moderate access
D = difficult access

Protective holster : This is a flexible plastic holster encasing the meter while in operation. Were the meter dropped, the holster might prevent damage.

Robustness : None of this batch are as robust as the ISO - TECH reviewed last time. The little Maplin *M 215* is reasonably robust, a whisker ahead of the rest. The perspex window of the Rapid *925* fell out. It was easily glued back in place. No other DMM fell apart in our examinations. Key :

A = mechanically robust, unlikely to be damaged if dropped
B = reasonably robust, liable to be damaged by dropping

Specifications

The tolerance table (Table 4) lists two values taken from manufacturers' specifications. The percentage error is a percentage of the reading. The absolute error is the uncertainty in the value of the least significant digit.

Only the basic or best specifications are quoted in Table 4. Usually these are for mid sensitivity ranges. Often the lowest and highest sensitivity range has a poorer tolerance than that listed by us here.

Because none of the manufacturers give confidence levels for their DMM specifications, their specifications are meaningless. We have however had to base our performance testing on the values given. We have assigned 95% confidence limits, this being the accepted value for electrical test equipment. To give an example, the Rapid *318* DMM's a.c. current specification is ±1.0% of the reading +3 digits. If the display value is 10.00 on the 20 mA a.c. range, then

1.0% of reading	= ±0.10 mA
final digit uncertainty	= ±0.03 mA
total uncertainty	= ±0.13 mA
Therefore current	= 10.00 mA ±0.13 mA

with an unknown probability of the actual value lying within this uncertainty.

Performance

The performance table summary (Table 5) key is:

A = performs to specification
B = performs slightly poorer than specification
C = performs considerably worse than specification

Most of the meters performed to specification most of the time. When they tended not to perform to specification this was at the extremes of their ranges. Sometimes, when only the extremes are affected, this poor performance is of no practical significance.

None of the DMMs in our sample are true r.m.s. reading instruments. They have all been tweaked to read the r.m.s. value for a sine wave signal. Thus AC readings generally lie within specification for sinusoidal waveforms, but may read erroneously for non-sinusoidal waveforms. For instance if the signal is a full-wave or half-wave rectified sine wave, then the readings are 90% or 64% of r.m.s. respectively.

Safety

In normal school usage, multimeters are put in circuits which are at very low voltage - certainly below the criteria for hazardous live [3]. All of the meters in our batch have voltage ranges that extend into regions that could be hazardous. However we recommend that none of these meters are used at hazardous live. Specifically, none of the test leads supplied with these meters are safe for such work.

For details of a DMM suitable for use at hazardous live, please refer to *Best Buys* for information on the ISO-TECH *IDM 600*.

Best buys

Our recommendation for Standard Grade and Higher Grade classwork is the *Rapid 318* (£17.90 for 10+). It covers the basic functions of voltage and current, both AC and DC, and resistance. It performs well and has many ranges selected by a 32 position rotary switch against clearly marked settings. The display height is 25 mm. It has a separate milliamp terminal. Battery current is quite modest. It is supplied in a rubber holster. The fuse would take some effort to replace, but not immoderately so.

Maplin's *M 215* DMM (£15.81 for 10+) is our recommendation for S1/S2, or as a supplement to the *318* in more advanced course work. Having very basic functions and restricted ranges, the rotary switch has only 18 settings, which are clearly marked, resulting in a simple appearance. It does not have an AC current function.

As for meters with specialised functions, the ability to measure frequency is perhaps the most useful. Sadly none of the three meters with this facility stood out as a clear winner over the other two. The Rapid *328* (£33 1+) performs well in many respects, but it only measures frequency to 20 kHz, and draws quite a large battery current. Although specified to have an auto-power off facility, this does not work or is non-existent. The *328* has a temperature measuring facility using an amazingly cheap probe with a non-standard connector.

Multimeter model	DC input impedance (MΩ)	AC max. frequency (Hz)	DC volts accuracy	AC volts accuracy	DC current accuracy	AC current accuracy	Resistance accuracy
Rapid 208	1	400	±0.8% +1	±1.2% +1	±1.0% +1	-	±1.0% +3
Rapid 318	10	400	±0.5% +1	±0.8% +3	±0.8% +1	±1.0% +3	±0.8% +1
Rapid 328	10	400	±0.5% + 1	±0.8% +3	±0.8% +1	±1.0% +3	±0.8% +1
Rapid 925	10	60	±0.5% +4	±1.5% +4	±2% +4	±2.5% +4	±1% +2
Rapid 935	2	400	±1.2% +2	±1.2% +5	±1.5% +2	±1.5% +5	±1.2% +5
Rapid 955	10	1000	±0.3% +2	±0.8% +3	±1.2% +3	±1.5% +5	±0.8% +1
Bosstek DT 9330	10	1000	±0.5% +1	±0.8% +3	±0.8% +1	±1% +3	±0.5% +1
Maplin M 215	10	500	±0.5% +1	±1.5% +4	±1.0% +1	-	±0.8% +1
Academy PG 017	10	500	±0.5% +1	±1.0% +4	±1.0% +1	±2.0% +4	±0.8% +1

Table 4 Multimeter specifications.

Multimeter model	DCV	ACV	DCA	ACA	R	C	Frequency
Rapid 208	A	A	A	-	A	-	-
Rapid 318	A	A	A	B	A	-	-
Rapid 328	A	A	A	A	A	(A)	A
Rapid 925	A	A	A	B	A	-	-
Rapid 935	A	A	A	A	A	-	-
Rapid 955	A	A	A	A	A	(B)*	C
Bosstek DT 9330	A	B	A	B	B	-	-
Maplin M 215	A	A	A	-	A	-	-
Academy PG 017	A	A	A	A	A	(B)	A

Table 5 Multimeter performance.
* Can display wrong capacitance reading with decimal point out by factor of ten.

The Rapid *955* (£29.50 1+) measures to 150 kHz, but readings could be out by 1%, not 0.1% as specified. We also found found that the decimal point could be out by one position when reading capacitance. But otherwise, this meter was pretty good.

The Academy *PG 017* (£42.54 1+) measures to 20 MHz and performs well. However its markings are cramped and untidy, it has a common V and mA terminal and has restricted current and voltage scales.

Some of the meters we recommended in 1993 [1] are still available.

We tested three Wavetek DMMs (*DM5XL*, £35), (*DM10XL*, £45) and (*DM15XL*, £55) (Tait Components). All performed well. Their markings are good. 10 A protection fuses are fitted. Models *5XL* and *10XL* have restricted current ranges. The *15XL* has a resistance range reading to 2 Gohm.

Both ISO - TECH models from RS Components performed well. Good quality features include the provision of merely two terminals and the absence of current ranges, which reduce the confusion in what is being measured and prevent a dangerously high short circuit current from flowing - excellent safety features. Other qualities include auto power off, automatic and manual ranging with SI units marked on the display, good markings and clear switch settings, robust construction and protection against damage by dropping. The *IDM 65* (£54.30) is designed for general lab work. It would suit those teachers willing to pay for the above qualities. The *IDM 600* (£53.95) is designed for test and measurement with circuits that might be at hazardous live. For this function it should be used with GS38 test leads (RS 212-966 at £17.95). Any school or college where staff work at hazardous live should only do so with a meter of this design standard.

References

1. *Digital multimeters* Equipment Notes Bulletin 178 SSERC 1993.
2. *Digital multimeters* Equipment Notes Bulletin 167 SSERC 1990.
3. *Preventing electric shock* Bulletin 173 SSERC 1992.

NEWS AND COMMENT

Teaching Chip publications

The following two publications were issued by the Edinburgh University / Motorola Teaching Chip Project in the last fortnight or so of the Summer term :

"Standard Grade Physics Practical Investigations"
"MOSFETs"

The first of these gives suggestions for ten different practical investigations with Teaching Chips for use in Standard Grade Physics Practical Investigations. The package includes worksheets for pupils and supporting notes for teachers. The pupil material is written at two levels. Firstly there are two pages of information about each of the four integrated circuits in the Teaching Chip set. This information is presented so as to provoke ideas for investigations. Trials with pupils indicate that this initial information usually suffices. However should some pupils need further assistance in devising a project, additional Help Sheets are available - one for each of ten investigations.

Standard Grade Physics Practical Investigations was written by Andrew Moore, Principal Teacher of Physics at Balerno Community High School, and was described by Andrew at the 1998 Stirling Meeting of the Institute of Physics. Copies have been issued to representatives of each council via the Scottish Science Advisory Group and may also be obtained directly through SSERC.

The publication on MOSFETs was written by a SSERC staff member and has been posted directly to the Principal Teacher of Physics in every school and college. Its purpose is to give teachers a level of information and ideas for usage one stage more advanced than that required by a narrow interpretation of the Higher Still syllabuses. It contains a guide to experiments and information on the structure, operation and applications of MOSFETs. The guide to experiments provides suggestions for practical investigations at Advanced Higher.

Technicians' SVQ knocked back

The Qualifications and Curriculum Authority (QCA) and the Scottish Qualifications Authority (SQA) have announced that they are not accrediting the proposed vocational qualification for educational technicians.

As far we can ascertain, some of the problems lie within the overall framework compiled partly by other bodies such as in the LAATSI Project (Laboratory and Associated Technical Standards Initiative). Unfortunately the S/NVQ developed through the Association for Science Education (ASE) relies on a number of Units imported from such other sources. All is not yet lost however, since a third party training and development organisation known as *VQset* has agreed to rework the materials so that they become acceptable to QCA, SQA and the awarding body.

cont./next col.

This is, to say the least, very disappointing (code for not cursing) for everyone who spent time on this project. Even if *VQset* succeed in their 'recontextualising' (boke?) of the standards to the satisfaction of the awarding body, the intervening period looks critical for the further development of any Modern Apprenticeship for technicians. In addition, we have never been entirely happy that a VQ based so squarely on science laboratory work would suit Scottish conditions, where whole school provision is now fairly common.

NCBE mailing list

The NCBE now maintains an unmoderated Email discussion group for those in schools and colleges who teach secondary level biology (i.e. with students aged 11 to 18 years) including Scottish courses. Others with a professional interest in the teaching of biotechnology at this level are also welcome to subscribe.

The mailing list (NCBE-BIOPRAC) is intended to help promote good practice, encourage development and to assist subscribers in resolving problems related to all aspects of the teaching of practical biotechnology. Some emphasis will be placed on the safety and curriculum constraints that pertain in the United Kingdom in particular and the European Union in general. Although the main focus is intended to be practical biotechnology, where appropriate, related issues such as ethical concerns may also be addressed.

Subscription to the list is entirely free. However, the discussion group is not intended for students. Consequently subscription requires a letter (on official stationery carrying the school or college letterhead) to be sent by snail mail to the list organiser - Dean Madden at NCBE (see address list inside rear cover of this bulletin issue). This letter should state clearly the name of the intended subscriber together with his or her Email address (a telephone number is also useful in case there are problems with the Email address). Please ensure that you give your correct Email address. State also whether you would like to subscribe to the *ordinary* list (where you will receive messages throughout the day) or the *digest* list (where you will receive just one message at about 4 pm (UK time) each day, containing a compilation of that day's messages).

Once subscribed, all further commands (including access to archives of previous messages, other useful information and switching between *ordinary* and *digest* mode) can be performed directly by the subscriber. Full details will be sent out once you have subscribed. Please note that your Email address and other information will not be used for any purpose other than of subscribing to this list. If you have any Email comments or questions about the mailing list please contact :

D.R.Madden@reading.ac.uk

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Bulletin 193 on CD

SSERC has produced a trial version of an interactive bulletin. This may be read using one of the popular Web browsers such as *Netscape Navigator* or Microsoft's *Internet Explorer*. We would be pleased to hear from anyone interested in trialling this format which includes an illustrated "Equipment Offers" list and a number of other interesting features. The CD version of the last issue is offered at the special introductory price of £5 including VAT (£4.26 Nett) to subscribing schools or colleges and in member EAs.

POST report summary

POST Report summaries were described in SSERC Bulletin 193. We have now received copyright clearance from the Parliamentary Office of Science and Technology and may thus supply limited numbers of copies for bona-fide educational use.

Food safety has been much in the news of late (what an understatement) POST summary 104 tackled microbial food poisoning and now number 115 summarizes the issues surrounding *Genetically Modified Foods* including benefits and risks, regulation and public acceptance. You may also access these summaries directly on the Internet:

http://www.parliament.uk/post/home/htm

Scion of SOLSN

The Science on-line Support Network (SOLSN) has, to date been a tightly focused and small scale feasibility study run by the Scottish Interactive Technology Centre. We have been involved throughout but at the fringes as helpers and members of the Steering Group. It has been agreed that next session SOLSN will move beyond the feasability study stage into a fuller pilot project.

Perhaps somewhat foolishly, SSERC has reached an agreement with the SOEID (Scottish Office Education and Industry Department) and three Councils to take on the day to day management of the pilot project. The idea is to develop a useful model for technical support and staff development which other EAs may wish to adopt or adapt for their own local use in educational network(s). We shall probably seek to meet with a number of EAs once the pilot has been underway sufficiently long enough to suggest its worth, if any.

TECHNICAL TIP

Urea assays: Some time ago we had a call from Joanne Cushley of St Margaret's, Airdrie (to whom many thanks), on a slight modification to the procedure described in Bulletin 186. She had substituted wider (35 cm^3 boiling type) tubes, for the test tubes we had suggested. Excellent results then appear in less than 24 hours. "Magic!" was her conclusion.

* * *

TRADE NEWS

New autoclave model: Prestige Medical have produced modified versions of their Clinical Autoclave series. We have recently finished testing the 2100/04 model which is the version with an extended body to take taller items of equipment, has both temperature and pressure gauges and is fitted with extra insulation in the form of a 'thermal jacket'. The results of our tests were favourable and a draft of the report is with the manufacturers for their comments.

The 2100/04 automatic autoclave is available directly from Prestige at £490 plus carriage. It is also sold by other suppliers such as Griffin or Harris - but note that the Scottish firm of Charles Allardyce Healthcare no longer sell Prestige Medical items. A full test report will be made available from the Centre on request.

Spore test strips: During our tests on the Prestige Medical Clinical Autoclave series, we discovered that Unipath (née Oxoid) no longer sell spore strips of the heat resistant *Bacillus stearothermophilus*. Nor do they supply the necessary medium - a tryptone soya based broth with added indicator. Alternative suppliers are *Southern Group* who sell both test strips and media. They have modified the broth to utilise a different indicator system (phenol red). Southern's spore strips are each made up of pellets and a strip of twelve (Code 0592) costs just under £12. The broth is £18.46 for a case of twenty five McCartney bottles each with 15 cm^3 of sterile broth.

Spare 'O' rings for burettes: In Bulletin 191 we gave incorrect telephone and fax numbers for the Cowie Technology Group - suppliers of such spares. Please see the inside rear cover for the correct numbers.

* * *

Endpiece - more on Bill

We're sure it's apocryphal but can't resist it: Bill Gates was speaking in Detroit at a conference on improving American industrial performance. Drawing a parallel with microelectronics, he claimed that - if the automotive industry had improved at the same rate as IT design - then cars would cost about $100 dollars each and would do 1,000 miles to the gallon. A senior motor executive stuck his hand up and Gates was asked if he thought that the American motoring public would ever accept two crashes a day on a regular basis.

* * *

Equipment Offers

Items are arranged by similarity of application, or for other reasons, and not by stock number sequence. Often the item number serves only for stock identification by us in making up orders. Newer stock items are underlined, so as to be more easily seen.

VAT : The prices quoted do not include VAT. However it is added to every customer's order. Local authority establishments will be able to reclaim this input VAT.

Postage : Postage and, where necessary, packing, will be charged for.

It is therefore best not to send cash with an order, but wait for us to bill you. Official orders may be used.

Please try and ask for at least £10 worth of goods because the administrative costs of handling orders are significant.

Don't send cash with orders

We repeat, please do not send payment with your order. Wait until you receive our advice note upon which payment may be made. This saves unnecessary complications, e.g. when items are out of stock, failure to make provision for VAT, or if a delivery charge needs to be made. Items of equivalent value may be deducted from your order to balance any shortfall.

Motors

778 Stepper motor, Philips MB11, been stored in damp conditions but unused and retested. 4 phase, 12 V d.c., 100 mA per coil, 120 Ω coil per phase, step angle 7.5°, with 7 mm x 2 mm dia. output shaft. Dimensions 21 mm x 46 mm dia. on oval mounting plate with 2 fixing holes, diam. 3 mm, pitch 42 mm, at 56 mm centres. Circuit diagram supplied. £2.50

755 Pulley wheel kit comprising:
- plastic pulley wheel, 30 mm dia., with deep V-notch to fit 4 mm dia. shaft,
- two M4 grub screws to secure pulley wheel,
- Allen key for grub screws, and
- 3 mm to 4 mm axle adaptor.

The whole making up a kit devised for SSERC tacho-generators with 3 mm shafts.
Specially supplied to SSERC by Unilab. £1.25

848 Motor, 12 V d.c., no load current 2 A at 12 V and 1.5 A at 5 V. Min. no load starting voltage, 2 V, min no load running voltage 0.8 V. 64 X 37 mm dia., shaft, 11 X 3 mm dia. £2.50

614 Miniature motor, 3 V to 6 V d.c., no load current 220 mA at 9600 r.p.m. and 3 V, stall torque 110 mN m, dims. 30 mm x 24 mm dia., shaft 10 mm x 2 mm dia. 45p

593 Miniature motor, 1.5 V to 3 V d.c., no load current 350 mA at 14800 r.p.m. and 3 V, stall torque 50 mN m, dims. 25 mm x 21 mm dia., shaft 8 mm x 2 mm dia. 30p

739 Miniature motor, 1.5 V d.c., dimensions 23 mm x 15 mm dia., shaft 8 mm x 1.7 mm dia. 25p

621 Miniature motor, 1.5 V to 3 V d.c., open construction, ideal for demonstration, dimensions 19 x 9 x 18 mm, eight tooth pinion on output shaft. 25p

839 Motor, solar, 12 mm long by 25 mm dia., shaft 6 x 2mm dia. (see also Item 838 - solar cell) £1.70

732 Motor with gear box, high torque, 1.5 V to 12 V d.c., 125 r.p.m. at 12 V, dimensions 40 x 40 x 28 mm, shaft 10 mm x 3 mm dia. with key. Suitable for driving buggies, conveyor belt, or any other mechanism requiring a slow drive £6.00

773 Tachometer (ex equipment) £2.25

811 Worm and gear for use with miniature motors, 34 : 1 reduction ratio plastic worm and gear wheel. 35p

378 Encoder disk, 15 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

642 Encoder disk, 30 slots, stainless steel, 30 mm dia. with 4 mm dia. fixing hole. 80p

772 Encoder disk, 4-bit Gray code, stainless steel, 81.28 mm dia., 3 mm fixing hole, slots sized to register with components mounted on 0.1" stripboard. Applications: shaft position sensing, wind direction indicator.
For related electronic circuitry see Bulletin 146. £3.00

Precision motor stock

785 Precision motor with optical shaft encoder, 0.25 to 24 V d.c., no load current and speed 9 mA and 6,600 r.p.m. at 24 V, stall torque 23 mNm, 9 segments. Overall body length including shaft encoder 59 mm, dia. 23 mm with output shaft 20 x 3 mm dia. Back EMF constant 3.6 V/1000 r.p.m. Suggested application - tachogenerator. Data on shaft encoder section available on application. £15

787 Precision motor with attached gearbox, 0.15 to 12 V d.c. With a supply of 3 V, the no load current is 25 mA and the output shaft turns at ca. 20 r.p.m. Gearbox ratio 1 : 365. Overall body length including gearbox 43.5 mm and diameter 16 mm. Output shaft 6 x 3 mm dia. with flat side to maximum depth of 0.3 mm along outer 5 mm length of shaft. Application - any system where a very slow angular velocity is required. £15

836 Motor mounts, plastic push-fit with self adhesive base pad, suitable for SSERC motors 593 & 614, pk of 10 £1.95

Miscellaneous items

801 Propeller, 3 blade, to fit 2 mm shaft, 62 long. (Replaces Item 791at lower cost). 35p

792 Propeller kit with 10 hubs and 20 blades for making 2 or 3 bladed propellers. 130 mm diameter. Accepts either 2 mm or 3 mm shafts. £3.40

790 Buzzer, 3 V. 55p

827 Buzzer, 6 V. 55p

629 Dual tone buzzer with flashing light back in stock 55p

846 Sound module, includes 'melody' chip and Piezo transducer. £1.00

710 Sonic switch and motor assembly. First sound starts the motor, a second reverses the direction of rotation, a third sound stops the motor. Driven by 4 AA cells (not supplied). 85p

715 Pressure gauge, ca. 40 mm o.d. case, 25 mm deep and 33 mm dia. dial reading 0 to 4 bar (i.e. above atmospheric). With rear fitting for $^1/_8$" BSP. Suitable for use as indicator for pneumatic circuits in Technological Studies. 75p

165 Bimetallic strip, length 10 cm;
high expansivity metal: Ni/Cr/Fe - 22/3/75
low expansivity metal: Ni/Fe - 36/64 (invar) 15p

166 Ditto, but 30 cm length. 40p

385 Pressure switch, operable by water or air pressure. Rated 15 A, 250 V (low voltage operation therefore possible). Dimensions 2" x 3" dia. 65p

758 Loudspeaker, 8 Ω, 0.5 W, 66 mm dia. 50p

771 Neodymium magnet, 13.5 mm dia. x 3.5 mm thick. £1.30

837 Ring magnet, 40 mm o.d., 22 mm i.d. 35p

815 Ceramic block magnets, random polarisation, 19 x 19 x 5 mm. 15p

823 Ceramic block magnets, poles at ends, 10 x 6 x 22 mm. 12p

824 Ceramic block magnets, poles on faces, 25 x 19 x 6 mm. 35p

825 Forehead temperature measuring strips 50p

745 Sub-miniature microphone insert (ex James Bond?), dia. 9 mm, overall depth 5 mm, solder pad connections. 40p

723 Microswitch, miniature, SPDT, lever operated. 40p

354 Reed switch, SPST, 46 mm long overall, fits RS reed operating coil Type 3. 10p

847 Rocker switches, panel mounting, (mixed stock). 15p

738 Relay, 6 V coil, DPDT, contacts rated 3 A, 24 V d.c. or 110 V a.c. 75p

774 Solenoid, 12 V, stroke length 30 mm, spring not provided. £2.25

742 Key switch, 8 pole changeover. 40p

382 Wafer switch, rotary, 6 pole, 8 way. 70p

688 Croc clip, miniature, insulated, red. 5p

759 Ditto, black. 5p

788 Crocodile clip leads, assorted colours, insulated croc. clip at each end, 360 mm long. £1.35

809 Wire ended lamp, 3 V 10p

741 LES lamp, 6 V. 15p
770 ditto, but 12 V. 15p
789 MES lamp, 3.5 V, 0.3 A 9p
690 MES lamp, 6 V, 150 mA. 9p
691 MES battenholder. 20p

692 Battery holder, C-type cell, holds 4 cells, PP3 outlet. 20p

730 Battery holder, AA-type cell, holds 4 cells, PP3 outlet. 20p

845 Battery holder, holds two C-type cells, PP3 outlet. 20p

835 Battery holder, AA-type cell, holds 2 cells, PP3 outlet. 15p

729 Battery connector, PP3 type, snap-on press-stud, also suitable for items 692 and 730. 5p

724 Dual in line (DIL) sockets, 8 way. 5p

760 DIL sockets, 14 way. 7p

826 DIL sockets, 16 way. 8p

808 Electrodes for making lemon or other fruit cells etc. 1 pair, comprising 1 of copper, 1 of zinc, each approx. 60 mm square, per pair 50p

716 3-core cable with heat resisting silicone rubber insulation, 0.75 mm² conductors, can be used to re-wire soldering irons as per Safety Notes, Bulletin 166. Per metre. £1.35

756 Silicone coated, braided glass sleeving, yellow, 2.5 mm dia., gives both heat and electrical insulation to conductors (e.g. for autoclave rewiring). Price per metre. 55p

714 Sign "Radioactive substance" to BS spec., 145 x 105 mm, semi-rigid plastic material. Suitable for labelling a radioactive materials store. With pictogram and legend. £2.70

763 Sign "DANGER, Electric shock risk" to BS spec., rigid plastic, 200 x 150 mm. £2.70

764 Sign "DANGER, Laser hazard" to BS spec., rigid plastic, 200 x 150 mm. £2.70

727 Hose clamp, clamping diameter from 8 mm to 90 mm, 101 uses - securing hose to metal pipe, tree to stake, joining wooden battens for blueing, etc. 30p

731 Re-usable cable ties, length 90 mm, width 2 mm, 50 per pack. 12p

752 Shandon chromatography solvent trough. £1.00

805 Condenser lens, bi-convex, 200 mm focal length, 75 mm dia. Crown glass. £12.50

806 Condenser lens, plano-convex, 150 mm focal length, 75 mm dia. Crown glass. £12.50

833 5¼" double density floppy disks, box of 10 60p
834 5¼" high density floppy disks, box of 10 60p

Components - resistors

420 resistors, 5% tolerance, ¼ W : Per 10. 6p
1R5, 4R7, 5R6, 6R8, 8R2, 10R, 15R, 22R, 33R, 47R, 56R, 68R, 82R, 100R, 120R, 150R, 180R, 220R, 270R, 330R, 390R, 470R, 560R, 680R, 820R, 1K0, 1K2, 1K5, 1K8, 2K2, 2K7, 3K3, 3K9, 4K7, 5K6, 6K8, 8K2, 10K, 12K, 15K, 18K, 22K, 27K, 33K, 39K, 47K, 56K, 68K, 82K, 100K, 150K, 220K, 330K, 390K, 470K, 680K, 1M0, 1M5, 2M2, 4M7, 10M.

421 DIL resistor networks, following values available: 62R. 1K0, 6K8, 10K, 20K, 150K. Per 10. 30p

BP100 Precision Helipots, Beckman, mainly 10 turn. 10p-50p

Components - capacitors

813 Capacitors, polystyrene: 4p
180 pF, 220 pF, 330 pF, 560 pF, 1000 pF, 2400 pF, 3000 pF, 3300 pF, 3900 pF & 4700 pF

695 Capacitors, tantalum, 15 μF 10 V, 47 μF 6.3 V. 1p

696 Capacitors, polycarbonate, 10 nF, 220 nF, 1 μF, 2.2 μF. 2p

697 Capacitor, polyester, 15 nF 63 V. 1p

698 Capacitors, electrolytic, 1 μF 25 V, 2.2 μF 63 V, 10 μF 35 V. 1p

358 Capacitor, electrolytic, 28 μF, 400 V. £1.00

Components - semiconductors

807 Schools' Chip Set, designed by Edinburgh University, comprises the 4 chips and prototype board.
Schools in member EAs, subscriber schools £4.00
FE colleges in membership of SSERC £15.00

Edinburgh University support material :
Volume 1 : Teaching Support Material (+£2 p&p). £4.50
Volume 2 : Laboratory Work (+£2 p&p). £5.00

322 Germanium diodes 8p

701 Transistor, BC184, NPN Si, low power. 4p

702 Transistor, BC214, PNP Si, low power. 4p

717 Triac, Z0105DT, 0.8 A, low power. 5p

725 MC74HC139N dual 2 to 4 line decoders/multiplexers 5p

699 MC14015BCP dual 4-stage shift register. 5p

711 Voltage regulator, 6.2 V, 100 mA, pre-cut leads. 10p

Sensors

615 Thermocouple wire, Type K, 0.5 mm dia., 1 m of each type supplied: Chromel (Ni Cr) and Alumel (Ni Al); for making thermocouples, see Bulletins 158 and 165. £3.10

640 Disk thermistor, (substitute type) resistance of 15 kΩ at 25°C, β = 4200 K. Means of accurate usage described in Bulletin 162. 30p

641 Precision R-T curve matched thermistor, resistance of 3000 Ω at 25°C, tolerance ±0.2°C, R-T characteristics supplied. Means of accurate usage described in Bulletin 162. £3.00

718 Pyroelectric infrared sensor, single element, Philips RPY101, spectral response 6.5 μm to >14 μm, recommended blanking frequency range of 0.1 Hz to 20 Hz. The sensor is sealed in a low profile TO39 can with a window optically coated to filter out wavelengths below 6.5 μm. Data sheet supplied. For application see SG Physics Technical Guide, Vol.2, pp 34-5. 50p

503 Kynar film, unscreened, 28 μm thick, surface area 12 x 30 mm, no connecting leads. £1.00p

504 Copper foil with conductive adhesive backing, makes pads for unscreened Kynar film to which connecting leads may be soldered. Priced per inch. 15p

506 Resistor, 1 gigohm, ¼ W. £1.40

Opto-electronic devices

838 Solar cell, 100 x 60 mm, 3.75 V per cell max. £2.10

507 Optical fibre, plastic, single strand, 1 mm dia. Applications described in Bulletin 140 and SG Physics Technical Guide Vol.1. Priced per metre. 50p

508 LEDs, 3 mm, red. Price per 10. 50p
761 Ditto, yellow. Per 10. 60p
762 Ditto, green. Per 10. 60p

New - economy variable volume micropipettors

Of slimline profile, these micropipettors are fully autoclavable (121° C max.). They have a nominal accuracy of ± 1.75%. Supplied with spare O-ring and lubricant. Tip ejector swivels, thus pipettors are suitable for either left- or right handed users. Colour coded bodies for ease of identification. Supplied with two tips and stocks of spare tips available. Three sizes :

849 micropipettor, 1 cm^3, range 100 to 1000 μl £16.00
850 micropipettor, 5 cm^3, range 500 to 5000 μl £16.00
851 micropipettor, 10 cm^3, range 1000 to 10,000 μl £16.00

Replacement tips in packs of 25 tips :

852 replacement tips for 1 cm^3 micropipettor, pack. £1.50
853 replacement tips for 5 cm^3 micropipettor, pack. £1.70
854 replacement tips for 10 cm^3 micropipettor, pack. £2.15

Items not for posting

All of the following items are only available to callers because of our difficulties in packing and posting glassware and chemicals. We will of course hold items for a reasonable period of time to enable you to arrange an uplift.

Glassware, chemicals etc.

664 Flat bottom round flask, 500 ml. 50p

768 Sodium lamp, low pressure, 35 W. Notes on method of control available on application. 85p

810 Watch glasses, assorted sizes 20p

712 Smoke pellets. For testing local exhaust ventilation (LEV) - fume cupboards and extractor fans : large, 50p, small, 40p

* * *

SSERC, St Mary's Land, 23 Holyrood Road, Edinburgh, EH8 8AE. Tel: 0131 558 8180, Fax: 0131 558 8191
Email: sserc@mhie.ac.uk
Web site: http://www.vtc.scet.com/links/sserc/

ASE (UK, HQ), College Lane, Hatfield, Herts., AL10 9AA. Tel: 01707 267411, Fax: 01707 266532

ASE Scotland Secretary, Dr Susan Burr, 18 Mainholm Holdings, Ayr KA6 5HE
Email : sburr@arran.almac.co.uk

ASE Scotland 1999 Annual Meeting Exhibition Co-ordinator : Mrs Jean Young, 22 Burnett Place, Aberdeen AB24 4QD

Cowie Technology Group, corrections to details given in Bulletin 191 : Ridgeway, Coulby Newham, Middlesborough, Cleveland, TS8 0TQ
Tel. 01642 599190 Fax. 01642 596810

Data Harvest, Woburn Lodge, Waterloo Road, Linslade, Leighton Buzzard, Bedfordshire, LU7 7NR;
Tel. 01525 373666 Fax. 01525 851638

Griffin & George Limited., Bishop Meadow Road, Loughborough, Leicestershire, LE11 0RG
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Tel. 01734 873743 Fax. 01734 750140
http://www.reading.ac.uk/NCBE

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http://www.parliament.uk/post/home.htm

Prestige Medical, PO Box 154, Clarendon Road, Blackburn, Lancashire, BB1 9UG
Tel. 01254 682622 Fax. 01254 682606
Email : customerservices@prestigemedical.co.uk

RS Components, PO Box 99, Corby, Northants., NN17 9RS
Tel. 01536 201201 Fax. 01536 201501

Rapid Electronics Limited, Heckworth Close, Colchester, Essex, CO4 4TB Tel. 01206 751166
Fax. 01206 751188 Email: sales@rapidelec.co.uk

RMR Measurements, 2 MacTaggart Road, Seafar, Cumbernauld, G67 1JL
Tel. 01236 728170

The Royal Society, 6 Carlton House Terrace, London, SW1Y 5AG Website http://www.royalsoc.ac.uk
Tel. 0171 451 2578 Fax. 0171 451 269
(Education Officer - Email: nigel.thomas@royalsoc.ac.uk)

Science and Plants for Schools (SAPS) Project, Homerton College, Cambridge, CB2 2PH
Tel. 01223 411141 Ext. 233 Fax. 01223 215004
http://www-saps.plantsci.cam.ac.uk
SAPS Biotechnology Scotland - Details to be announced.

The Scottish Antibody Production Unit (SAPU), Law Hospital, Carluke, Lanarkshire, ML8 5ES
Tel. 01698 351161.

The Scottish Interactive Technology Centre (SITC), Moray House Institute of Education, Holyrood Road, Edinburgh, EH8 8AQ
Tel. 0131 558 6039 http://www.mhie.ac.uk

The Scots Language Society, A. K. Bell Library, York Place, Perth, PH2 8EP Tel. 01738 440199
Fax. 01738 477010 Email: slrc@sol.co.uk

Southern Group, Unit 3-7 Pyewell Court, Pyewell Road, Corby, Northants., NN17 5WA
Tel. 01536 403815 Fax. 01536 403814

Tait Components Ltd., 20 Couper Street, Glasgow, G4 0BR Tel. 0141 552 5043 Fax. 0141 552 8826

Technology Enhancement Programme, (TEP), 4/7 Red Lion Court, London EC4A 3EB
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http://www.tep.org.uk

Technology Teachers' Association, Secretary : Lorna Nicolson, 3 Conifer Place, Lenzie, G66 4EJ.