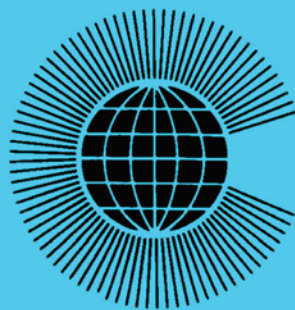


Resources for Science Teaching

Report of a Survey
in the Commonwealth Caribbean



Commonwealth Secretariat

Resources for Science Teaching

Report of a Survey
in the Commonwealth Caribbean

Judith Reay

Commonwealth Secretariat

COMMONWEALTH SECRETARIAT

Marlborough House, Pall Mall, London SW1Y 5HX

First published 1982

© Commonwealth Secretariat 1982

ISBN 0 85092 212 7

Governments of developing Commonwealth countries wishing to reproduce the material in this book in whole or in part in any language should inform the Commonwealth Secretariat which may be able to offer them some assistance in doing so.

Copies may also be purchased from the Publications Section of the Commonwealth Secretariat.

Printed and published by the Commonwealth Secretariat

CONTENTS

Preface	(i)
Introduction	1
Background to Education in the Commonwealth Caribbean	2
Prototypes, Models, Experimental Designs and Mass Production of Equipment	4
Improvisations	13
Improvements on Commercial Equipment	20
Science Rooms	24
Audiovisual Resources	28
Printed Resources for the Classroom	32
Centres and Information Sources	38
Servicing of Equipment	42
Science Teachers' Associations	43
Retrospect and Prospect	44
Conclusion	50
Notes and Sources of Information	51
Bibliography	57
Appendix 1: Products of 1977 Guyana Workshop	60
Appendix 2: Contents of Jamaica <u>Improvisations in Science Handbook</u>	61
Appendix 3: Summary of Responses to Survey of Materials for A Level Physics	62
Appendix 4: Summary of Responses to Survey of Materials for O Level Physics	63
Appendix 5: Summary of Responses to Survey of Apparatus Resources and Needs of Lower-Secondary Integrated Science Teachers	65
Appendix 6: Specimen Text from a <u>Science in the Press</u> Booklet	72
Glossary of Abbreviations	74

The plate section appears between pp. 50-51. The photographs are by Neil Hokan, Multimedia Production Centre, School of Education, UWI St Augustine, Trinidad.

PREFACE

In response to a recommendation of the Seventh Commonwealth Education Conference which urged the Commonwealth Secretariat to publish a resource book on science materials produced in various countries, the Education Division commissioned this study as the first of a series of publications describing the work so far undertaken in this field in various parts of the Commonwealth. It highlights trends in science education - particularly physics and integrated science - in the Commonwealth Caribbean which emphasise the use of the environment as a resource and attempts to relate science education closely to national development.

The book supplements efforts so far undertaken by the Secretariat to promote the development and use of low-cost science teaching equipment in member countries - efforts which include the collection and dissemination of ideas and practical experience among member states. The present publication takes the process one more step forward.

We are indebted to Judith Reay of the University of the West Indies for preparing this survey and are delighted to record our appreciation. In offering it to member states, it is our hope that it will stimulate educational administrators not only in the Commonwealth Caribbean but indeed all who are concerned with science education, to re-examine these issues in the light of their own experience so as to carry forward the challenge of making science education more closely an instrument of the development needs of member countries in the 1980s.

Rex E O Akpofure
Director
Education Division
Commonwealth Secretariat

INTRODUCTION

This report discusses resources for school science education in those Commonwealth countries which encircle the Caribbean Sea. There is also mention of the Bahamas, a Commonwealth country which has educational links with the University of the West Indies. With the exception of Belize and Guyana on the American continent, all the countries are island groups.

Included, therefore, are something under 20 countries which were once British possessions although nearly all are now independent states. While it has not been possible to obtain detailed information about conditions and practices in every country, a number of generalisations are valid. The histories of the countries have much in common, and there is considerable regional cohesiveness. Certain regional educational bodies (to be described later) link science-educators in common activities.

With the possible exception of Trinidad and Tobago, all the countries are developing ones. With its fairly good petroleum resources, Trinidad and Tobago ranks high in GNP per capita in the Commonwealth and in the Western Hemisphere, but recognises that its pool of skilled manpower does not match its financial resources. Regionally, a distinction is made between the more developed countries (Jamaica, Barbados, Trinidad and Tobago, and Guyana - the four with the largest populations) and the less developed countries. There is no evidence, however, that science education practice, worldwide, is in any significant way related to the degree of development of countries. Consequently, although this report, in its details, has a bias towards the more developed countries, it would be wrong to conclude that conditions in the less developed countries are less acceptable: the converse is often true.

With very rare exceptions, the sciences taught in most schools are biological sciences, chemistry, physics and integrated or general science. In this survey, it was not possible to obtain information on resources for all the sciences taught. Consequently, the emphasis is on physics and integrated science, subjects whose resource demands encompass the resources for nearly all science; and subjects which anyway are associated with most problems, worldwide.

Throughout this report, a number of acronyms and abbreviations are used. A translation of these is given in the glossary at the end of this survey.

BACKGROUND TO EDUCATION IN THE COMMONWEALTH CARIBBEAN

The Commonwealth Caribbean countries have suffered from the increasing instability of the sugar cane and tourist economies on which they used to rely, so that government provision of science teaching facilities has failed to match not only the demands of the modern curricula but also the standards that science teachers have come to expect.

Education systems in the region broadly follow the British pattern with a major examination (1) at the end of secondary education. Educators in the Commonwealth Caribbean have virtually no contact with the United States territories or the Spanish, French and Dutch-speaking countries of South America and the Caribbean. Although many Caribbean educators receive first or higher degrees in North America, there has been very little impact from USA and Canada on school systems and curricula.

The Caribbean Examinations Council (CXC) has been welcomed as an opportunity to make Caribbean education truly Caribbean. The only science so far examined (and this is under trial) is a demanding integrated science seen as a filter for further studies in science up to A Level and undergraduate studies. Encountering all the difficulties of integrated science, well-documented in the literature on science education, CXC integrated science is agreed to be well suited to the Caribbean; and its syllabus, examination and test papers are an important resource for teacher-educators and secondary science teachers (2). A less demanding integrated science examination for the same age group, and biology, chemistry and physics for the more able 20% of the population, are under development.

There are two universities in the Commonwealth Caribbean, the University of Guyana (UG) and the University of the West Indies (UWI), the latter having three campuses, Mona in Jamaica, St Augustine in Trinidad and Cave Hill in Barbados. There are also University Centres in the smaller countries, these being administered by the Extra-Mural Department of UWI. Teachers' colleges, though government institutions, have academic links with the universities.

Science teachers' associations are an important resource. In addition to a number of national associations (Jamaica's, the oldest, is some 30 years old), the Caribbean Regional Organisation of Associations for Science Education (CROASE) is an association of associations. Of special note is the contribution of CROASE to curriculum development; the Caribbean Integrated Science Curriculum (CISC) is under development as a resource for schools preparing for CXC (3). CROASE has also provided a number of regional workshops and stimulated the formation of new national associations. A larger association whose beginnings can be traced to the Caribbean is the London-based Commonwealth Association of Science and Mathematics Educators; its membership is open to individuals as well as national associations. A still larger

association of associations is the International Council of Associations for Science Education (ICASE) of which CROASE and most if not all national associations are members.

Science educators in the Caribbean are indebted to a number of international agencies for professional and financial assistance. UNESCO, the organisation of American States (OAS), the Commonwealth Secretariat and the Commonwealth Foundation have all given valuable help. The British Council in particular assisted UWI with the Caribbean Regional Science Project (CRSP), which developed and published the West Indies Science Curriculum, WISC (Adey, 1976), an integrated science course for the first three years of secondary education.

Collaboration among science educators of the Commonwealth Caribbean is excellent. The 1970s saw the growth of a dedicated and able group of teacher-educators who work closely with one another and with a significant number of classroom teachers and university scientists. Caribbean integrated science is probably at least as healthy as integrated science is anywhere, although a great many problems in physics education remain to be solved.

PROTOTYPES, MODELS, EXPERIMENTAL DESIGNS AND MASS PRODUCTION OF EQUIPMENT

Participants at the 1976 Bahamas Workshop judged it premature to discuss the establishment of a Caribbean-wide mass production unit. Even national mass production does not yet exist, although the idea has received some consideration. While local mass production is unlikely to result in mass financial savings, there would be other benefits, some of which will be mentioned below. This section outlines some investigations into the possibility of mass production, together with designs and activities which could provide a foundation for, at least, mini-mass production.

In Jamaica, discussion among members of the Ministry of Education, the Science Education Centre and the plastics manufacturers revealed that the cost of moulds would be prohibitive. Once the national educational needs were satisfied, the moulds would be redundant, and it was concluded that local plastics production for schools was out of the question (4). This is disappointing; much of the landed cost of imported apparatus arises from shipping charges on bulky and fragile equipment. Laboratory glassware is both bulky and fragile, and at least some of it can be replaced by versions in plastics, whose bulk in the raw state is small. For primary school children, learning materials in plastics versions are most attractive. A regional or international mould-sharing enterprise seems worthy of very serious consideration.

Guyana approached the issue of local production through teacher workshops. The Ministry of Education, Social Development and Culture has a very clear policy of teacher development through the encouragement of teacher creativity in workshops. Whether teachers' equipment designs will lead to feasible mass production is an issue secondary to the personal growth of the teachers as they go through the experience of designing the equipment and constructing a prototype. This philosophy lay behind the workshops of 1977 and 1979, supported by the Commonwealth Secretariat and the British Council. Significantly, the workshops were named Teacher Vacation Courses (TVC), and according to Dalgety and Farley (1979) the evidence was that participants did gain confidence in teaching integrated science for CXC.

Participants at these workshops were drawn from laboratory assistants, industrial arts technicians and teachers of science and industrial arts in primary, community high and secondary schools (5). Special emphasis in the 1977 workshop was laid on the fact that participants should learn to use a certain number of tools and, apparently for this reason, the 1977 workshop was judged especially effective. The cross-disciplinary nature of the participants was supposed to lead to in-school co-operation, although whether this actually took place is

not known. The substitution of local resources for materials used in imported designs was an aim of the workshops; Guyana, unlike the Turks and Caicos for example, has a large timber industry, and it was thought likely that some designs could be modified to use wood instead of metal.

The products of the 1977 workshop are listed in Appendix 1. Aware that prototypes must be evaluated over a period in schools, the organisers made no claims that these were models. Although feedback about such evaluation is not available, design of equipment for the community high schools has continued in the hands of an educator with carpentry skills, teacher training and a science degree. Meanwhile, the 1977 course co-ordinator, a physics teacher (6), has returned home after receiving further experience in Britain, to lead prototype production. An Equipment Production Centre is planned, although it is unclear whether the activities of this centre will be confined to promoting in-school production or whether it will attempt to provide a design base for mass production. (7,8).

In Trinidad and Tobago, local production of equipment for secondary school science is unlikely, at least in the near future. Research and development is expensive and can be best afforded by firms with world-wide markets. When a country has foreign exchange to spare, as Trinidad and Tobago has, the most effective stimulus to child-centred learning of science may be the ready provision of the best designs from abroad. A sudden expansion in 1975 of upper secondary education brought so much good imported equipment that teacher development activities could focus on the educational opportunities provided by these. And for the small islands, local equipment production for secondary schools would appear to be a most expensive proposition.

At the primary level, however, the numbers of children who are, or should be, learning science are so large and the research and development problems are so relatively small that local production deserves some consideration. At least in Trinidad and Tobago, this issue is under consideration by the developers of Science - a Process Approach for Trinidad and Tobago (SAPATT), (9). Among the most difficult problems facing designers of science apparatus are considerations of safety of children and apparatus. Especially risky are chemicals, electricity and fire, and primary science does not need to make much use of these.

There are also good educational reasons for encouraging teachers to depend mostly on common materials, and Warren and Lowe (1975) make a special point of this. In the Eastern Caribbean the trend is towards an environmental approach to primary science education (3), the successful Rural Education and Agricultural Project (REAP) of Belize, outlined by Raymond (1979, 1980), being a well-known example.

Whether or not go in for local production is not simply a cost issue. Below are outlined some designs which have implications of closer concern to (secondary) science educators.

Solar Stills

Distilled water, conventionally prepared by an imported electric still, is needed for the preparation of solutions of chemicals (10). Electric stills do not appear to remain serviceable for very long, and a good deal of time and money elapses between the ordering of a new element and its arrival. Teachers are justifiably suspicious of the battery water to be obtained from motor car service stations.

Today, solar energy as a concept is a feature of recent science courses, and school solar stills provide opportunities for discussion of scientific, technological and environmental principles. These considerations have received attention in the Commonwealth Caribbean.

The Chemistry Department of the University of the West Indies at St Augustine has for many years met all its distilled water requirements from a bank of solar stills designed and built by a staff member, Oliver Headley (11). Headley's stills are also being installed in Trinidad schools, where they not only provide an adequate supply of distilled water (several gallons a day) but also provide a good example of principles of energy conversion, thermal physics, an 'alternative energy' source and local technology. Some stills have been in continuous operation since 1970 (Headley, 1979). One school's stills are shown in Figure 1.

A solar still has also been designed in Guyana by Sankies (1978), who provides data on its performance and suggests its possibilities both for schools and as a means of providing fresh water for the interior of Guyana. The Ministry of Education has installed a few experimental versions in schools and is exploring the idea of large scale production. A detailed scale drawing of this still is available; enquiries may be directed to the Commonwealth Secretariat Education Division.

No functional solar stills are known elsewhere in the Caribbean. A Barbados firm is manufacturing solar water heaters. And the St Lucia Association of Science Teachers (SLAST), at its first science exhibition, displayed an impressive collection of models which depended on alternative energy sources, including solar stills and ovens (3).

Biogas Generators

Compared with countries of the Far East (India, Thailand and China, for example), investigations into the production of biogas in the Caribbean are still on a small scale. As a teaching resource, the possibilities of a school biogas generator seem almost endless. Attitudes towards 'alternative energy' and the environment can be fostered; the chemistry and microbiology of the generation of gas from domestic and farm waste, and the physics and technology of its collection, distribution, and use, can be investigated; agricultural considerations, for instance the comparative value of manure before and after it has been through the generator, are of interest; and the hazards and strategies of overcoming them, are concerns often neglected in science courses. As a resource for the development of problem-solving ability, central to the study of science, the installation of a school biogas generator is an exciting prospect. (It is not, however, a matter to be left entirely to the amateur; the hazards can be serious.)

Recognising the potential contribution of a school biogas plant to the study of integrated science, the Caribbean Examinations Council has distributed a design to its pilot schools, although as yet no schools appear to have built any (12).

The Scientific Research Council of Jamaica is also exploring biogas generation, and has helped a teacher (13) to build one for his home. This unit also acts as the home septic tank, and is enriched by manure from the teacher's chickens, ducks, geese and pigs. It provides him with virtually all the cooking gas he needs and could

supply lights and a refrigerator. Only a few yards from the house, the plant is inoffensive and the teacher has shown great ingenuity in refining the design.

A project of this kind is likely to receive enthusiastic support from Government ministries and other public agencies, not least because it should save money.

Power Packs

All school laboratories, especially those for physics, need plentiful sources of electricity at low voltage. Distribution through bench terminals from a central fixture is not nowadays recommended; it is difficult to supply different voltages to different benches; terminal voltage is subject to variation as students switch their circuits on and off; children have a tendency to fiddle with and damage any kind of bench fixture; and if the central unit is a bank of accumulators, it needs skilled maintenance from the technician or teacher.

The most common alternative is dry cells. Their advantages are that they are readily purchased locally; they are so familiar that young children easily understand how to use them; there is no danger to children and comparatively little danger to apparatus. Disadvantages are that current available from them is so low that certain experiments are impossible; they need auxiliary cell holders which are sometimes a little complicated to set up; the cells and cell holders tend to 'disappear'; and, most serious of all, their useful life is so short that no school anywhere is likely to be able to afford to keep a good supply. At current 1980 prices, it would cost approximately US \$20 in a particular country to equip a class with (locally manufactured) dry cells on the Nuffield scale for two or three lessons. This figure could represent half the entire annual fund available for science teaching in a school in one of the less affluent countries. The consequence is that not enough children have the opportunity to get their hands on enough electrical circuits. Dry cells are probably essential for the first few experiences in the study of electricity; after that, teachers agree, a more permanent power supply should be provided.

The next most common source of power is accumulators. The lead-acid accumulator has few, if any, of the disadvantages of the dry cell. However, its maintenance demands skill in physics which few teachers and laboratory assistants have, and its useful life is likely in practice to be limited to a few weeks. Discarded car batteries can, however, be a useful auxiliary source, since they can usually be obtained free from pupils themselves. The NiFe (alkaline) accumulator is much more difficult to damage from misuse or neglect, and it can be a most useful resource. However, for high voltages a large bank of accumulators is needed, and the current available is too small for some purposes, since the internal resistance is fairly high. None of the cells mentioned above can, of course, provide alternating current.

It is easy to see, then, why the Report of the 1977 Guyana Production TVC (p.12) states that power supply units are essential for laboratories. They are not cheap but, if carefully designed, should last for years and be usable by the average science teacher and his pupils. Once the money is available, the main problem with power packs is that the variety in the catalogues is too complex to make choice easy for anyone but the very experienced physics teacher. A survey of 48 physics teachers in three Caribbean countries showed that only 10% considered that they had enough low voltage power units for their

needs; another 12% of the A Level teachers and 16% of the O Level teachers were seriously handicapped by having too few; and the rest had none at all. More disturbing, 19% of the A Level teachers and 22% of the O Level teachers would not use these units even if they had them! The message for teacher education is clear. Teachers cannot even rely on others to choose for them and some teachers have been given certain equipment by their Ministry of Education but not the power supply essential for its use. Local production, preceded by extremely careful design and accompanied by user advice, would appear to meet a great need.

Recognising this in 1972, a lecturer in the Physics Department of UWI Mona (14) explored the possibility of production by students and technical staff of the Department. He designed and costed the most useful type; input 110 V AC, output 0-12 V AC or DC at 8 A. The project was abandoned when he found that, even given free labour and duty free components, the packs would be more expensive to assemble locally than to buy from abroad. (But he was doubtful about the adequacy of the switches being used by overseas manufacturers). Since 1972, foreign exchange problems for some Caribbean countries have added a new dimension to cost considerations, so that it may be worthwhile to pay more for local manufacture as long as the materials are also local. This would not be the case for items built from electrical components, which are always imported. Nevertheless, labour costs in Britain and elsewhere may have increased enough to warrant reconsideration of the project. Anyway, assembled power packs are not being imported, even if they are cheaper, and the teachers' need for local help may over-ride the cost aspect.

A similar need has been recognised by the Science Teachers' Association of Guyana (STAG), which saw the possibility of an input from the Faculty of Technology. The Faculty provides a technicians' course in which an assignment is the production of a 9 V DC power supply unit. Objectives, notes on components and construction details are provided in a workbook which itself should interest some science teachers (15). Intended to supply a transistor radio or calculator, the output of the unit is only 50 mA, quite inadequate for school science (and therefore unlikely to survive a single teaching period in the hands of most teachers). However, the Faculty technical staff have designed and built other power packs to meet specifications for individual experiments, and they see no reason why they could not meet design and large-scale production demands from schools. What is now needed is a formal request from STAG through the Ministry of Education, assuring the technicians of adequate compensation for their time and expertise. A preliminary needs assessment of the kind reported above would be useful.

The design team for local production must include a teacher knowledgeable about the uses and abuses to which power supplies are put in schools. There must be very careful protection against overload, not by using a convenient cut-out which can be instantly reset, but by a more clumsy fuse (which, nevertheless, should be readily available locally). Once a teacher has gone to a little trouble to replace a few fuses, he will come to understand the ways in which power packs are commonly abused. There should also be strategies to protect the secondary equipment from an excessive voltage - a device on some kinds of overseas power packs is a voltage setting operated by an Allen key, simple for the teacher who has the key in his possession, difficult for all but the most mischievous and determined of pupils. The mains outlets in schools are often without a third (earth) connection. Mains-operated equipment requires

special attention to the safety of the child and all members of the design team must ensure that this consideration is paramount. Bench testing under the most rigorous conditions should precede distribution to schools.

Regional manufacture would have to take account of the different characteristics of mains supply. Some teachers, but not all, are aware that they must specify input voltage. In some countries of the region, the national supply is at 110-120 V, in others it is at 220-240 V. And the school supply, or parts of it, may be different from the national standard, and not always explicit to users of the outlets. Also, there is no regional common frequency - we find 60 Hz in some countries, 50 Hz in others. Although power packs are not sensitive to mains frequency difference, other apparatus such as ticker-timers and signal generators will not function properly on the wrong frequency, and suppliers and consumers must be aware of options.

A considerable proportion of the cost of imported equipment is the research and development cost; local producers must be prepared to substitute their own research and development, and the low tension power supply is a good illustration of the importance of this.

Electronics Teaching Kit

Final year physics students at the University of the West Indies are required to undertake a project, which may be a teaching project. As an example only one student has chosen the design and construction of a school equipment kit. This is a set of modules for the teaching of electronics, the modular approach being chosen because it provides flexibility and is easier to understand. The kit contains :

1. A basic unit, an unbiased transistor amplifier with three inputs and two outputs.
2. An indicator unit, which is essentially a digital voltmeter.
3. A multivibrator unit.
4. An AND gate unit.
5. A JK flip flop unit.
6. A square wave generator.
7. A tuned circuit.
8. A detector unit.
9. A filter unit.

All modules except the tuned circuit are of identical dimensions. Leads with banana plugs are provided to link the modules, and a simple aerial is provided. A booklet describes the construction and suggests ways in which the kit can be used to explore the applications of electronics (16).

Because school physics and integrated science courses do not yet include much in the way of electronics, kits have not yet been put into production. Even at present, however, there are electronics courses in the technical wings of the senior comprehensive schools of

Trinidad and Tobago, and, although these wings are very well equipped, it could be a useful exercise for the children to build their own kits from this or similar designs. It would also provide an appealing project for a science club or an individual student, who could do much of the work at home.

Models of Applications of Physics

Physical science courses in schools are especially open to the charge from students that they are 'not relevant'. To help children realise that physics contributes much to engineering and medical technology and the quality of life, the Physics Department at UWI Mona has set up a Mini-Physics Museum with the aid of a grant from the Organisation of American States. The models in the museum, built by staff of the Department, are available for schools to borrow for events such as an Open Day (17). The list of models so far produced is as follows :

1. Model of retinal processing, which takes up where elementary textbooks leave off. The 'retina' is an array of 156 photo-transistors and can be used to demonstrate image perception, colour vision and its deficiencies, and relative distribution of rods and cones in the retina. The display is a box containing flashlight bulbs and a viewing screen.
2. Heart monitor (electrocardiogram) connects points on the surface of the body through an amplifier to a cathode ray oscilloscope.
3. Coupled oscillation and resonance. Two sets of pendulums are driven by a stream of air from an electric blower in order to demonstrate the principle of resonance common in everyday life.
4. Electronic organ, consisting of an oscillator, amplifier and speaker.
5. Windmill generator which depends on the principles of Bernoulli and electrical generation to pump water and to generate electricity for immediate use or storage.
6. Magnetic suspension which depends on a transducer whose voltage output is proportional to the light incident on it, and this is dependent on the position of a suspended ball. The principle is used in frictionless bearings and magnetically suspended trains.
7. Tesla coil, put into the context of the magic of physics since it can produce 'such fascinating effects'.

A handbook for users is available.

This enterprise will make little contribution to solution of the day-to-day classroom problems of the teacher. However, supplemented by a discussion of the physical principles, it can do much to show A Level physics students how their classroom physics can be put to work and can encourage them to engage in design, construction and investigation themselves. Even at a lower level, there are motivational opportunities. For example, two D stream fourth formers,

potential drop-outs, encountered the Tesla coil in a book on physics models in a science club and, as a consequence, went on to take physics PhDs. For a team of 16 university physicists to engage in a project to make physics exciting for school children is an action that can only be beneficial to both the university and the schools, and one that is unfortunately too rare.

Local Manufacture

The foregoing description of prototypes, models and design which could lend themselves to large-scale production for schools is a short one. Clearly, curriculum development in the Caribbean has not been accompanied by the development of equipment for the curriculum, such as was undertaken for PSSC, the early Nuffield projects and Kenya's SSP. One reason for this is that the largest country in the Commonwealth Caribbean has a population of only some two million, while the combined population of the 16 other West Indian countries from Bermuda and the Bahamas in the north to Guyana in the south is less than three million, only a small proportion of who are of secondary school age. Bhattacharyya, of India's NCERT, listing basic equipment for a low cost science equipment production centre in his presentation at the Bahamas Workshop (Commonwealth Secretariat, 1977, pp.37-40), mentioned an average production worth £100,000, and observed that the list might prove uneconomical for small countries. As a solution he suggested a common regional centre. Although this idea has merit, it is difficult to identify any existing regional organisation which could be expected to initiate such a centre.

For primary science, however, national or regional mass-production is a possibility for the future. As has been said earlier, primary science makes smaller demands on research and development; the numbers of children are larger; primary science curriculum development has assumed an importance that it did not have in the 1970s; and a regional UWI/USAID project for primary schools has come into being.

In discussing local design and production, we should not confine ourselves to financial issues, as the foregoing account should show. A financial investment may or may not lead to financial profit; we can be sure, however, that the educational gains would be valuable and the human creative ability in the region would be recognised and used.

It is unlikely that the Caribbean will ever produce even most of the science equipment used in schools as has been achieved in Turkey, where DAYM produces over 80% of the equipment required for teaching physics (Commonwealth Secretariat, 1977, pp.77-80). It is probable that local design will lead to mass production of some items and accordingly provide better learning of science and an outlet for the talent in the region. There has so far been no co-ordinated approach to this.

However, there is the possibility that the Caribbean Development Bank might be interested in the local fabrication of science apparatus for use in primary and secondary schools, given the following evidence:

1. There is an economically significant demand for science apparatus which can be fabricated locally or within the region.
2. There exist prototypes or models for apparatus which can be developed for local fabrication through appropriately designed studies which may involve activities such as:

- (a) Adaptation to local materials, local requirements or local skills.
 - (b) Design and testing of a suitable small scale plant for fabricating scientific apparatus.
 - (c) A feasibility study.
3. Governments and science teachers' associations will give strong support to the project and will participate in the development of a system to programme production, supply raw materials and deliver finished products in a way that is well suited both to the needs of schools and to the operating limitations of the production plant.

It is hoped that the Bank, a finance organisation, could commission studies to establish such evidence, and a project of this kind could benefit from the experience of the Commonwealth Secretariat, NCERT, RECSAM, DAYM, SEPU of Kenya and others. The Bahamas and Guyana Workshops could well prove important first steps towards the solution of some regional needs.

IMPROVISATIONS

Teachers who improvise do so when commercial apparatus is not available or not suitable. Even in laboratories with the best equipment, good teachers will improvise; this aspect will be discussed more fully in a later section. Most schools, however, are not adequately equipped, so that their teachers are faced with the choice of improvising or denying their pupils valuable experience. As any science-educator knows, the second option is most commonly chosen, and it is easy to describe the teachers as overworked or lazy. The explanation is probably much more complex (although, of course, most teachers are overworked, or believe they are, and most schools have some lazy teachers). More fundamental explanations probably lie in teachers' attitudes and beliefs about science and about their own competence, and in social circumstances which may be unexpected.

The best-known guide to improvisation is the UNESCO Source Book for Science Teaching; other well-known guides are listed in the Bibliography. The Source Book has been very popular with teachers in the Caribbean although possibly mainly while they are in training. A lower-secondary general science text of the 1960s, written by a teacher-educator in the Caribbean, was based on the premise that teachers would have to make most of their equipment. The principle was welcomed by decision-makers, and the book was widely prescribed. But teachers would not use it.

Most teachers' college courses require students to improvise some apparatus, but it is reported that they want 'the real thing' when they go out into schools. While the Jamaica primary curriculum development, for example, stresses the use of local materials, teachers want what they used in college, for example metre rules instead of knotted string or uncalibrated rules. The Guyana TVC Report (p.5) and information from the Eastern Caribbean support this experience. It has been suggested that teachers' colleges, simply by being equipped with commercial apparatus, are misleading student teachers about priorities in the teaching and learning of science. A sixth-form teacher justified his position with the statement: 'Because that is what scientists are using' (18). Teacher-educators in the Caribbean have not been very successful in giving teachers confidence in their own creativity and critical ability.

Khoo (1976) draws attention to the development of decision-making skills in the RECSAM courses of training in the development of primary science and mathematics apparatus, and the RECSAM systematic approach may be one which we in the Caribbean would do well to emulate. Meanwhile, an energetic Guyanese teacher, in his reference to 'style', may have put his finger on what teachers are looking for in their science materials. It seems clear that locally produced learning resources (apparatus and printed guides) should be well finished and pleasing to handle. Perhaps users have more confidence in resources

which have a professional appearance.

Improvisation in the less affluent countries may encounter unexpected difficulties. Dish-washing detergent bottles lend themselves to the construction of wash-bottles, filter funnels, beakers, force pumps and other useful laboratory items. But one forgets sometimes that countries short of foreign exchange may not have dish-washing detergent. When large-scale improvisation begins, creating a demand for 'throw-away' items such as thread spools used in clothing manufacture, local people in need of money themselves suddenly put a price on these items. In the Caribbean we are only now discovering what has been known in India and Bangladesh for a long time.

Any good science teacher is something of a scavenger, and probably the first purchase for a science room should be a simple set of tools. The Ministry of Education in Jamaica has produced a four-page list, Suggestions for Equipment and Materials for Grades 7, 8 and 9 Science (4). Beginning with a list of tools, it includes other hardware materials, other household materials, stationery supplies, electrical supplies, supermarket/pharmacy/market supplies, chemicals not so readily available, and other supplies. The ways in which these materials could be useful are outlined, and any teacher is likely to find new ideas in it. Some years ago some teachers in Dominica produced a booklet on improvisation from locally available materials, but it was not widely known even at that time and has not been seen by this author (3). Locally available materials also constitute the bulk of equipment and materials recommended for the Caribbean integrated science curriculum published as New World Science (Reay and Turner, 1975 and 1976). Even given adequate finance and foreign exchange, experienced teachers, and better processing of orders than is described in the Bahamas Report, a year or more may elapse between the preparation of the order and the receipt of the equipment (19), and the local shops can be more useful to science teachers than most of them realise (20).

From Jamaica comes another resource designed to help improvisation. Supported by the Organisation of **American States**, the Co-ordinator of the Project for All-Age Schools has produced an Improvisations in Science Handbook for teachers of Grades 1-9 (5, 21). The handbook, whose contents are listed in Appendix 2, freely acknowledges ideas from a fairly varied bibliography, while being selective for local curricula and resources. A written description is often not enough for teachers, especially primary teachers. In Jamaica there are six primary science centres in teachers' colleges and schools containing some equipment supplied by OAS. While teachers can borrow this, it does not exist in quantity, and teachers are encouraged to make their own copies (22).

A Survey of Secondary Teachers

In order to find out what secondary teachers possessed, needed and had made, a survey was carried out with considerable help from the Jamaica Science Education Centre and the Guyana Ministry of Education (23, 24). With Trinidad and Tobago included, the three largest countries of the Commonwealth Caribbean, containing 80% of the population of the region as defined, were sampled. (An attempt was made to include Barbados, the Eastern Caribbean and Belize, but communication problems arose.) It is unfair to ask teachers to take time to count the number of pieces of each item of apparatus in their schools and, in any case, the number of items available to a given teacher tells the researcher nothing about whether the teacher would use them

or not, and in what way. In this survey, teachers were asked to indicate:

- A if some of the equipment (or adequate equivalent) was available in quantities which enabled them to prepare all their students more or less adequately in the time available to them.
- B for items (familiar and unfamiliar) which were not available and would not be used if they were made available; this category was especially useful in identifying the problems of teachers in keeping up to date.
- C for items which they did not have, would certainly use if they had them, but could manage reasonably well without.
- D for items which they possessed in such limited quantities that the preparation of their students was severely handicapped.
- E for items which they did not have and whose absence made it impossible to cover crucial areas of the curriculum.

It was hoped that such questions would be non-threatening and would provide a reasonably valid description of the teacher/equipment inter-relationship in schools.

Four such checklists were distributed to named secondary teachers. To avoid personal bias in the researcher, the checklists were prepared from lists constructed by others for other purposes. The nature and sources of the checklists, and the number of responses, are shown in Table 1.

Table 1 : Science Equipment Checklists Distributed in Caribbean Survey

Curriculum	Source of Checklist	Response
A Level physics	Verbatim from APPIL Teachers' Handbook Appendices 2 and 3 (25).	19
O Level physics	Complete list prepared by an ASETT committee (26).	29
Upper-secondary integrated science	Verbatim list prepared by some Guyanese educators for CXC integrated science - not comprehensive.	19
Lower-secondary integrated science	List extracted from Philip Harris and Griffin & George special catalogues for WISCIP and WISC and from <u>New World Science</u> ; locally available materials excluded,	33

Very few schools and almost no teachers were asked to complete more than one checklist, so that nearly 90 schools and teachers in the three largest Commonwealth Caribbean countries provided information

about their resources and needs. A and O Level physics teachers were also asked to indicate the number of GCE candidates entered in 1980. Although two A Level and six O Level teachers overlooked this information, the total reported GCE physics entry was 246 A Level candidates from 17 schools and 1055 O Level candidates from 23 schools. All teachers were asked to indicate any items produced in their own countries. Any items for which there was a great demand would merit serious consideration for local mass production.

The information emerging from both physics checklists was thin. Only one school (27) appeared to have any home-produced equipment. There were indications that teachers did not recognise the equipment items listed. For example, a teacher who describes himself seriously short of ticker timers, while indicating no use for ticker tape, may be interpreting 'ticker timer' as 'stopclock'. If this is so, the information provided about equipment needs and stocks is unreliable and details about each item are not worth reporting. However, the categories of responses are summarised in Appendix 3 (A Level physics) and Appendix 4 (O Level physics). We can examine these in an attempt to learn something about the teachers, for it is no good making equipment that teachers will not use.

The A, D and E responses must be treated with caution. In one of the countries, the checklists were distributed and collected by a Ministry of Education officer, and it appeared that some teachers did not lose the opportunity to indicate to the Ministry that they should have injection of equipment. Indeed, one return was accompanied by a letter which said "...we are sorry to say that we do not have any of the items. We are preparing students We will be grateful Thanking you in anticipation" It did appear, however, that items of the type demanded in quantity for the GCE practical examinations were much more likely to fall into the A/D/E categories (have, or need badly) than were other items with at least as much potential for the teaching of physics.

A school which does not have laboratory apparatus and materials cannot provide practical experience. In many Third World countries, foreign exchange and school budgets are so limited that teachers must either improvise or provide little or no concrete experience. What of countries without such problems? Can we expect teachers' perceived problems and needs (their view of their resources) to be related to the money available? In other words, is money the fundamental problem? Since the checklists for this survey were distributed in countries representing the economic extremes in the region, there was an opportunity to search for a relationship. None was found. A Wald-Wolfowitz runs test of significance on the data in Appendices 3 and 4 failed to show, for any category of response, anything approaching near the 0.05 level of significance, with the exception of the A Level booklist summarised in Appendix 3 (28). At least for physics, it appears that both resources and needs of teachers are related only remotely, if at all, to the amount of money available from governments. It would appear that decisions about the local production of resources should take into account much more than economic considerations, and should pay special attention to teacher education. This might become clearer if we look at the B/C responses to the physics checklists, shown in Appendices 3 and 4, both disturbingly large. There are too many items which teachers are happy enough to do without (C) or, worse, would not use if they had them (B). Of course, the lists are not definitive; but if they contain items which are not really useful for the teaching of physics this would have been

recognised by knowledgeable physics teachers whose B/C response would have shown a low standard deviation. This kind of finding failed to emerge from the survey, which showed that teachers are not in agreement about what is needed for the teaching of physics. The best we can do to evaluate the list is to consider the response of Teacher 25 in Appendix 4, without doubt the most experienced and expert physics teacher in the region (27). Of the 215 items suggested for O Level physics, this teacher selected 35 as in category C and only one in category B, the other 179 items being regarded as essential. We thus have some support for the judgement of the ASETT Physics Committee which prepared the list.

Where there is no in-school improvisation, a large number of C responses would suggest either a teacher who does not teach the related concepts or one who attempts to teach them by chalk and talk. And a large number of B responses suggests a teacher who does not know about the apparatus and its educational potential. The nature of responses to the physics surveys conform to what is well-enough known anyway in the Caribbean: much of the physics teaching is being done by teachers who are not comfortable with physics; and there are hardly any teacher-educators themselves comfortable enough in physics to help teachers of physics and integrated science. Obviously, one cannot expect much in the way of designs for improvisation from teachers already struggling with physics content and methods. Further, such teachers need help in selecting commercial apparatus and materials; with this in mind, each teacher was sent two copies of the survey checklist with an invitation to keep the second copy as an aid to determining future requirements (29). Accordingly, the checklist itself might be described as a resource.

The physics surveys, then, provided little useful information about the adequacy of equipment stocks but strong indications that physics teacher education is badly needed.

The upper integrated science checklist, being incomplete and specific to a Caribbean course, did not yield information of general interest, and the data from it will not be reported here.

The lower integrated science checklist, however, raised some general issues. While the very large majority of Caribbean secondary schools teach science which is more or less integrated in at least the first two years, there is no single curriculum. To be sure, the majority of schools in the Eastern Caribbean and Guyana use WISC, but half of the schools responding to the survey did not come from these 'WISC countries'. In Trinidad and Tobago, less than half of the responding schools teach WISCIP (the forerunner of WISC) while the rest teach integrated science curricula developed in-school. In Jamaica, none of the schools teach WISC or WISCIP although most teach the Grades 7-9 curriculum developed and recommended by the Ministry of Education. It was not surprising, therefore, that the 33 responses from the three countries showed no curriculum-related or national patterns.

In contrast to the physics survey, teachers gave the impression that they knew what they were talking about, and they appeared to have given much thought to their responses (30). Some locally-made materials did emerge, although not more than two schools indicated this for any particular item. In the Caribbean in the 1970s, teacher development and curriculum development have concentrated on integrated science, and this may account for what appeared to be a greater level of awareness in lower-secondary integrated science teachers.

Responses appear reliable enough to report in more detail than those from the physics surveys.

Accordingly, Appendix 5 lists each item on the checklist in descending order of adequacy for the teachers' practices, with a summary of the way in which teachers responded. (Items readily available in the local shops were not included in the checklist.) Appendix 5 also indicates how many items have been locally produced, all in-school as it turns out, with notes on some of these.

Bearing in mind that the checklist included the term 'or adequate equivalent', teacher-educators may feel that teachers were not dissatisfied enough about the lack of certain items of equipment. As with the physics surveys, this could indicate a tendency to chalk and talk and/or a lack of knowledge about aspects of the discipline and ways of teaching it. Teacher-educators selecting experiences for in-service courses might find the list useful as an indication of where to start.

If we examine the order of adequacy, we note a tendency for what is generally described as 'standard laboratory apparatus' (equivalent to apparatus for general chemistry courses?) to appear high in the list. Apparatus required for GCE biology and physics practical examinations also tends to be high, in accordance with the physics teachers' responses. Physics equipment for the teaching of ecology, and visual aids tend to be low. Remembering that lower-secondary integrated science demands are relatively attractive to market-conscious manufacturers, and that teacher demand and use is closely related to teacher education, priority areas for attention in local production and teacher education may be identified. Clearly, we cannot expect to provide many of the high-demand items by local production in the near future (e.g. item 168, colour blindness text book, and certain components of item 160, the electromagnetic kit); but there is no reason why excellent versions of item 161, kinetic theory model, cannot be put together locally and why animal skeletons (e.g. 83, 87, 96, 111, 112 and 154) cannot at the same time clear carcasses from the roads and provide schools with materials which appear to be in reasonable demand (31).

The physics and integrated science surveys confirmed that mass production and in-school design and production in the Caribbean are virtually non-existent. They may, however, have achieved something more positive by identifying needs to educational decision-makers in the Caribbean and suggesting problems that may be paralleled elsewhere. Clearly, local production of science equipment should be much more concerned with issues of teacher development than with the idea of saving money and foreign currency, even if one adopts the priorities of the financiers rather than those of the educators. No matter how centralised the decision-making processes in a country, the teachers who intervene between the resources and the children must understand what they are up to.

Finally, one wonders whether the adequacy of provision of resources from those who hold the purse strings has any effect on the children. Could it not be that any teacher conscious of the value of direct experience will arrange for the children to have this? Obviously, a teacher, in a well-equipped school will have spend relatively little time in designing learning experiences in science, but can we expect the same teacher in a different kind of school to subject children to experiences in which they will not learn well? It is more likely

that good equipment helps the teacher, not the children, reducing the demands on his ingenuity. At least, responses from teachers known to the author indicated that needs and perceptions depended much more on the teacher's insight and competence than on the resources in his school. Decisions about whether or not to undertake local production, and the priorities of local production, ought to begin with the teachers, not the economy, nor the children, nor the examination. This is the Guyana position. In a different Caribbean country, a decision at Cabinet level to undertake local production of science equipment, including equipment for schools, was taken without consulting a single science-educator or scientist (32). This illustrates the simplistic view of those not at the chalk-face, and educators should be alert to the possibility of such uninformed decisions.

IMPROVEMENTS ON COMMERCIAL EQUIPMENT

The preceding section examined the extent to which Caribbean educators had improvised equipment when commercially produced models were in short supply. Among the roles of the science teacher, Silber (1979) has included that of experimenter/tinkerer, and some teachers improve on their commercial stocks for educational reasons. It may be an improvement to allow the commercial pinhole camera kit to gather dust on the shelves while the children are given toilet paper cardboard cores, carbon paper, greaseproof paper, rubber bands and pins. Improvements may convey the concept better, or show children that science is all around them, or facilitate investigations at home, drawing family members into the child's experience and giving them a better understanding of what the school is trying to do, or be more convenient to use, more flexible or more easily repaired. In the Caribbean, improvements appear to have been few.

Of course, what is an improvement to one teacher will certainly be described as an inadequate substitute by other teachers. A school in Guyana was found to have burette stands made by the school carpenter, the burette being held by spring clothes pegs nailed to a frame. The risk of damage to burettes was less than from the conventional design, which screws, and the whole stand, though quite robust, could be repaired easily. The incumbent teacher, however, was unimpressed because it did not look like 'the real thing'.

Science educators in the Commonwealth may find some new ideas among the following short description. The first eleven items were contributed by one teacher of physics and integrated science in Jamaica (27); sources of the other items are as indicated.

Circuit boards were quickly made as a large class set some ten years ago and have given good service ever since. They are readily repaired. The base is a simple square of 2.5 cm plywood; the pegs are flat-headed aluminium nails driven through the plywood using a template to ensure exact spacing; the battery holder is a set of four fuse-holders fixed at appropriate distances apart to provide springy connections for the cells; the connectors between components are strap steel taken from wooden crates.

Pinhole cameras made from chalk boxes may be adjusted in length by pulling the two sections of the box apart.

Lamps for optics work consist of well-ventilated wooden boxes lit by mains bulbs, readily replaceable. The 'object' is a triangular aperture which may be covered with a scrap of wire gauze to facilitate sharp focusing. If the sides of the triangle are made to be exactly 1 cm, quantitative work is simplified. One mains outlet

can safely supply three such lamps which are therefore not dependent on a good supply of low voltage power packs.

Resistance boxes can be constructed from a few standard resistors and a few terminals to provide resistances of up to 50 or more ohms in steps of 1 or 2 ohms.

Electrical meters. In an ammeter, voltmeter or galvanometer, the main cost is in the 'movement'. Teachers need a good range of meters, and often find it difficult to provide enough of each range for class sets. It so happens that the commercial meters bought in variety by teachers are generally based on only a single basic movement, perhaps capable of carrying currents up to 15 mA. Difference in performance is provided by different resistances connected in series or parallel by the manufacturer. Since any O Level candidate is expected to be able to work out the resistance required for a particular job, it is not at all difficult for a teacher, given a class set of galvanometers, to design and put together meters to serve all his needs for galvanometers, ammeters and voltmeters of whatever ranges. (He does, however, need a good assortment of high resistances and of resistance wire which, though not expensive, did not appear from the Caribbean survey to be well stocked.)

Rheostats. Components of all kinds of electrical equipment in common use, rheostats (sometimes called potentiometers) may be scavenged from unserviceable domestic appliances or surplus stocks. Mounted for ready connection in the school laboratory, they provide adjustable resistances.

Apparatus to investigate the magnetic effect of an electric current. An important component of a physics course, this investigation demands a piece of demonstration equipment (or many different pieces of equipment) not available to many teachers. It demands an exploration of the effect on a magnet of varying the current, the length of the conductor and the radius of the current-carrying conductor, combined with a facility to control variables. A wooden board with a slot to carry the magnetic needle (which may come from a tangent galvanometer) contains large-headed nails arranged in concentric circles so that insulated wire can be wrapped round any of the circles as many times as required. Since the board must be mounted vertically, it is convenient to provide it with a foot.

Apparatus to investigate the electrical effect of a magnet. Given some good bar magnets, the apparatus is readily constructed by winding lacquered copper wire (readily obtained from discarded appliances) round hollow formers, for example, short lengths of plastic piping. The electrical effect is readily demonstrated, and the laws of electromagnetic induction investigated.

Tangent galvanometers. The coil can be made by winding insulated copper wire round a short length of a cylindrical tube, such as a container. The pivoted magnetic needle and scale are nevertheless commercial models.

Lever kit. The Nuffield physics lever kit lends itself readily to local production. The grooved levers and fulcrums are quickly made from wood by a carpenter with ordinary tools. The square 'pennies' are cut in a metal workshop from a strip of brass. After checking their masses on a laboratory balance, the heaviest ones have a small

hole drilled in the centre. Final adjustments with a touch of solder make the masses uniform.

Current balances. These have been made in Jamaica, although details of the design are not available (27). The current balance, incidentally, provides an example of where local production can go wrong. The UWI School of Education at St Augustine has some supplied by UNESCO designed apparently by someone who did not know how a current balance is used. The mini-magnets are polarised across the wrong dimension, which means that a current of any magnitude will exert a strong force on the magnet, so that the current balance cannot be used quantitatively.

X ray photographs. Some teachers use X rays from a friendly dentist in preference to a wall chart of tooth decay (33).

Wall charts. The educational implications of having wall charts made by sixth-form scientists or by children working with the art teacher are obvious (34, 35).

Force measurers. WISCIP provides a design for push-pull measurers superior to spring balances, which can only pull. Children make their own force-measurers from bamboo or plastic pipe and take them home (34).

Prisms. A plane mirror in a bowl of water in the sunshine provides an excellent spectrum, and can lead to a discussion of more physical principles than are involved in the use of the simple glass prism, which is usually chipped or broken anyway. (6, 36).

Stroboscope (flasher). Five of the 29 schools in the O Level physics survey had xenon stroboscopes, which are very useful if one can afford them. However, the Guyana Report mentions a strobe flasher made by a teacher who connected a bulb to a signal generator. No details are provided, but it is unlikely that this on-the-spot flasher would serve exactly the same purposes as a xenon strobe. One is tempted to make an empirical investigation of suitable lamps and output terminals, and to explore the educational opportunities.

There may, of course, be many other examples from energetic and imaginative teachers in the Caribbean, but they did not come to light in the survey, which showed beyond doubt that the majority of teachers do not improve on commercial designs for anything. The term 'energetic and imaginative' is used to describe the foregoing list, although it is possible that some or all have been described in the extensive science education literature. Teachers do not generally have, as a resource, guidebooks on in-school construction although the Maryland Guides (Lockard, 1972) and others were written for just this purpose. Journals from science teachers' associations, School Science Review and Science Teacher for example, and the ASE Lab Books, tend to be expensive and few science teachers belong to an association other than their own local one, most of which in the Caribbean do not produce regular publications. It seems fair, then, to describe teachers who pounce on the designs in the literature, and/or who design their own, as energetic and imaginative improvers. They have had little help from their universities, Ministries of Education and associations. The author of this paper, a member of one of the universities and of two of the associations, has anyway found most of the teachers' improvements in the above list stimulating and useful. One teacher (Yhip, 1979) favouring a 'more blue-collared approach to implementing science courses', has outlined some

'job-cards' which, used in workshops of educators, could increase sensitivity to such an approach and lead to the planning of strategies for small and large scale production.

SCIENCE ROOMS

It is surprising how many school architects are unaware of the need for flexibility in a laboratory. The great majority of Caribbean school laboratories are furnished with massive fixed benches which make small group work impossible and limit the range of strategies available to the teacher. The older chemistry laboratories are particularly awkward, tending to confront the child with a rack of bottles which cannot be seen through so that their view of the environment is limited to a couple of metres on either side. When the bottle racks are unscrewed and discarded, or turned into bookshelves elsewhere in the school, teachers and children are enchanted with the change in social climate of the room (37). When the benches are not fixed, they tend anyway to be too heavy for children to rearrange quickly; and teachers tend to arrange for one group per bench, which leads to 'groups' being as large as ten children.

The older benches tend to be made of excellent hardwood, and can readily be cut down to two-person tables, sanded and covered with plyurethane varnish. A modular strategy proves effective. This means that if the length of a table is twice its width, and if any fixed units and trolleys have both sides equal to the width of a table, the furniture can be arranged in a multiplicity of ways. Since a single table of dimensions about $1\frac{1}{2}$ metre by $\frac{3}{4}$ metre can comfortably accommodate two children, a useful modular dimension would be about $\frac{3}{4}$ metre, although this is subject to modification within the constraints of floor area of the room available and the number of children to be accommodated. Benches also tend to be too high and chemistry laboratories in particular appear to have been designed for a standing population. It is no wonder that children have to climb on to stools to use burettes. Tall benches demand tall stools quite unrelated to the length of a child's legs and tending to be unstable. A suitable bench height for medium-sized children is about the height of an ordinary office desk, and office tables assembled by local furniture manufacturers may well prove excellent as laboratory tables. Laboratories furnished according to these principles may be used in a variety of ways. For school functions, the tables are available for use elsewhere in the school. It is of interest that such a laboratory is much cheaper to build than the conventional type.

Laminated table tops have not proved satisfactory. They are expensive and non-resistant to many of the activities that go on in a laboratory. A polyurethaned hardwood surface is more resistant to most chemicals and heat, and is easily restored. Fibreboard does not stand up well to leaky taps. It follows that wooden furniture should be used when feasible.

Many schools do not have enough laboratories, and the younger children tend to be denied access to those that exist. Some

teachers have provided quite satisfactory classroom arrangements by treating the desks as the modules; desks with sloping tops may need to have their lids propped up with blocks of wood (38).

A flexible laboratory calls on the ingenuity of the designer if services (water, gas and electricity) are to be available to children. Some solutions are outlined below.

Water

For most purposes, a fixed unit will be required. A cover to the sink converts this space to a working unit for other purposes when necessary. It may be noted in passing that most laboratory sinks are far larger than they need to be, making unnecessary demands on space. When a classroom must be the laboratory, it is possible to solve some of the plumbing problems by providing a few buckets of water. One teacher has found a solution which may be original. It is worth quoting her report verbatim.

'My boys and I have found a fairly reasonable solution to the sink problem in the classroom...Some of them came up with the brilliant idea of using large Vaseline Intensive Care bottles with the squeeze down type of jet. With these bottles, they can control the amount of water being poured out quite easily and also, if the bottles fall, there isn't much spillage! So that's our tap. Our sink consists of a 250 mL styrotex cup. Twenty five of these cost less than \$2 and the cups can also be used for storing hot water and as a beaker when large volumes are being worked with. We try to use test tubes as much as possible to cut down on volumes where possible' (39).

Gas

Two possible solutions have been identified. The first provides the gas lines and outlets along the walls or on fixed service islands placed strategically round the room. Unless well thought out, they could lead to crowding of the children in too small a space, providing a hazard; one teacher in Jamaica, faced with a laboratory with gas taps on only two walls, refused to do any gas work at all. Many educators would agree with the soundness of his position although perhaps more would be willing to take chances on the safety of the children. The second solution is usually a consequence of problems with providing the school with a central gas supply, which in the Caribbean commonly comes from 100 lb cylinders distributing their propane or butane gas through built-in pipes. Pipes corrode and sometimes large gas cylinders are in short supply, and, often, a school is opened long before any gas is installed. Teachers faced with this kind of problem have picked up portable 25 lb cylinders and joined them in some way to the children's bunsen burners, either through existing uncorroded gas lines or through rubber tubing (40). However, there are hazards which need careful exploration: there may be only one control cock; connections can fall off; suck-back from one burner may affect other users; and the gas reservoir is in the laboratory, where it could cause an explosion.

Electricity

Unless one uses cells and batteries, pupils at their tables need to be able to reach a mains electrical outlet. Several effective solutions have been found, and choice from these will depend on the conditions in the laboratory.

1. Power outlets are available at the wall only. As with the distribution of gas mentioned above, this could lead to crowding at the walls.
2. Power outlets available from overhead. Ordinary overhead light sockets fitted with appropriate adaptors can provide drop cords to apparatus. There is little danger of children falling over wires, but the teacher needs to employ a simple calculation to ensure that the socket is not over-loaded, which is unlikely, given the load from school electrical equipment and the tolerance of the fittings in buildings.
3. Distribution from wall outlets. One school has fitted its small tables with double sockets of the standard mains type. With the aid of connecting leads with male pins at both ends, the tables can be connected to one another and to the wall outlets in any sequence. This strategy, while very neat, does provide hazards which could be dangerous in the hands of an inexperienced teacher: (a) children can trip over the wires; (b) a lead with a male connection at the output end can cause a shock to a mischievous child being taught by an inexperienced teacher; (c) the circuit may become overloaded.
4. Power outlets available in the floor, a high risk situation in a laboratory which also has plumbing. Flooding, and cleaning staff with wet mops, are other hazards which provide good reasons for avoiding this type of installation, and it has not been observed in the Caribbean.

Once there are no fixtures except on the walls, the science room, having maximum flexibility, becomes a much more useful place in the school than a mere laboratory. However, the provision of a few fixed service islands (of modular dimensions) does not much reduce flexibility and provides plumbing as well as gas and electricity throughout the room. Up to four tables may be served by each island, so that a class of 32 children working in pairs would be adequately served by four islands; perhaps the teacher would need a fifth island to which could be joined modular trolleys and/or tables to make a demonstration bench. If the sink is sunken and fitted with a removable cover, each island can provide an extra working surface. Some of the laboratories of the multilateral schools of Guyana have service islands carrying electricity and gas at strategic locations within the room, while others have wall islands which carry plumbing only.

Laboratories in the Caribbean have sacrificed black-out facilities for ventilation. More recently-built ones tend to have adjustable metal or (more satisfactory) wooden louvres, which could darken a room very quickly were it not that somewhere in the room there is usually a glass or wire-covered window. Older laboratories are likely to have glass windows. When these are painted dark green or boarded over with plywood, partial to total blackout becomes

available. Such a modification makes the room suitable for optics and other experiments, and for the use of all kinds of visual aids. This strategy is more satisfactory in the tropics than much more expensive options such as curtains and blinds (41). The usual pin-board, or even a white wall, doubles as a satisfactory projection screen. A sheet of galvanised iron, painted some appropriate colour, acts as a useful magnet board and can serve other purposes as well, depending on its colour. The plywood on the windows can even serve as a set of chalkboards.

Where there is a separate storeroom, storage facilities within the laboratory are little used as teachers find that children tend to interfere both with the cupboards and the apparatus in them. Laboratory cupboards therefore simply take up space and may give the laboratory a derelict appearance. The storage capacity of a small storeroom can be increased by storing some apparatus on trolleys standing against the fixed shelves but easily moved. Trolleys are almost essential for moving apparatus into and around the laboratory, and have a range of other uses as well, including macro-kinematics investigations. They are readily made locally from angle-iron and bagasse (fibre) board.

Storage and transport trays are also of great value. Wooden trays which have for decades served a teacher in Jamaica without a laboratory assistant, and small plastic boxes, once containing surgical sutures and obtained from hospitals, are ideal (27). In Guyana, the school carpenter designed and built storage boxes with sliding lids. The boxes are long enough to hold thermometer cases, and wide and deep enough to hold glass blocks for optics experiments. Fitted with partitions they hold lenses and mirrors (38).

The Guyana Report discusses the importance of planning for storage. In primary schools one of the biggest obstacles to the teaching of science is the fact that the classrooms are generally not equipped with secure cupboards, and indeed the rooms themselves are easily broken into by vandals. While the primary curriculum under development in Trinidad and Tobago demands the usual inexpensive and locally-available materials, it demands quite a variety of these and most teachers do not have the time or money to buy what they need for each lesson. The designers of SAPATT have put together a kit of these simple materials all contained in a strong wooden box which can be padlocked and kept in the Principal's office if necessary (9). The same precaution has been observed in Jamaica and the Bahamas, usually (and unfortunately) with the consequence that the materials spend much more time in the Principal's office than in the classroom. It is unrealistic to expect the majority of teachers to plan ahead in order to arrange for all materials to be in the classroom in advance of the lesson. Indeed, it would be impossible for the primary teacher prepared to respond to stimulus from the children. Similarly, a science resource centre, while economically attractive, will not do much to meet the needs of either the disorganised teacher or the flexible one. Teachers need to be able to put their hands on resources at once.

AUDIOVISUAL RESOURCES

In the Caribbean, the facilities for the production of audiovisual software are more than adequate for the demands. Audiovisual or multimedia production centres exist at UWI Mona, UWI St Augustine and the Guyana Ministry of Education. The Guyana multilateral schools each have small audiovisual centres. The Trinidad senior comprehensive schools have video-tape recording (VTR) equipment. All countries have commercial radio; and Barbados, Jamaica and Trinidad and Tobago each have one commercial television channel. In many respects these are greatly under-used, essentially because educators with the time and talent to spare for teacher education for the creation and use of audiovisual resources for learning are few. Social studies educators appear to perceive the value of such resources more readily than science-educators do. To be sure, there are difficulties with the availability of hardware, electrical outlets and blackout; but resourceful teachers appear able to solve any difficulties of this kind. The main problem appears to lie in the priorities of teachers and, especially, teacher-educators. Science teacher-educators consulted in this survey knew that the audiovisual centres existed; generally they did not know what these centres had produced and clearly had not advised them or drawn on their resources. A list of audiovisual resources, and the extent to which they have been or have not been used in science teaching, follows.

Radio and Television on Public Channels

Jamaica's Ministry of Education maintains an Educational Broadcasting Service which provides radio programmes for primary schools and television programmes and television sets for secondary schools, both including science as a component. The educational television service takes account of the double shifts in some schools, and the programmes are part of the curriculum development materials (4). Teachers' notes distributed each term allow teachers to prepare themselves for the lessons. There are also, or used to be, teachers' television seminars.

The Barbados Ministry of Education developed an educational television programme to support WISCIP/B, the first modification of Trinidad's WISCIP carried out by the Barbados Association for Science Education (BASE). As WISCIP/B eventually became WISCIP/C (the next modification from the Caribbean Regional Science Project) and then WISC, the West Indies Science Curriculum, the Ministry television teacher faced difficulties in keeping up with changes in the curriculum and its timing. Now that WISC is a published curriculum used by most secondary schools in Barbados, the Ministry has been able to revise the tapes which are telecast according to a timetable and outline of the programme sent to schools (42). Primary science is transmitted on both television and radio, supported by a timetable and

outline. Radio receivers have been supplied to primary schools as a matter of course and to some secondary schools and these, being Rediffusion, do not suffer from many of the problems experienced in Guyana (mentioned below). There are also programmes for children in out-of-school time (evenings and holidays). It is reported that the Barbados science programmes are used by teachers, but that they need guidance on follow-up activities (43).

Guyana has no television, but the Ministry of Education Curriculum Development Centre scripts radio programmes for primary schools, and provides them with radios, timetables, notes for teaching staff and wall charts which make the resource an audiovisual one rather than a merely audio one. An example of a science wall chart is shown in Figure 3 (44). The Guyana Ministry of Education materials distributed to teachers are outstanding in the Caribbean for the care taken in presentation, an important factor in marketing often overlooked by educators who expect teachers to respond positively to the ideas without being too critical of appearance. There is also a series on innovations in education addressed to teachers, parents and the general public, and broadcast at a time in the evening when the family is very likely to have its radio on while the evening meal is being prepared (45).

In Trinidad and Tobago there are some primary school radio programmes, although none for science. And while there is no educational television series per se, the Mucurapo complex of three schools (a junior secondary, a senior comprehensive and a highly selective secondary) has recently been very active in developing VTR tapes on education and in promoting their screening in colour at prime time (46). That educational broadcasting to schools in Trinidad and Tobago lags behind developments in Barbados, Guyana and Jamaica is very clear. Whether such broadcasting is effective is much less clear, and some educators doubt that teachers make much use of the programmes. Some possible reasons suggested in Guyana are: radios not working or stolen; no money to buy radio batteries; classes too large for children to hear or for a teacher to help. And teacher-educators in Guyana and Barbados have identified a need for in-school teacher education for educational broadcasting.

The conclusion is that the time has come to carry out a market survey or evaluation among teachers in at least the largest Caribbean countries, Jamaica, Barbados, Trinidad and Tobago, and Guyana. Enough experience and expertise exist to enable the design of television and radio programmes to move towards solving the needs of teachers as perceived by the teachers themselves.

VTR Facilities in School

Microteaching and videotape recording came to the Caribbean in the early 1970s as part of the UWI/UNESCO Teacher Training Project. A few science teaching protocols were prepared, e.g. 'Laboratory Storage', 'Planning a Field Trip', 'Questioning in Science', and 'Blackboard Presentation' (3). The early equipment was not compatible with commercial television and it has since been supplemented, at the Multimedia Production Centre at St Augustine at least, by colour facilities which are compatible. Meanwhile, a large part of the tape library was lost when the air-conditioning failed, as it does frequently, a hazard to be taken into account in future.

New schools in Trinidad and Tobago have also been equipped for VTR although the education of teachers for this medium is not yet really

off the ground. The exception is the Macurapo complex mentioned earlier, where first class videotapes in colour are being made, especially in social studies. There are few science tapes so far, and the Association for Science Education of Trinidad and Tobago (ASETT) has been invited to act as consultants to fill this gap.

Some teacher educators are cool to the idea of demonstration lessons on film, since there is a risk that teachers will regard these as models when they would be unsuited to the styles of many teachers. It has been suggested that different ways of teaching the same topic could be collected together into a film, although this has not yet been tried.

Sound Tapes

Almost any teacher-educator or teacher has fairly easy access to a cassette tape recorder which is portable and capable of picking up at least the teacher's transactions in the classroom. In a region where most of the postgraduate teacher education is in-service (in the sense that the student teachers spend most of their time in their own schools), the teacher-educator can fairly quickly build up a library of realistic examples of teacher behaviour and children's responses. Student-teachers, in turn, can tape their experiments in teaching for home study as described in the Science Teacher Education Project Theory into Practice (Hayson and Sutton, 1974), or invite their tutor to comment on a lesson at which the tutor was not present. Tapes produced in this way often have inaudible patches and are likely to be useful only to the particular teacher and tutor. Tapes which demonstrate nothing of interest are of course erased. Teacher and child behaviour in the face of a sound tape recorder has proved to be much more natural than when they are conscious of a camera.

Guyana's Primary Methodology Project, which includes the teaching of science, collects on sound tape the good things that teachers do. Assuming that the strategies are fairly general ones (e.g. questioning, motivation), these are analysed to produce handbooks of the strategies, to provide the bases for workshops (7). A very few teachers are experimenting with self-paced learning/auto-instruction, and one such **biology** teacher makes sound tapes for inclusion in her package (47).

Photographs

Once again stimulated by the social studies teacher-educators, the School of Education at UWI St Augustine is in the process of building up a collection of black and white and colour photographs related to science and its applications and to science teacher-education (48). The potential of this resource has not yet been fully realised, as teacher-educators have not yet taken enough time to advise the staff photographer on suitable subjects.

In the teaching of life science, and the life science component of integrated science, microscope slides are well known and good slides are made by teachers and laboratory technicians. When, as is often the case, the teacher needs to project the image, he uses a micro-projector. From Appendix 5, item 102, we see that microprojectors are not common in schools, and some educators question their value anyway; and teachers do not find them easy to understand and use. An alternative is the 35 mm colour picture, available from commercial suppliers or, given suitable equipment for photography, made locally. Although some scientists have made such photographs, they have not

yet been mass produced. Much easier to photograph by the amateur are macro-pictures of local specimens to demonstrate biological principles, and Dalgety and Farley (1979) have observed that one of the best investments a teacher can make is to purchase a camera. A good set of some 30 slides was produced in Jamaica to support the ecology component of CISC, and offered to CROASE (49). The British Council turned these into multiple sets, which were distributed to CXC integrated science pilot schools. It should not be a difficult matter to finance and execute much larger scale reproduction and distribution.

In the teaching of physics, particularly kinematics, photography as a tool is well understood and all the equipment and most of the materials are available. The strategy has, however, been accorded low priority in the issues facing physics educators, and not much has been produced. It is hoped that schools will in the future be offered class sets of diffraction slides made from a design by Whitworth (1979) as soon as a source of high resolution film and chemicals is found.

Other Visual Software

Equipment exists at UWI Mona and UWI St Augustine for the production of overhead projector transparencies from masters, for example the set of masters produced for Nuffield Advanced Level Chemistry. Under the sponsorship of OAS, the Physics Department of UWI Mona has designed and produced a set of transparencies to illustrate applications of physics (17). Item 27 in Appendix 5 shows that overhead projectors are more common in schools than they used to be. There does seem to be constant difficulty with obtaining replacement lamps for the projectors, and pens, which have a habit of 'disappearing', are not always in good supply.

Astronomy is becoming a feature of integrated science courses, and star maps for Caribbean latitudes have been produced. The Jamaica type, drawn by John McDougall (14), is a set of twelve maps, one for each month; it was published in the journal of the Association of Science Teachers of Jamaica, Science Notes and News (1973), and has also been extensively copied from Gestefax stencils and distributed by the Science Education Centre (23) and the Astronomical Society of Jamaica for use in workshops. The Trinidad type is a single map spanning 12 months and latitudes 60°N to 60°S - more complex but more useful to some users. Drawn by Father Benedict (50), this map was printed in ASETT's Journal in Science for Trinidad and Tobago (February 1979, p.43).

PRINTED RESOURCES FOR THE CLASSROOM

This section is more of a sample than a list of the great volume of printed material that is being produced for science teaching in the region. We must consider, I think, whether teacher educators and curriculum developers are finding the most effective means of reaching teachers who are too numerous for them to meet in person as often as they would like. The common solution is to send the teachers materials which, it is hoped, they will read and use. Since the materials, in practice, are read and used to an extent which does not match the time and expertise which went into producing them, one must ask if there are better printed resources, or better ways of producing printed resources, than are being developed at present.

Production Methods

Leaving aside for the moment large scale commercial printing and small scale production for up to 10 copies, teacher-educators in the Caribbean rely on three main methods.

1. Stencils, which may be typed or cut electronically. This, by far the most common method, is the most readily available, the least difficult to learn, and production can be very quickly executed by a small team of one to three people (the writer, the typist and the machine operator). However, the products tend to be dull, lacking in variety, bulky and fragile, and these are important considerations for writers anxious that teachers should read and use what they have written. Most associations, ministries, universities, centres and teacher educators know only too well that teachers commonly say "A pink booklet? Oh, yes, I think I got one of those...". For production runs of up to a few hundred, materials costs are probably somewhat lower than by the other methods to be discussed below, but hidden costs (labour, for example) could lead to a smaller cost differential than is generally supposed.
2. Typed camera-ready for production on an offset press of the kind that exists at the three UWI campuses. The carbon ribbon typewriter necessary for a good image is now common, and the method is considered satisfactory enough for Commonwealth Secretariat and UNESCO publications. Because it allows reduction, paper costs and bulk can be reduced by, say, one third. The plates are much more expensive than even an electronic stencil, and a production run of at least several hundred might be considered necessary before the cost becomes justifiable. However, the automation of the printing press and ancillary equipment reduces labour costs of printing, collating and stapling. An excellent example of such an efficiently produced circular is the CLEAPSE Bulletin, a single double-page spread, reduced in order to accom-

moderate a fair amount of material. Impressed by this example, educators in Trinidad and Tobago explored the feasibility of bringing out publications in a similar format. A newsletter from the UWI St Augustine Teachers' Centre was estimated to cost about US \$30 for 1,000 copies of approximately 3,000 words. The Association for Science Education of Trinidad and Tobago has estimated that production of 250 copies of its monthly Bulletin by this method would cost less than US \$10 for each issue, and would make very much smaller demands on its members and those who help them. Where printers are under-employed, the delay between receipt of camera-ready copy and production may be only a day or so. (Larger publications requiring collating and stapling would take longer. Taking all these factors into consideration, it has been agreed by some groups in Trinidad and Tobago that camera-ready typing for offset printing could, in real terms, be more economical and more effective than the familiar stencil method.

3. Composed for production on an offset press. Composing looks more professional, allows for a justified page, and gives more words per page without reduction in print size. However, composer operators and graphic artists who paste up their corrections tend to be expensive and slow, and the St Augustine experience is that this process is a serious bottleneck in production. One wonders how many of our works really need such (slow, expensive) quality production.

It is suggested here that the second method of production deserves more use than it has had in the Caribbean so far. We may have been slow to come to terms with the existence of the printing press and the carbon typewriter ribbon, and a change in strategy might prove effective in reaching teachers sensitive to the appearance and bulk of materials with which they are swamped.

Curriculum Guides

It is probably safe to say that every Commonwealth Caribbean country has been engaged in science curriculum development during the past decade.

The first projects were lower-secondary integrated science projects, which become documented in the International Clearinghouse Reports (e.g. Lockard, 1977). Their relationship to one another and to other international projects has been outlined in Reay (1977) and I W Williams (1979). WISCIP of Trinidad and Tobago, still on stencils, is on the verge of a major revision exercise; WISC of the Caribbean (Adey), complemented by a choice of three sets of pupils texts from UWI Mona of Jamaica (Reay and Turner), have been printed commercially; Jamaica's Grades 7-9 materials (on stencils) are to undergo endless evaluation and revision; and Guyana's SDSP is currently under evaluation (51).

At the upper secondary level, Jamaica's Core Curriculum (on stencils) is also undergoing endless evaluation and revision, the philosophy being that the curriculum should never be static. The CROASE curriculum for CXC (2, 3) has been given considerable help in its pilot stage by a commercial publisher, who type-set even the first draft pupil materials and is prepared to wait for final publication as long as is needed for refinement of ideas. The only specialised science guide known to have been produced for the Caribbean is the Physics

Teachers Guide developed by the UWI Mona Physics Department under sponsorship from OAS (16).

The list of primary science curriculum development is so large that probably no single person in the Caribbean knows what is being done. In the Eastern Caribbean, every country is developing its own curriculum, many of them supported by science kits donated by UNICEF/UNESCO (3). Jamaica's primary science has received support from OAS and has set up six centres in a range of educational institutions in strategic rural locations, one of them having a delivery van (22). SAPATT, a joint enterprise of the Ministry of Education and UWI St Augustine (9), produced its first draft on stencils and evaluated this draft, with the aim of publishing small booklets with sturdy covers all printed by the typed/reduced/offset method outlined earlier. Guyana's Primary Science Education Programme guides are similar, except that they are not reduced, and the books are approximately A4 in size (45). Barbados was the first country in the Caribbean to undertake primary science curriculum renewal, in the early 1970s. A complete revision on stencils has since been completed by staff members of the Ministry of Education and the Teachers' College, and the material, which takes children up to 11+, is in all primary schools (3). After trials of teaching guides and basic science modular kits, the Bahamas expected to provide all primary schools with them, as well as with a Children's Reference Library of topic books. A Science Resource Centre in each school was to house the bulk of these materials. Although improvisation was to be encouraged, the programme would not rely solely on it. Although these plans were expected to be implemented in 1978, the survey has not been able to confirm that the plans were realised.

Most if not all of the curriculum development teams involve teachers as writers of the materials, with some editing being carried out by the co-ordinators. It has, however, been observed in Jamaica that primary teachers are more likely to use the materials if these are given after a workshop or if they are familiar.

They appear to lack the confidence to modify the activity or the suggested materials, and have difficulty in generalising from an example (e.g. from 'red pea' to 'seed'). Accordingly, while workshops help, the teachers want a very specific set of instructions to hold on to. It is also felt in Jamaica that printed materials should take account of the reading levels and Piagetian levels of the teachers, so that there is a need to collect data on these levels (52). The co-ordinators are sad to hear so often from teachers the request, "We're running out of facts - please send us some more." SAPATT's emphasis is an attempt to overcome this well-understood, but generally unsolved, problem of primary teachers.

Books for Children

Commercial publishers have produced a good selection of Caribbean texts for lower secondary integrated science. For the same level, one publisher embarked on a series of single concept books for the Caribbean (for example, one on sugar), filling an educational need (Adey 1974). These have not proved commercially viable, possibly because a slim spineless booklet of the Nuffield Background Reader type vanishes into a stack of books and is overlooked by readers and teachers; accordingly, the series was discontinued after only four were published.

Two commercial primary series for the Caribbean are known, one for the upper levels and one for all levels. When each country is developing its own primary course, always with at least major co-ordination by the Ministry of Education, a Caribbean-wide market, or even a national one, may not evolve, and publishers are assessing developments closely, conscious that the primary population in even one country is large and that few countries have the equipment and money to produce more than teachers' guides for primary schools. With its Timehri Readers, the Guyana Ministry of Education collaborated in an interesting way with a commercial publisher. With the help of a Commonwealth Secretariat regional course on book production in 1974, Guyanese teachers have been preparing manuscripts in workshops and are thrilled to see their work in print. While local production facilities do exist, they work out more expensive than when the international publisher arranges for printing in some other Commonwealth country; in any case the local printers cannot handle the 35,000 or so copies required. The art-work, layout and editing services, initially all provided by the publisher, are gradually being taken over locally. Although the Timehri Readers do not pretend to be science readers, and the primary science curriculum team plans in due course to produce readers to support its curriculum, it is not at all easy at the primary level to distinguish between science and non-science. For this reason, it seems appropriate to draw attention to this attractive series in a paper on science resources (7).

Jamaican primary teachers have asked for a regular 'newspaper' for children, an interesting idea. In Trinidad at least there is a Government periodical for children, but science content is absent.

Worksheets

While worksheets are no new idea, this author has been startled at the discovery that entire generations of postgraduate students have never come across them. The developers of WISCIP recognised the production problems of such a venture in the late 1960s, and provided none. By the time the Caribbean Regional Science Project had come into being, school resources were somewhat better, and worksheets were included in the WISCIP/C guides; a little in advance of the publication of the WISC Teachers' Guides, these were edited and published as WISCIP/C workbooks. While they sold well, a teacher-educator visiting a class generally found that very few pages in the book had been completed. Some teachers have expressed the view that worksheets produced by others are unlikely to suit a teachers' style and may even damage it (35). The Caribbean experience has been without doubt that the Scottish Integrated Science Worksheets, provided as a resource during lower-secondary curriculum development, have not proved useful to teachers.

The Jamaica Grades 10-11 programme provides materials for children who will not be proceeding to further education in science. These materials are programmed to make the children to some extent independent of their teachers. For children of the same age group preparing for CXC integrated science, Jamaica revises the CISC materials provided in insufficient quantities by CROASE, and includes worksheets (4).

There has been some interest in the production of worksheets on spirit duplicators. The machines are cheaper than the more well-known stencil duplicator, and easier to use in classroom or staff-

room and the masters may be prepared by the teacher on a table at home without access to a typewriter. Amongst the equipment given to the all-age schools of Jamaica has been spirit duplicators, but the software has been found expensive (4). It is not generally understood how many copies can be made with this method of reproduction - a hand-operated machine may, under local conditions, prove more useful than the more expensive electrical model, and no special duplicating paper and spirit solvent may be needed. We must be aware, however, that anything handwritten by the teacher consumes much more paper than a typewritten worksheet, and that paper costs may constitute the major part of total costs.

Science in the Press

A number of teachers and teacher educators build files of press clippings, conscious that there is a gap between the textbook and science in daily life, especially daily life in the Caribbean. A single copy of a press clipping, however, does not have much impact on a class of 30 or more children and in the Caribbean some thought has been given to ways in which they may be made available in quantity. Recognising also that teachers would welcome help about when such a resource could be best used, the 'Science in the Press' series was explored. A couple of sample booklets for children were prepared. These were made by pasting-up press clippings on a theme, together with questions which could prove useful for discussion, for examinations and tests, for assignments, and for thought. They included factual questions; questions to guide comprehension and criticism; open-ended questions on attitudes and social issues. It was made clear that the main resource was the press extracts, teachers being invited to use the questions and exercises provided or to design their own. The idea was that the region contains a rich potential of human expertise, and that kind of resource would make demands within the capabilities of almost any science-educator and the available material resources, and could contribute to regional co-operation. A regional planning meeting, at which constraints were faced, led to the following general decisions : any individual or group could design a booklet; preparation of paste-up would be carried out by colleagues within the country who had access to suitable equipment and expertise; reproduction on electronic stencils would be carried out by the local science teachers' association, where possible, and a set of the stencils would be sent to each of four reproduction centres in the Caribbean; from that point on, local decisions would be made about quantities, distribution and financing. It was agreed that a teacher would need at least one copy between two or three members of the class and would probably wish to acquire class sets for use from time to time. ASETT's decision, for example, has been to distribute single copies free with an invitation to interested teachers to purchase bulk sets at cost, which would range from approximately US \$1 for five copies of a 12-page booklet to free if paper were to be donated by, for example, the Ministry of Education. Other issues discussed included the question of copyright; the possibility of enlisting the aid of the regional UWI/USAID Project and the Caribbean Examinations Council; and the ways in which CROASE might be associated with the scheme.

One of the most appealing features of the 'Science in the Press' venture is its simplicity. Any teacher in a few spare hours at home can design a booklet or half a booklet (a specimen text is shown in Appendix 6). The teacher's design is quickly turned into a set of electronic stencils. Distribution of stencils to colleagues in the Caribbean is complimentary, because of the reciprocal nature of the

enterprise, and local production is carried out in ways which suit the needs and resources of science-educators in the various countries.

In addition to the educational value of the booklets themselves, the series offers opportunities for co-operation within a country and regionally. One example is Technology, prepared by a teacher-educator in Jamaica and a teacher in Trinidad (who do not know each other), with the cover design from a fourth former. A dozen or so 12-page booklets have already been prepared or nearly prepared, and there appears to be no limit to the number expected in the future.

Other Printed Resources

In addition to printed resources for the classroom, there has, of course, been a large variety of reports, handbooks, notes for teachers, workshop manuals and similar materials not intended for large-scale circulation or long-term use. Such materials tend to drop out of sight rather more quickly than they deserve to, and it is probable that educators in the Commonwealth Caribbean are constantly reinventing the wheel.

Some more permanent, out-of-classroom, printed resources will be mentioned later.

CENTRES AND INFORMATION SOURCES

An important resource is the science education centre or teachers' centre, and it seems appropriate to report briefly on those that exist in the Caribbean.

The oldest and best-known centre regionally and internationally is the Science Education Centre of UWI Mona. Created by and situated in the Physics Department, staffed by a variety of science teacher-educator members of the regional university, and funded by a grant from the Jamaica Ministry of Education to the University, the Centre finds itself in an ambiguous position. Funded by only one government, the Centre has a special responsibility to Jamaica - and there are more than enough issues in that country to keep the staff fully occupied. Meanwhile the Centre, by not being tied to any specific programme or project in the University, could fulfil a regional co-ordination role not provided by any other body or individual in the Caribbean.

The southern Caribbean would welcome some regional or international finance for the Science Education Centre, so that contributions from it to the region would be seen as a legitimate activity. Other science-educators in the region, however, welcome the regular Science Education Centre Newsletter (more of a journal, really); the speed and care with which it responds to requests for advisory services; and its dissemination of publications from outside Jamaica (23).

The history of the Centre reflects in an interesting way the science education developments in the region: first a Physics Centre, (it was renamed the Physics and Maths Centre), then the Science Centre for Schools, and eventually the Science Education Centre, which name without further modification allowed it to accommodate staff and activities for primary science.

Jamaica also has rural centres, first conceived in the early 1970s as a cupboard or two in strategically located schools, a small stock of equipment from UNESCO, and a science teacher willing to organise the loan of equipment to secondary schools in the locality. The current primary science centres, though not the same centres, and equipped with OAS materials, have the same general aims and strategies and one of them now has, additionally, a delivery van envisaged but not obtained at the beginning of the decade (22).

In Barbados, the Barbados Association for Science Education (BASE) established its Science Centre with the co-operation of the Faculty of Natural Science of UWI Cave Hill. The equipment was solicited by BASE, the room was provided by the Natural Science Faculty, and the staff of the School of Education were willing to open up the room for teachers on request. The very useful resources collected by BASE were only used as long as teachers could find someone in the office

to handle their requests, but School of Education staff, by their very nature, are more often out of the office than in it, and teachers are often unwilling to trail out to the university on the off-chance that they can get what they want. Eventually, Natural Science needed the space, and the Centre moved to Erdiston Teachers' College. The move was a successful one, and the Science Centre is now maintained jointly by BASE, the College and the Ministry of Education. It is well equipped with power saws, drills and other tools, and teachers attend ad hoc workshops at which they construct circuit boards and similar equipment (3).

In Trinidad, proposals for a science centre were laid in turn by Iolo Williams as he developed WISCIP, by the UWI/UNESCO regional teacher training project, and by the UWI St Augustine in-service Diploma in Education programme. Apparatus and materials came from UNESCO, books and audio-visual aids came from the British Books Development Programme, and the space and furniture were made ready by the University. Free and low-cost sources of materials were approached, publishers were invited to put the School on their list for review copies, and contacts with curriculum developers were established.

Donors proved generous, and the centre was quickly and easily set up without any money at all. It has become not so much a science centre as a science component within a Teachers' Centre, but the opportunities for borrowing equipment and books are limited to the unpredictable occasions when a science-educator is in the office. Interestingly, teachers make much more use of the printed resources than of the apparatus and materials, perhaps because they are more visible and also form a more comprehensive collection. The centre serves as a focus for science teachers - there they have meetings, direct their inquiries, convey their ideas, renew old acquaintances and make new friends. Perhaps it would be more accurate to describe the Trinidad and Tobago science centre as a concept rather than a physical reality, for its library is a staff member's office, its laboratory/meeting room is primarily a School of Education teaching room, and its staff member is employed fully time to teach students of School.

While Guyana has no science centre, its Curriculum Development Centre with secondary and primary science components serves many of the functions provided by Jamaica's Science Education Centre. Its proposed Equipment Production Centre and rather more distant Resource Centre should meet any remaining needs (7, 8).

Two science teachers associations are known to maintain small libraries rather than centres. ASETT, allocated space by the Trinidad and Tobago National Commission for UNESCO, built shelves and is developing a collection of books, reports and periodicals. StVAST has a room at the University Centre in St Vincent. Assistance for these libraries has come in the form of materials provided by the Caribbean Regional Science Project (53), publishers' agents, and many international organisations.

Teachers of integrated science and life science need access to information about local flora and fauna. Jamaica is particularly well served in this respect. The celebrated Institute of Jamaica has a museum whose insect collection is especially comprehensive and whose herbarium is very fine indeed, the collection covering a great part of the Caribbean (54). The Natural History Society, an associate of the Institute, publishes Natural History Notes, a readable and

respected periodical (55). The ASTJ has for decades conducted an annual Easter ecology field trip, collecting an enormous amount of information about one river and two sea shore habitats, although this, until recently, has never been compiled into a form which can be readily consulted. However, in 1981, the UWI Mona Biology Diploma in Education students, as part of their course work, sifted the materials and compiled a dossier which deserves to be entered for a CASME award. The Herbaria at UWI Mona and UWI St Augustine are very willing to receive visits and request for identification from teachers (56).

Two major science education conference reports have been produced in the Caribbean. The first (Reay, 1974) reports the UNESCO/CEDO Workshop on Integrated Science and Teacher Education in Barbados in 1973, and this has been found a useful resource for teachers, student teachers and teacher-educators in the Caribbean and elsewhere. The second (Lancaster and King, 1979) reports the CROASE/NSTA regional Conference on Science Education for Progress in Barbados in 1979. Consisting largely of abridged versions of papers presented at the Conference by Caribbean and North American science-educators, this report promises to be a much-used resource in the future.

An important component of the CXC integrated science syllabus is a knowledge of nature resources in the Caribbean, not yet documented for the secondary school level. Guyana brought teachers together in workshops to prepare resource materials on Guyanese industries (e.g. rice, bauxite, wood), and these were distributed to local schools preparing children for CXC. They are currently in the process of editing for wider distribution and may stimulate the production of similar booklets about the resources of other countries (24).

Science education journals are an excellent resource for science teaching. Perceiving a need for a listing of what is available, or at least what has been read by individuals, the School of Education at UWI St Augustine has begun the publication of a regular series of Annotated Bibliographies for Science Education. Once again, here is an opportunity for educators at various levels to collaborate, and contributions are invited from any science-educator anywhere. The method of preparation and production is relatively simple, and financing has so far not proved difficult. There are indications locally, regionally and internationally that the Bibliography series fills a need first perceived by the British Council and ICASE although libraries and teacher-educators have responded better than teachers (57). Dalgety and Farley have suggested the need for annotated bibliographies on texts and tradebooks.

In the Bahamas, Belize and Guyana, great distances separate teachers from other teachers, workshops and teacher-educators. Even in Jamaica, many teachers would have to travel half a day to reach the Science Education Centre. While a Centre in each country ought to be high on the priority list of resources for science education, teachers (especially those in the large countries) cannot expect to be kept up to date unless they are stimulated in school. At least one senior member of the science staff should read; but the post of Head of Department is not institutionalised in the Caribbean, and teachers anyway tend to give low priority to the reading of professional literature. Special attention should be given to 'customer appeal'; while local science teachers' association journals and newsletters seem to be read fairly well, the most successful formula, whatever it is, appears to have been found by Chem 13 News, published by the

University of Waterloo in Canada. Any sixth-form chemistry teacher who receives the monthly periodical really seems to use it.

SERVICING OF EQUIPMENT

One of the greatest needs in the Caribbean, and the one that has received the least positive attention, is a maintenance and repair service. A problem in any country, apparatus breakdown is aggravated where there is high teacher mobility, as there is in most Caribbean countries. A teacher faced with unfamiliar equipment may fail to take the necessary precautions which helped the equipment to survive in the hands of a predecessor. The responsible teacher is expected to facilitate access to the laboratory for evening classes whose teachers he or she may not even know. In some countries the same laboratory is used by two shifts per day with two sets of teachers. One is more likely to find apparatus repair skills in physics teachers, but we have already seen that physics graduates are thin on the ground.

Even where a school or country can find finance and foreign exchange to replace defective apparatus, import procedures are cumbersome and slow, and laboratories once adequately equipped fall into decay. Ministers of Education need to explore ways of reducing bureaucratic procedures in order that schools can respond within a few months to their needs. Up to the early 1970s teachers in Jamaica and Trinidad, at least, were able to find firms which would service and repair equipment, at a price, and for microscopes this is still possible in Trinidad. Those who repaired electrical apparatus have one by one gone out of business, or no longer handle such repairs, and laboratories are full of unserviceable equipment packed away in the hope that one day someone can be found to repair it.

A very limited and friendly service is provided occasionally by the Physics Department of UWI Mona and the electronics technicians of the Multimedia Production Centre of UWI St Augustine. Antigua's Teachers' College and Technical College, which are adjacent, are reported to co-operate (3) but no formal arrangement is known anywhere in the Commonwealth Caribbean.

Guyana's STAG identified the possibility that school equipment could be serviced by the Faculty of Technology of UG, and has had informal discussions with both UG and the Ministry of Education. The formal channels of approach that are necessary have yet to be made (15).

In any country, and especially in one with foreign exchange problems, one of the best investments that could be made by the Ministry of Education would appear to be a school equipment maintenance and repair service. Certainly it would not be easy to find the skilled technicians necessary, and they would expect salaries which compare with those paid by industry. They would be worth it.

SCIENCE TEACHERS' ASSOCIATION

Science teachers' associations as a resource were mentioned early in this paper. It is worthwhile at this point to draw attention to some specific resources which have been found useful by members of these associations.

The list of suggested apparatus for the teaching of physics which was used for the survey of O Level physics teachers was welcomed by physics teachers and senior science teachers. Conscious that they were not aware of the opportunities provided by the apparatus developed for the Nuffield Science Teaching Project, they sought advice on what to order so that teaching could be brought into line with advances of the past 15 years.

The publications of an association can be a most useful resource. ASETT publishes a bulletin for its members nearly every month containing short items of news of the Association's activities, information from international newsletters which could be useful, and news of apparatus and materials. The other regular ASETT publication is its Journal of Education in Science for Trinidad and Tobago, which is published three times a year. The publication, if any, from the other Caribbean associations are more spasmodic. STAG of Guyana and BASE of Barbados used to produce useful newsletters, although these have not been seen for some time. Jamaica's ASTJ publishes Science Notes and News several years apart, which is disappointing for an association which, for the first 20 years or so of its existence, produced an immensely practical and useful periodical several times a year. The main difficulty with all associations is not with finding people to write, but with costs.

The associations also publish occasional publications, for example a guide to the teaching of ecology (Jamaica) and investigations based on sodium thiosulphate (Trinidad and Tobago).

RETROSPECT AND PROSPECT

Innovation in science education in the Caribbean is largely a phenomenon of the 1970s. Before that, the only Ministry of Education with a science education officer was Jamaica's, and the only UWI campus with any science teacher-educators was also Jamaica's until St Augustine in 1968 began the development of WISCIP. Accordingly, the only attempts to co-ordinate and improve the work of science teachers outside Jamaica came from the associations of science teachers themselves, BASE in Barbados and STAG in Guyana. In Jamaica in the 1960s, the honourable work of the ASTJ and of the Science Education Officer of the Ministry of Education was supplemented by a series of UWI staff who gave their spare time to the improvement of science education. Of these, George Bishop and Keith Warren have since become well known in other Third World countries for their ingenuity in the improvisation of science teaching equipment. But none of them were appointed to tackle the problems of science education at source, even in Jamaica itself, and they could do no more than help some science teachers with some of their day-to-day difficulties.

When Caribbean governments and universities recognised the need for projects in science education, and sought the assistance of international aid agencies, the innovations of the 1970s were introduced. At the beginning of the decade, the first priority in the immense task was to 'West Indianise' science teaching and to bring together teachers all round the Caribbean confident in the contributions they could make to solving the problems. Accordingly, the emphases were on curriculum development, associations for science education, and a variety of strategies for achieving teacher education and reorientation. These emphases account for the volume of curricula developed nationally and regionally, the growth of the science teachers' association concept, the books, monographs, reports and so on that have been written by science-educators. The consequence has been that the workload of the teacher-educators is now shared with hundreds of classroom and university teachers in the region, all speaking a common language in science education. The list of sources of information at the end of this paper represents only a fraction of those involved; ten years ago, it would have been difficult to list half a dozen. The number of science teachers in the region with postgraduate qualifications in education must now be approaching a thousand, where there were only a handful at the beginning of the decade.

The region, then, has become richer in human resources and in curricula and printed materials. In the matter of other material resources, very little progress has been made. Warren in the 1960s was the last to give much time to designing apparatus, and more recent science-educators have not found the time to utilise the audio-visual expertise and equipment that exist.

The Caribbean survey has shown that few science teachers are resourceful in attempting to meet their own needs. Richmond's deliberately provocative argument (1979) that laboratories are desirable luxuries and that school workshops might be a better investment is likely to meet an especially negative reception from Caribbean teachers. But D C Williams (1979) has pointed out that, in many countries, the teacher who does not organise the making of his own equipment will have none to use; this already seems to be the case in some Caribbean schools.

The laboratory experiences which are provided too often make little contribution to the learning of science, especially in physics. White (1979) has made reference to research which shows that the common type of physics laboratory exercise achieves no more than the improvement of manipulative skills. He and other participants at the 1978 Oxford Conference on the Role of the Laboratory in Physics Education have suggested how educational theory needs to be brought to bear on the design and selection of practical work in the learning of science. The Caribbean has no grounds for complacency in this respect.

Not the responsibility of educators, but one which is of very serious concern to them, is the very immediate danger of losing treasures which exist, namely the collection in the National Herbarium of Trinidad and the entomological and plant collections of the Institute of Jamaica. The Trinidad collection is decaying for want of adequate support, and there was recently a risk that the Jamaica collections would be dumped to make room for a collection of the art and culture of Jamaica. Science-educators do recognise their responsibility to make a contribution to the preservation of living natural resources and to prepare tomorrow's decision-makers. Scientists and science-educators are coming closer together in attempting to preserve the heritage of the countries of the Caribbean.

The decade since 1970, then, has moved science teaching from the closed world of the teacher's own classroom to a shared enterprise in which primary, secondary and tertiary teachers, as a cohesive regional group, work towards the improvement of science education, and in which scientists and educators work together in preserving threatened resources

Where should we go in the 1980s? The aims of science educators in the Caribbean might be summed up as follows :

1. Improving the teaching and learning of science in a local context, including the development of attitudes, values and decision-making abilities in children.
2. Enhancing the cohesiveness of Caribbean science educators and scientists.
3. Identifying and developing Caribbean talent so far untapped.
4. Coming to terms with governments' needs to save money and foreign exchange and to train technicians and technologists.
5. Providing classroom teachers with the right kind of help so that they are confident that it is within their power, as individuals, to do a worthwhile job.

To these ends, the following are suggested as priority areas for attention.

Teacher-Educators

Science teacher-educators in universities, ministries of education and the UWI Science Education Centre should continue with much the same kind of work they are already doing, with perhaps less intensive work in the development of integrated science curricula. They should be freed as much as possible from more general duties which could be carried out just as well by teacher-educators in other disciplines. Examples of these general duties are teaching foundation courses in universities and general administrative duties in ministries. Teachers' college tutors should reduce their dependence on conventional laboratory equipment, and all teacher-educators should find ways of stimulating their students to improvise and improve on apparatus.

There is a need for very much increased attention to physics and primary science teaching, and to this end it may be necessary to send promising teachers abroad for further experience and training.

Curricula

Teachers' college curricula should move a long way from the current pattern, which is not unlike GCE, towards courses which prepare teachers to give effective science teaching in primary schools. (In Trinidad and Tobago a new examination emphasising process angered students and tutors at the first encounter but achieved a dramatic change in teaching during the following year). For secondary schools, physics, chemistry and biology courses, in that order of priority, need to be brought more into line with matters of scientific interest in the 1980s. (For example, alternative energy sources, which was the theme of the 1979 NSTA/CROASE conference in Barbados.) The current process of developing CISC for CXC, by classroom teachers in their spare time, is too slow and the curriculum does not hang together well. The CXC integrated science syllabus, while well intentioned, is not clear for teachers. These needs, long recognised, have been tackled by ad hoc one-day or one-week meetings with too many leaders and very little finance. All of them could be met by an ambitious residential workshop, lasting up to two months, with one experienced co-ordinator and an assistant co-ordinator for each of the separate areas. Adequate incentives for participants should be provided and commercial publishers should be invited to co-operate. This would be an expensive exercise but, at a stroke, could go a long way towards providing appropriate curricula for the Caribbean. The initiative for this might come from the USAID Project, which might find it necessary to seek aid from CARICOM, OAS, CIDA and/or UNESCO. Caribbean educators and regional organisations are ready for such an exercise.

The new Independent Learning A Level curricula developed in Britain deserve serious consideration, not only for their intrinsic excellence but also because they could allow the more qualified and experienced teachers to devote more time to younger children. The Trinidad and Tobago trials of APPIL should show whether Caribbean teachers and pupils can come to terms with such an approach. These curricula should also help teachers to take a fresh view of their own sciences and to develop their own concepts more soundly.

The need for regular re-training of teachers should be recognised. This may be achieved by residential courses or by distance learning of the Open University type. The UWI Communications Project may be able to provide suitable strategies.

Apparatus Manufacture

Without attempting to replace entirely the import of apparatus from overseas suppliers who can absorb research and development costs, there are good educational and economic reasons for Caribbean design and fabrication of a limited number of items of science teaching equipment, beginning with plastics, materials for primary science, and power packs. The Caribbean Development Bank might commission studies towards such a regional enterprise. A number of firms which at present confine their activities to acting as agents for overseas suppliers may become involved in the distribution of the products. Such an enterprise would do well to draw on experience elsewhere, for example from RECSAM of Southeast Asia, NCERT of India and SEPU of Kenya. Particular attention should be paid to the importance of feasibility studies, criteria of excellence, and educators with a strong background in science and teacher training, issues mentioned by Khoo (1979).

Audiovisual Software

Problems in the development of such materials are relatively non-existent. All that is needed is for science teachers associations, ministries of education, and teacher-educators to turn their attention to the issue on a national basis. Regional accessibility should follow without too much difficulty. Since those who are described as educational technologists have not so far done much to seek help from the science-educators, it looks as if the latter should initiate discussions with the former.

Printed Resources

Those who produce printed resources should seek to emulate the quality of reproduction which is standard in Guyana. The same people should be alert to the fact that teachers who are given a great deal of printed material are likely to read it little and use it less. Government publication units should do more than they do at present to publish materials unattractive to commercial publishers, who do not show interest if less than 10,000 copies are required. Equally, ministries of education should facilitate the publication and local distribution of Science in the Press booklets, and CROASE should explore ways to cover the cost of preparing electronic stencils for distribution to its member associations.

Science Centres

If the Jamaica Science Education Centre is to serve a regional co-ordination function, it must have some regional finance. While the Centre is no doubt exploring such support, its case for a regional service would be much enhanced if a variety of organisations in the region would give public recognition to the actual or potential contribution available from the Centre. Especially, UWI Cave Hill, CROASE, CXC and national groups could stimulate and actively share in this resource. Finance for regional activities could be available from CDB, CARICOM, OAS, UWI/USAID, to name only some organisations with money set aside for educational development in the Caribbean as

a region.

Meanwhile, each country needs its own science education centre, primarily to act as an information centre and as a depot of laboratory equipment and other materials, which, for financial reasons, cannot be provided for each school. To provide an effective service, the centre needs a full-time custodian whom teachers can be sure to find on duty after school hours. Such a custodian will reduce by one, at least, the number of excellent teachers of science in schools. Ministries of education could nevertheless consider the centre and its custodian an excellent investment.

Servicing of Equipment

For some reason which has not emerged from the survey, provision of maintenance and repair services has received almost no attention from either educators or commerce. Such services would appear to be one of the best investments that could be made by any government, especially one which needs to spread its foreign exchange as far as possible. The literature on science education worldwide appears to have paid equally scant attention to a problem which science teachers consider one of their most pressing. If a ministry of education cannot find the expertise and finance to set up a fully staffed maintenance and repair unit, it should at least provide a clearing-house which will distribute defective apparatus to repair centres, and pay for restoring them to serviceable condition.

Science Teachers' Associations

Unless a national science teachers' association can keep itself alive and active, it does not deserve to exist. However, science teachers' associations take over much of the work that usually is considered as the province of the ministry of education and university. This of course is all to the good of education, but the associations are supposed to carry out this work from the subscriptions of its members, which is unfair and impossible, given the size of these subscriptions. It is not that governments do not recognise the associations - on the contrary, they value them highly - but that government administrative procedures are not always fast and flexible enough, so that a science teachers' association project is often a thing of the past before the government gives an assurance that the costs will be covered. Education ministry science education officers should work out a strategy for more speedy processing of approaches from professional associations.

CROASE, as a regional association, has no funds at all beyond token subscriptions from its members. Its executive, and its member associations, should become more active in soliciting support from organisations with a regional interest and in producing marketable materials. The experience of the Hong Kong Association for Science and Mathematics Education (Tao, 1979), may provide a lead.

Documentation and Preservation of Existing Knowledge

The ASTJ ecological studies over the past 20 years should be published. The Faculty of Natural Sciences of UWI Mona might appoint a Research Fellow and provide funds specifically to undertake this task; if it is ever completed, he should go on to co-ordinate further ecological studies by the ASTJ and other national associations. Science educators should make better use of the Institute of Jamaica science museum and

the Trinidad National Herbarium, and should add their own voices to those of the scientists who seek more adequate support for these.

Research into Science Education

University science educators have so far found very little time for research into science education in the region. The time may now have come for them to hand over some of their teaching and development activities to the next generation, and to turn their attention to research, perhaps using some of the members of this new generation as research assistants. The School of Education of UWI should set up a small committee of its science teacher-educators and those from UG, in order to identify issues which deserve investigation. Reading levels and Piagetian stages of primary teachers, and the impact of educational broadcasting have so far been suggested.

Science Education for the Less Able

CXC should treat as a matter of urgency the development of a syllabus and examination in integrated science for the children in such schools as Jamaica's new secondaries, Trinidad and Tobago's senior comprehensives and Guyana's multilaterals; that is to say, CXC should take immediate action on offering a science examination at the basic level. The examination could be brought that much nearer if the CXC group would begin from the Jamaica Core Curriculum.

Laboratory Design

School architects should consult science educators when designing laboratories. And older schools should give consideration to cutting down existing benches into flexible tables.

CONCLUSION

In the 1970s considerable advances in science education, nationally and regionally, were made. Given that the populations of the countries of the region of approximately five million people vary from 11,000 upwards to only two million, and given a regional university, it was appropriate and not too difficult to put together a regional force of science-educators. This force, commonly respected, is now the most valuable resource of the region and is ready for more ambitious projects. The current major task is to identify the means by which those individuals and groups with insight and talent may be utilised to further those involved in science education, science and society in the next century.

There is nothing really unique about science education in the Commonwealth Caribbean. Conditions, problems and solutions are broadly similar to those found elsewhere, not only in the Third World. Indeed, some countries might consider the Caribbean problems to be minor compared with their own - there is a common language, for example. The most serious problem, familiar everywhere, is that teachers are not very good at using whatever resources exist, and teacher-educators have yet to find ways of developing suitable attitudes towards resource-based learning of science.

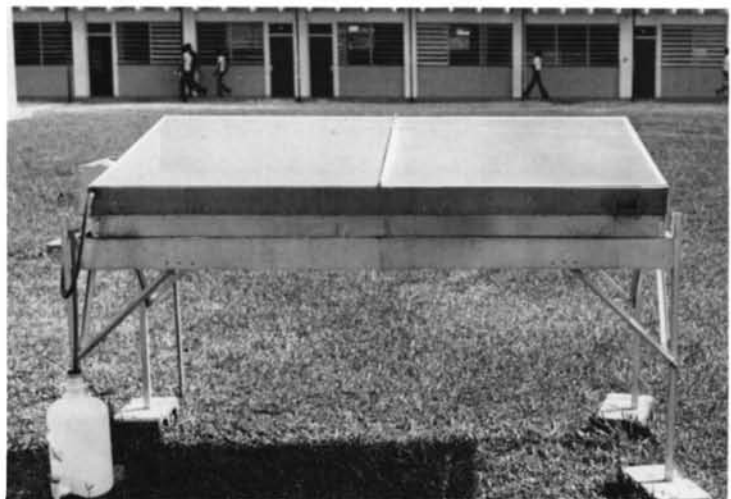
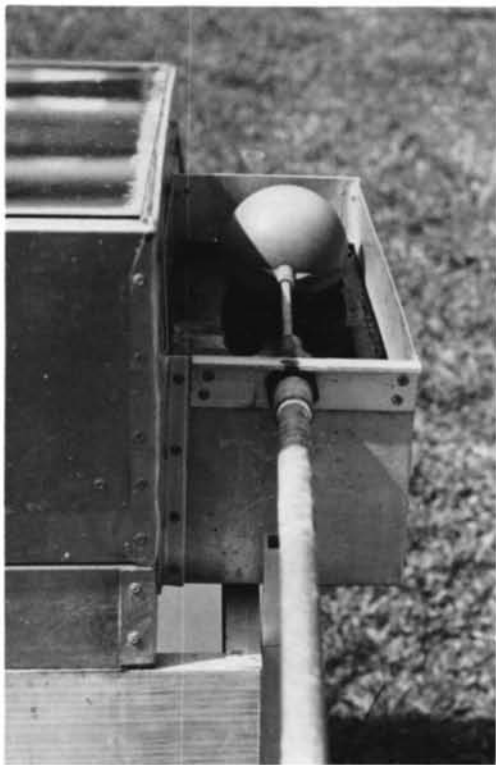
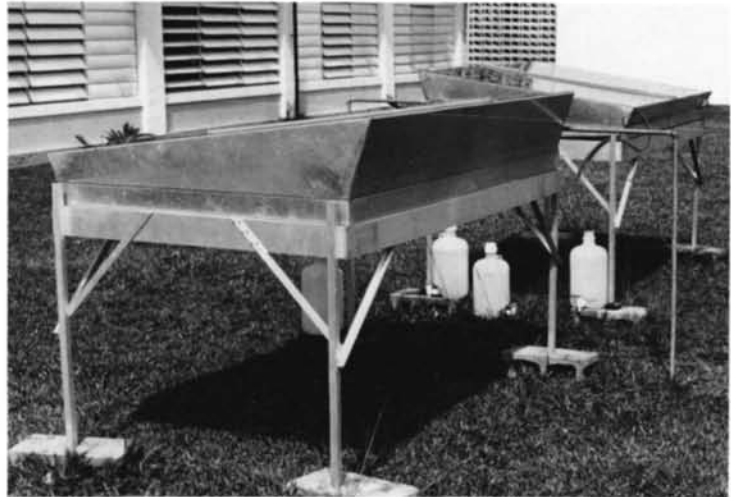


Figure 1: Four views of a solar still at Chaguanas Senior Comprehensive School, Trinidad. Designed by Dr Oliver Headley, Department of Chemistry, UWI St Augustine, Trinidad.



Figure 2: *above* A boy demonstrates his solar still.

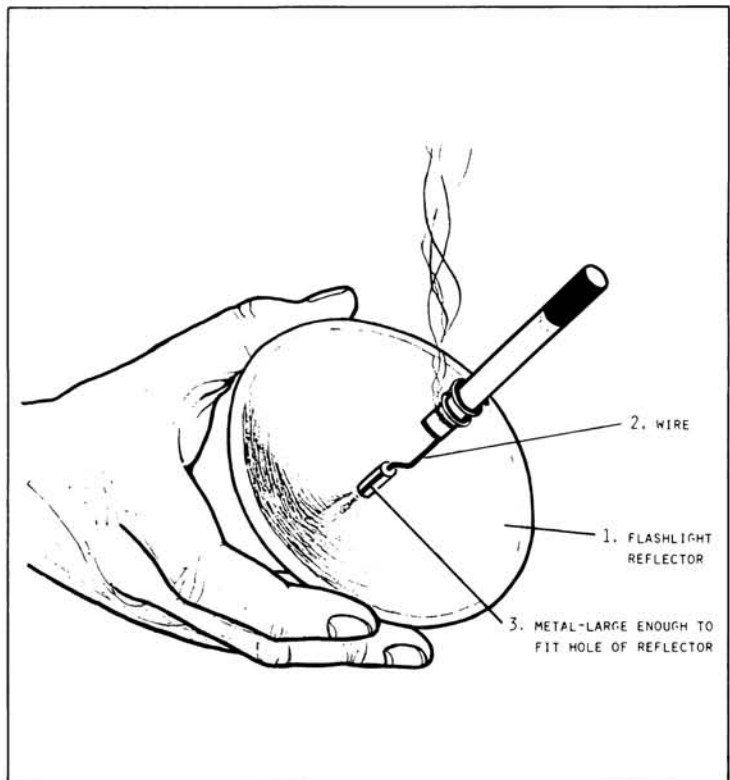


Figure 3: *right* A solar cigarette lighter. Designed as a wall chart by the Guyana Curriculum Development Centre to illustrate a radio broadcast to primary schools.

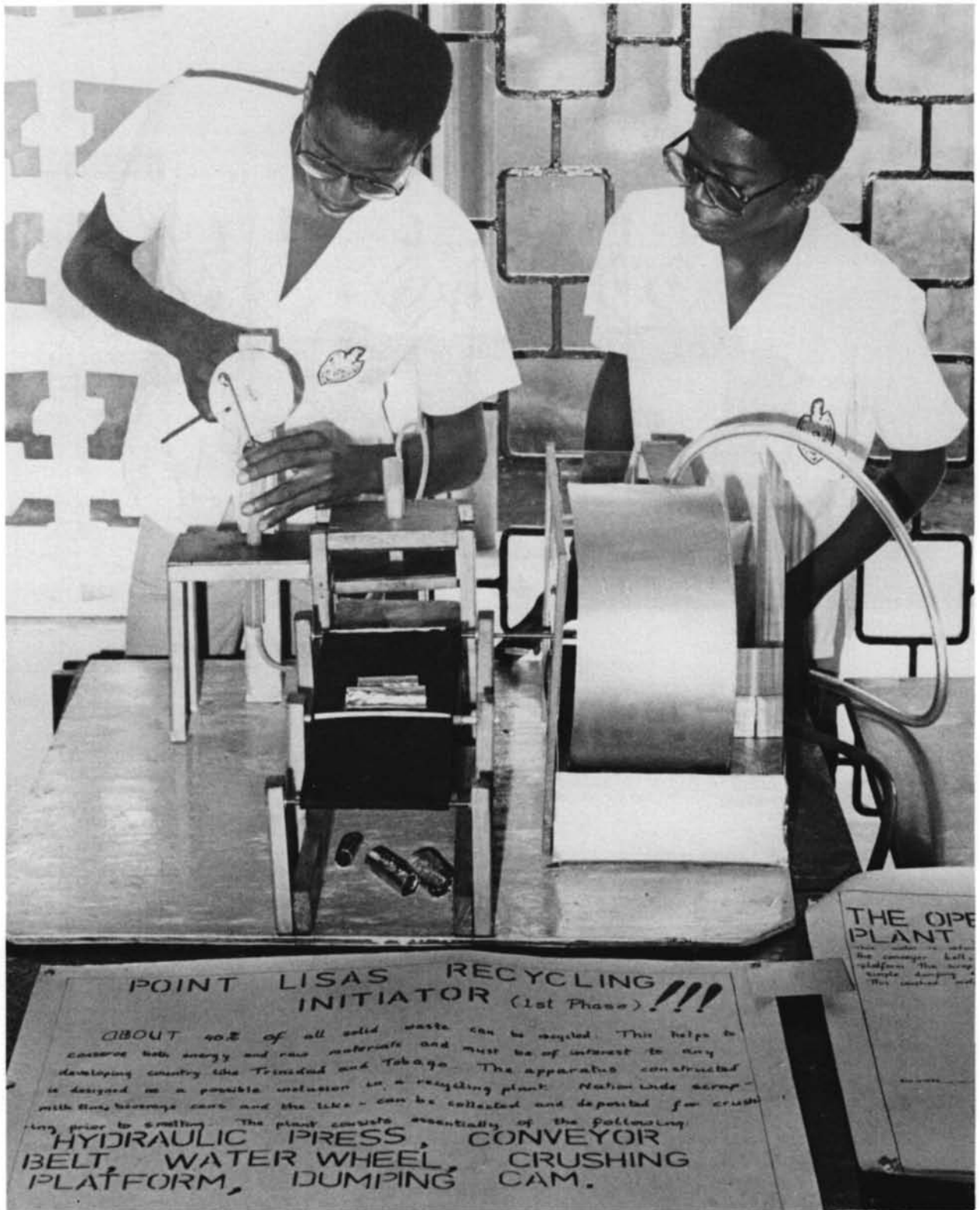


Figure 5: Pupils design a hypothetical recycling initiator.

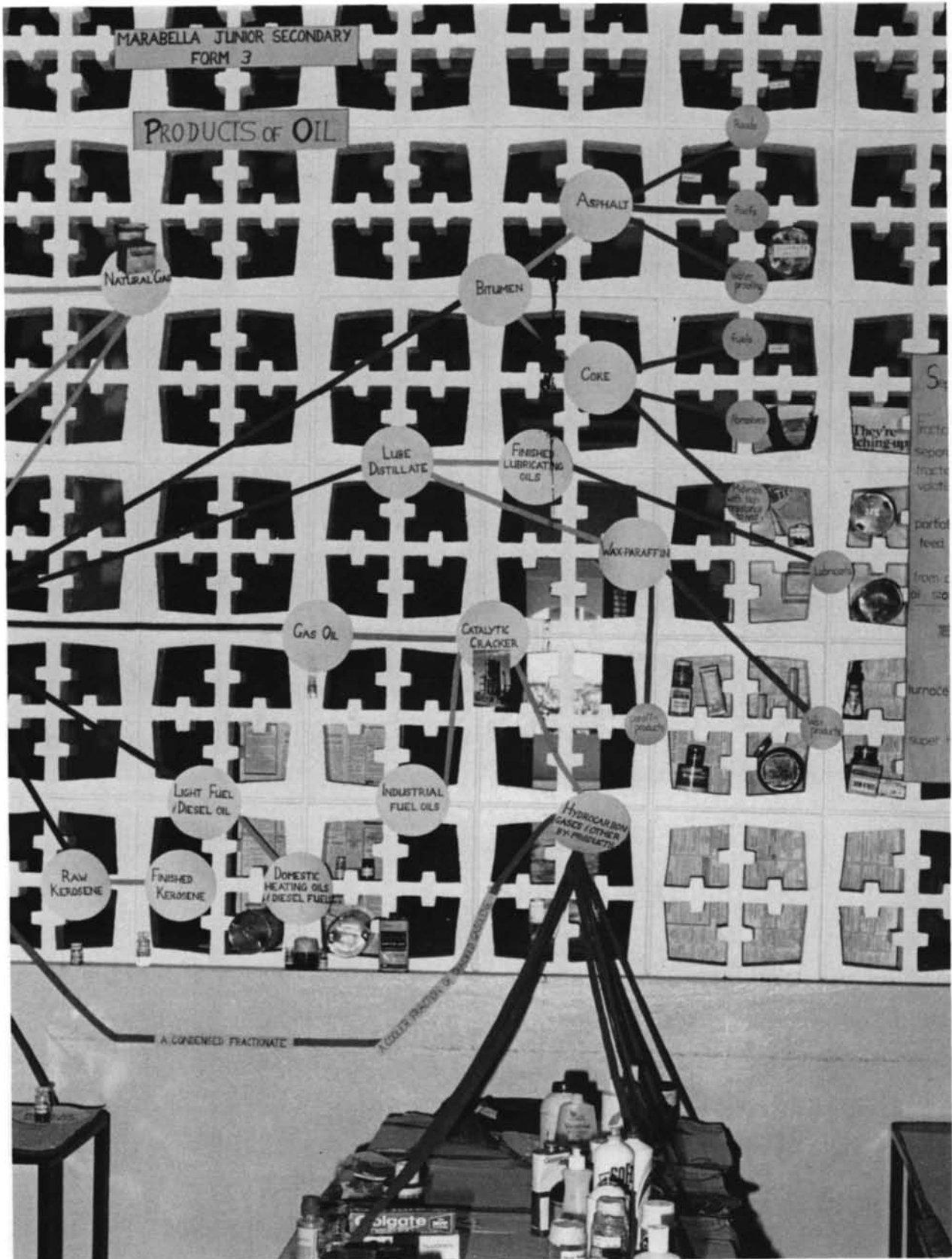


Figure 6: A Trinidad school displays a matter of national concern — the uses of oil.



Figure 7: A science exhibition in a school.

NOTES AND SOURCES OF INFORMATION

Many colleagues in the Caribbean have been consulted in the course of collecting information for this survey. While the responsibility for accuracy of facts and soundness of opinions is entirely that of the author, the following list includes the names and addresses of colleagues round the Caribbean who assisted in the survey and/or may be willing to provide further information or to direct inquiries. All of those who have been approached in the final stages have confirmed their willingness to field enquiries, but a very small number did not receive the opportunity to assure the author that they would do so. Accordingly, inquiries should be directed in the first instance to the appropriate address given below or, in the case of difficulty, to the author.

1. Education has been, and still is, dominated by GCE, well known in other parts of the Commonwealth. Only the Cayman Islands appear to have adopted CSE. The first CXC examinations for the same age group, in a limited number of subjects, took place in 1979 and were on the whole optional. The impact of CXC on education in the region is already considerable and will certainly increase.
2. Caribbean Examinations Council Headquarters, The Garrison, St Michael 20, Barbados. (But the syllabuses and papers are so far not available for general circulation.)
3. Winston King, School of Education, UWI Cave Hill, Barbados. King, by virtue of his post with the Research and Development Section of the Cave Hill School of Education, is the best source of general information about the 'small islands'. He is also regional representative on the ICASE Executive.
4. Dr June Mitchelmore, Education Officer (Science), Ministry of Education, Kingston, Jamaica.
5. Since an 11+ or Common Entrance Examination, which filters children from primary to secondary school, is a feature of the region, some children fail to pass through the filter. These children were, and in some countries still are, accommodated in the secondary classes of primary schools. In Guyana, the community high schools have been set up to accommodate them although SDSP, the science course for this population, retains its old name.
6. Cde Alec Farley, c/o Ministry of Education, Social Development and Culture, Georgetown, Guyana. Farley's Report of the 1977 Guyana TVC has proved most useful for this survey, and is to be commended for its objectivity (see Bibliography, Dalgety and Farley).

7. Cde Esther Burrows, Deputy Chief Education Officer, Ministry of Education, Social Development and Culture, Georgetown, Guyana.
8. Cde Florine Dalgety, Education Officer (Science), Ministry of Education, Social Development and Culture, Georgetown, Guyana.
9. Mrs Pamela Fraser-Abder, School of Education, UWI St Augustine, Trinidad; and Raphael Douglass, Ministry of Education and Culture, Port of Spain, Trinidad.
10. Khan (1980) carried out a useful investigation into the extent to which teachers actually need to use distilled water in chemistry. He concluded that the tap water in his neighbourhood was quite adequate for titrations but could lead to problems with qualitative analysis.
11. Dr Oliver Headley, Department of Chemistry, UWI St Augustine, Trinidad.
12. Recent information is that the design, reproduced with permission from elsewhere, is outmoded.
13. Hewell Campbell, Jamaica College, Kingston 6, Jamaica.
14. Dr John McDougall, now in Canada; inquiries to him c/o Department of Physics, UWI Mona, Kingston 7, Jamaica, may be forwarded.
15. Clarence Drayton, c/o Faculty of Education, University of Guyana, Georgetown, Guyana; semi-retired, Drayton maintains contact with UG and with STAG.
16. Dr Anthony Chen, Department of Physics, UWI Mona, Kingston 7, Jamaica. The electronics teaching kit was the work of Chen's student, P G Wilson. With some support from OAS, Chen has put a lot of work into the improvement of physics teaching in schools.
17. Dr Patrick Chin, Department of Physics, UWI Mona, Kingston 7, Jamaica. An associate of Chen (see Note 16), Chin was the main co-ordinator of the Models project and was responsible for the production of the set of overhead projector transparencies for the teaching of applications of physics.
18. It is not true that apparatus chosen from the laboratory suppliers is always like the apparatus used by scientists; and one sometimes wishes that teachers would select apparatus rather closer to the scientists' apparatus than the designs of a century or more ago.
19. Some schools order direct from the UK manufacturers; others order through local manufacturers' agents or governments. In any case, the local agent receives a commission; some teachers are very dependent on the service he provides, so that he can serve an essential, though rather expensive, function. One Trinidad school has discovered that air freight costs no more than surface shipment, and is much quicker.
20. Many teachers do not find it easy to obtain petty cash from their schools, so that local purchase is not as simple as it might seem. Some schools require that the purchase should be made by the Bursar in person; since local purchase generally demands some kind of compromise between specifications and availability, the

Bursar is quite likely to return with materials which the science teacher cannot use.

21. Mrs Janice HoLung, c/o Ministry of Education, Kingston, Jamaica.
22. Mrs Dorothy Pottinger, Ministry of Education, Kingston, Jamaica.
23. Leo Jones, Acting Director, Science Education Centre, Department of Physics, UWI Mona, Kingston 7, Jamaica. Jones gave invaluable service in selecting the sample for the survey of resources in schools in Jamaica, reproducing the checklist from stencils, distributing it, and returning the responses. His Centre has always acted as the ultimate information resource about science education in the Caribbean.
24. John Masters, Ministry of Education, Social Development and Culture, Georgetown, Guyana. Masters is to be especially thanked for the fact that the Guyana return for the checklist exceeded that of the other countries, while its population is the least.
25. Advanced Physics Project in Independent Learning. Teachers' Handbook. London: John Murray, 1978. (Developed by the ILEA.)
26. Lockhart, J. O Level Physics Apparatus: Journal of Education in Science for Trinidad and Tobago, vol. 7, no. 1 (October 1979), pp. 22-27. Suggested quantities and prices were omitted from the checklist sent out for the survey.
27. Rev R E McCluskey SJ, St George's College, North Street, Kingston, Jamaica. Fr McCluskey is Teacher 25 in Appendix 4.
28. Although the difference in responses to the booklist did not quite meet the 0.05 test of significance, Trinidad and Tobago responses were higher than those of the other two countries. It is doubtful that there is a direct relationship with national economy, since teachers were asked to indicate only if 'at least one copy can be made available to yourself and your students'.
29. Catalogue references were supplied, but it was subsequently discovered that a valuable resource not available to some teachers is the suppliers' catalogue. Even where laboratory supplies are centrally ordered by the government, the catalogues provide a wealth of information to the teacher and laboratory assistant in their laboratory.
30. A few integrated science teachers, like the physics teachers, probably hoped to catch the eye of the Ministry and were over-demanding; it is not easy to accept that a school would have some ear models, for example, in grossly inadequate quantities.
31. It is curious that local preparation of skeletons is so rare. One school heard of a report of a whale carcass on a distant beach; the resourceful teacher organised a large truck to transport the bones so that the school now has a stunning collection. A whale vertebra two metres across is an impressive visual aid. Children in another school reported a dead horse and helped the teacher to bury and ripen the carcass and eventually to get it to the school. A colleague in Fiji built up a thriving business by collecting the dog-catchers' carcasses, treating them, and

exporting the sets of bones to suppliers in New Zealand. While some teachers do make their own bone specimens, Appendix 5 suggests that a need could be filled by local mini-mass production, perhaps by a science teachers' association. Advice on techniques appears to be scarce in the available literature.

32. In one country a non-scientist teacher-educator proposed to a National Consultation Committee on Education a company which would manufacture 'a whole range of science equipment which could be used in hospitals, factories and schools'. Unfortunately, the idea came to nothing.
33. Miss Myrtle Manbodh, Holy Name Convent, Port of Spain, Trinidad.
34. Mrs Jean Bahadur, Naparima Girls' High School, San Fernando, Trinidad.
35. McSood Hosein, Queen's College, Georgetown, Guyana.
36. Miss Bernadette George, Bishop's High School, Tobago, Trinidad and Tobago.
37. Bottle racks appear to be a relic of the days when chemistry curricula contained much more qualitative analysis than they do now, and when the only children allowed into a chemistry laboratory were mature and responsible sixth formers. The tendency today for younger children to tamper with bottles makes the contents of the bottle racks untrustworthy.
38. Richard Ishmael School in Georgetown, Guyana, has separate laboratories for biology, chemistry and physics; but the integrated science teacher, Cde Jaggernaut, worked in a flourishing laboratory provided by re-arranging the desks in a classroom. A large class was observed to be working very comfortably in small groups carrying out a titration with burettes. This school's carpenter had made a range of equipment such as burette stands, pipette racks and lamp boxes for optics work. Since school carpenters also make laboratory stools usually much more functional than the commercial variety, a school carpenter might be considered a valuable member of the science staff.
39. Miss June Alfred, St Mary's College, Port of Spain, Trinidad.
40. A teacher in training under Guyana's Emergency Science Programme, Cde Frankie Gordon at Charlestown Government Secondary School, has found such a use for an installation that other teachers abandoned as hopeless; additionally, he has worked out an instant way of diverting the gas from the children's benches to the teacher's.
41. The idea of covering glass windows in this way has been curiously difficult to sell. The objections appear to arise from an intuitive aversion to an unfamiliar strategy, and teachers who perceive the potential must still face resistance from their principals and then the workmen. The St Augustine experience is that the room is attractive, convenient and easy to work in, not least because the excessive tropical light can be controlled at will. At no time does rain force closure of windows on more than one side of the room, so that an adequate level of illumination is always available. With all the windows closed for blackout,

the room is hot, but ventilation is quickly restored at convenient breaks in the presentation.

42. Michael Owen, Ministry of Education and Culture, Bridgetown, Barbados, has stimulated much of the achievements in science education in Barbados, not least the educational television, primary science curriculum and BASE, and is well informed about the current state of science education activities in the country.
43. Workeley Brathwaite, School of Education, UWI Cave Hill, Barbados.
44. This example from a variety kindly supplied by the Guyana Ministry of Education was chosen for its interest to physics-educators as well as to those concerned with integrated science. And it provides an opportunity for reminding children of the dangers of cigarettes.
45. Cdes Edith Callendar and Carol Allicock, Curriculum Development Centre, Ministry of Education, Social Development and Culture, Georgetown, Guyana.
46. Bruce Paddington, Mucurapo Senior Comprehensive School, Port of Spain, Trinidad.
47. Mrs Denise DeBique, St Stephen's College, Princes' Town, Trinidad.
48. The staff photographer, Neil Hokan, has kindly taken the photographs for this paper.
49. Mrs Florence Commissiong, School of Education, UWI Mona, Kingston 7, Jamaica, guided the production of the master set of photographs.
50. Fr Benedict OSB, Mt St Benedict Comprehensive School, Tunapuna, Trinidad.
51. Details of pupil texts for integrated science produced in the Caribbean may be obtained from the publishers, Heinemann, Longman and McGraw-Hill Far Eastern. Macmillan should also be able to provide a useful list.
52. Mrs Herma Perkins, Science Education Centre, Department of Physics, UWI Mona, Kingston 7, Jamaica.
53. CRSP provided book collections to quite a few Eastern Caribbean countries.
54. The entomological collection is in the care of Tom Farr; G R Proctor is responsible for the plant collection. The Institute of Jamaica, King Street, Kingston, Jamaica.
55. An earlier series, Glimpses of Jamaican Natural History, in two editions between 1946 and 1949, was re-issued in about 1976.
56. The UWI Mona Herbarium is at the Department of Botany, UWI Mona, Kingston 7, Jamaica. The curator of the Trinidad National Herbarium is Miss Yasmin Baksh, c/o Head, Department of Biological Sciences, UWI St Augustine, Trinidad. Detailed descriptions of the flora of Jamaica and of Trinidad have been published; these are not easy for the average secondary school teacher to use, and while science-educators repeatedly ask for biological keys, such

keys are not feasible, given the variety of organisms that may be encountered on a field trip. Teachers are encouraged to approach museums and herbaria, by mail if convenient, to seek identification.

57. In a personal communication, the ICASE Secretary has commented on the opportunities for inputs from science teachers' associations worldwide into a more ambitious publication of this nature. The present problems, he observed, were time and money, but it is this author's view that such demands would be relatively modest.

BIBLIOGRAPHY

- Adey, P S. Sugar from Cane. Caribbean Science Readers. Trinidad: Longman Caribbean, 1974. 24p.
- Adey, P S (ed). West Indies Science Curriculum. Teachers' Guides 1-3. London: Heinemann, 1976.
- Blackwell, F F. Apparatus: a Source Book of Information and Ideas. Nuffield Junior Science. London: Collins, 1967. 288p.
- Commonwealth Secretariat. Low-Cost Science Teaching Equipment. Report of a Commonwealth Regional Seminar/Workshop, Nassau, Bahamas, 16-26 November, 1976. London, 1977. 98p.
- Dalgety, F and Farley, A. 'In-service strategies for teacher re-orientation in integrated science: the Guyana experience.' In: Lancaster and King (below), pp. 64-71.
- Hayson, J T and Sutton, C R. Theory into Practice. London: McGraw-Hill, 1974.
- Headley, O. 'The role of solar energy in Caribbean development.' In: Lancaster and King (below), pp. 80-83.
- Khan, A. Journal of Education in Science for Trinidad and Tobago, vol. 7, no. 2 (February 1980).
- Khoo, T L. A Collection of Apparatus Assignments. Apparatus developed by course participants in Course TC-Q1, Training in Development of Primary Science/Mathematics Apparatus. Penang: RECSAM, 1976. 75p.
- Khoo, T L. 'RECSAM's experiences in developing low-cost aids for elementary science teaching and learning.' Journal of Science and Mathematics Education in Southeast Asia, vol. 2, no. 2 (July 1979), pp. 42-59.
- Lancaster, C and King, W (eds). Science Education for Progress: a Caribbean Perspective. Report of a Regional Conference, Barbados, 19-22 April, 1979. London: ICASE, 1980. 149p.
- Lockard, J D (director). Guidebooks to Constructing Inexpensive Science Teaching Equipment, Vols. I, II and III. College Park: Science Teaching Center, University of Maryland, 1972.
- Lockard, J D (ed). Twenty Years of Science and Mathematics Curricular Development. The Tenth Report of the International Clearinghouse on Science and Mathematics Curricular Developments. College Park: The International Clearinghouse, University of Maryland, 1977. 515p.

Melton, R F. Elementary Economic Experiments in Physics, vols. I, II, III, IV. London: CEDO, 1972.

Production Teacher Vacation Course 1977 Report. Georgetown: Guyana Ministry of Education, Social Development and Culture, 1977. 31p.

Rao, C S (ed). Science Teachers' Handbook. Hyderabad: American Peace Corps, 1968. 311p.

Raymond, W E. 'Rural Education and Agricultural Project in Belize.' Caribbean Journal of Science Education, vol. 1, no. 1 (April 1979), pp. 29-30.

Raymond, W E. 'Environmental approach - primary science curriculum Belize.' In: Lancaster and King, op. cit, pp. 40-45.

Reay, J F (ed). Integrated Science and Teacher Education. Report of Caribbean Science Educators Workshop, Barbados, 1-13 April 1973. Trinidad: University of the West Indies Schools of Education/UNESCO, 1974. 258p. + job cards.

Reay, J F (ed). 'Summative evaluation of Caribbean integrated science projects.' In: Cohen, D (ed). New Trends in Integrated Science Teaching vol. iv. Paris: UNESCO, 1977, pp. 142-151.

Reay, J F and Turner, A D. New World Science. Teacher's Book 1, pp. 12-14, Teacher's Book 2, pp. vii-ix. Trinidad: Longman Caribbean, 1975 and 1976.

Richmond, P E. 'Who needs laboratories?' Physics Education, vol. 14, no. 6 (September 1979), pp. 349-350.

Sankies, A M B. 'Performance of a solar still at Georgetown, Guyana.' GAPE Magazine, vol. 9, no. 2 (June 1978), pp. 5-23.

School Science Equipment. Report of a Regional Seminar in Asia, New Delhi, 11-20 December 1972. Bangkok: UNESCO, 1973. 65p.

Silber, R L. 'The role of the teacher.' In: Lancaster and King, op. cit., pp. 19-23.

Simpson, R F. The Construction and Use of Simple Physics Apparatus. Hong Kong: Department of Education, University of Hong Kong, 1972.

Tao, P K. 'Production of low-cost science equipment in Hong Kong.' Hong Kong Science Teachers Journal, vol. 7, no. 2 (December 1979), pp. 52-62.

Teaching of Science by Using Local Resources. New Delhi: Department of Education in Science and Mathematics, National Council of Educational Research and Training, 1977. 93p.

Using Science Apparatus: A Guide for Teachers. New York: UNICEF, 1974. 230p.

Warren, Keith and Lowe, Norman K. The Production of School Science Equipment: A Review of Developments. London: Commonwealth Secretariat, 1975. 47p + appendices.

White, R T. 'Relevance of practical work to comprehension of physics.' Physics Education, vol. 14, no. 6 (September 1979), pp. 384-387.

Whitworth, R W. 'A simple diffraction kit.' Physics Education, vol. 14, no. 2 (March 1979), pp. 101-103.

Williams, D C. 'Improvising school science equipment, using discarded ballpoint pens.' School Science Review, vol. 60, no. 213 (June 1979), pp. 761-765.

Williams, I W. 'The implementation of curricula adapted from Scottish Integrated Science.' In: Tamir, P, Blum, A, Hofstein, A and Sabar, N (eds). Curriculum Implementation and its Relationship to Curriculum Development in Science. Report of the Bat Sheva Seminar, Rehovot-Jerusalem, July 23 - August 2, 1978. Jerusalem: Israel Science Teaching Center, Hebrew University, 1979, pp. 295-299.

Yhip, L. 'Improvisation in science teaching.' In: Lancaster and King, op. cit, pp. 122-125.

APPENDIX 1:
PRODUCTS OF 1977 GUYANA WORKSHOP

PRIMARY EQUIPMENT

equal arm balance	sonometer
battery holder	windlass system
colour filter box and pictures to go inside	comparison of heat absorption apparatus
question and answer board	floating apparatus
mystery box	sundial

SECONDARY EQUIPMENT

Community High

metre rule graduated in cm	spring balance
spring/lever combination	lever balance
opisometer	adjustable height measurer
caliper graduated in cm	

CXC Integrated Science

basic ripple tank	multiple-use ray box
ripple tank accessories: lamp support with lamp socket and heads, ripple bar support, rippler bar, flat triangular and rectangular perspex prisms, concave and convex lenses, plane and curved reflectors, single and double slits	rectangular and triangular perspex prisms to contain liquids for refraction experiments
coated slide with double slits for observing diffraction	plane mirror stands
polarimeter	cylindrical mirrors
grease-proof screen	a chest with standardized drawers/kit containers
biconvex (spherical) lens/mirror holder	transverse wave machine
opaque screen and stand	switch
falling plate apparatus	longitudinal wave machine
	resonance tube apparatus
	resonating strips apparatus
	battery holder

Taken from the Guyana Production Teacher Vacation Course 1977 Report, pp. 17-18.

APPENDIX 2:
CONTENTS OF JAMAICA 'IMPROVISATIONS IN SCIENCE HANDBOOK'

aquaria	electromagnet	plant press
aquatic collecting nets	evaporating dish	pressure pan
balance	filter funnel	pulleys
ball and ring	filter paper	separating funnel
beakers	flower pots	stroboscope
burners	hair hygrometer	sundial
biological models	galvanometer	terraria
bulb holders	graduated cylinder	test tubes
cages for animals	light source	test tube holder and stand
circuit boards	measuring instruments (length)	tripod or heating stand
containers	microscope	water clock
dissection tools	mirrors	weather instruments
egg incubator	overflow can	

For information about this handbook, write to Mrs Janice HoLung,
c/o Ministry of Education, Kingston, Jamaica.

APPENDIX 3:
SUMMARY OF RESPONSES TO SURVEY OF MATERIALS FOR A LEVEL PHYSICS

The survey contained a list of 209 items of equipment and respondents were asked to categorise them as listed below; not every teacher replied in full. They were also asked to indicate how many of the 135 books on the list supplied they possessed.

- A. Reasonably adequate supply.
- B. Not available, teacher would not use if supplied.
- C. Not available, teacher would use if available but can manage without.
- D. Available, but in seriously inadequate quantities.
- E. Not available, badly needed.

Teacher	Apparatus and materials					Booklist	A Level Entry 1980
	A	B	C	D	E		
1.	104	4	27	39	35	6	40
2.	72	66	50	4	17	13	4
3.	15	27	61	30	76	7	32
4.	64	88	40	16	1	8	22
5.	66	42	62	26	13	13	6
6.	101	53	51	3	0	13	22
7.	75	19	91	23	1	11	?
8.	41	4	86	49	29	10	15
9.	93	13	57	11	35	14	8
10.	63	30	112	3	1	13	8
11.	65	98	26	15	4	14	11
12.	61	147	0	0	0	7	6
13.	109	1	29	33	37	18	6
14.	33	110	34	20	12	0	40
15.	73	71	32	3	29	9	11
16.	13	108	40	25	23	2	2
17.	11	30	131	31	6	2	8
18.	38	20	88	58	5	2	5
19.	8	10	87	92	9	8	?

APPENDIX 4:
SUMMARY OF RESPONSES TO SURVEY OF MATERIALS FOR O LEVEL PHYSICS

The survey contained a list of 215 items of equipment and respondents were asked to categorise them as listed below. Not every teacher replied in full.

- A. Reasonably adequate supply.
- B. Not available, teacher would not use if supplied.
- C. Not available, teacher would use if available but can manage without.
- D. Available, but in seriously inadequate quantities.
- E. Not available, badly needed.

Teacher	Apparatus and materials					O Level Entry 1980
	A	B	C	D	E	
1.	47	115	1	1	50	19
2.	82	2	8	63	60	160
3.	60	152	0	3	0	180
4.	62	19	92	10	32	24
5.	96	3	95	14	7	?
6.	36	171	5	3	0	15
7.	86	1	85	39	2	50
8.	42	103	43	18	9	?
9.	18	25	45	20	106	17
10.	101	2	41	27	44	60
11.	21	59	8	12	114	15
12.	23	0	134	8	49	20
13.	0	152	0	0	63	9
14.	38	0	81	12	82	25
15.	18	122	34	26	15	?
16.	15	164	0	18	18	10
17.	27	87	60	3	36	120
18.	26	101	28	6	49	8
19.	20	26	75	35	59	110
20.	26	39	59	14	76	3

Teacher	Apparatus and materials					O Level Entry 1980
	A	B	C	D	E	
21.	12	0	17	21	165	12
22.	9	5	94	32	75	?
23.	15	54	2	33	111	26
24.	0	0	34	17	164	?
25.	92	1	35	72	14	60
26.	21	153	29	12	0	16
27.	57	24	83	50	1	?
28.	15	164	20	10	6	40
29.	114	53	27	11	10	56

APPENDIX 5:
 SUMMARY OF RESPONSES TO SURVEY OF APPARATUS RESOURCES AND
 NEEDS OF LOWER-SECONDARY INTEGRATED SCIENCE TEACHERS

32 teachers were approached for this survey, and were asked to categorise each individual item of equipment as listed below. One teacher did not complete the survey.

Items marked with an * have been locally produced by one or two teachers themselves. For items marked n., see notes below.

Item	A	B	C	D	E
1. tripods	27	0	1	3	2
2. measuring cylinders	26	0	0	7	0
3. glass tubing	25	1	2	5	0
4. flasks	25	0	2	6	0
5. bungs	23	2	3	4	1
6. anatomical model, human ear	23	1	3	1	4
7. bunsen burners	23	0	3	7	0
8.* test tube holders	23	0	3	4	3
9. glass rod	23	0	2	7	1
10. test tube racks	23	0	1	9	0
11. filter funnels	23	0	1	8	1
12. beakers	23	0	0	9	1
13. dissecting dishes	22	1	2	5	2
14. retort stands, bosses and clamps	22	0	2	8	1
15. cork borers and sharpener	21	0	4	2	5
16. corks	21	1	1	8	1
17. test tubes	21	0	1	11	0
18. reagent bottles	20	2	3	6	1
19. petri dishes	20	1	3	8	1
20. metre and ½-metre rules	20	0	2	10	1
21. anatomical model, human eye	19	2	5	1	5
22. crucible tongs	19	2	5	5	2
23. watch glasses	19	2	5	4	3
24. gas jar cover glasses	19	1	5	5	3

Item	A	B	C	D	E
25. rubber tubing, ordinary	19	2	2	7	3
26. gas jars	19	1	3	6	4
27. overhead projector	19	1	2	4	7
28. thermometers	19	0	0	11	3
29. clips for rubber tubing	18	2	4	6	2
30. teat pipettes	17	3	5	8	0
31. masses and hangers	17	2	3	7	3
32. crystallising basins, evaporating dishes	17	0	4	11	1
33. plane mirrors	17	1	1	8	5
34. thistle funnels	16	2	6	7	1
35. electrical switches	16	1	8	4	4
36. crucibles	16	1	6	10	0
37. bell jars	16	0	2	12	2
38. voltmeters	16	1	2	11	3
39. ammeters	16	0	2	13	2
40. gauzes for tripods	16	0	2	8	7
41. microscopes	16	0	0	15	2
42. standard resistors	15	5	4	5	3
43. chart of ear	15	3	6	2	6
44.* chart of human eye	15	3	6	2	6
45. pneumatic troughs	15	4	2	10	1
46. desiccators	15	2	5	9	2
47. hand magnifiers	15	0	2	9	7
48. pipeclay triangles	14	2	11	3	3
49. dropping bottles, 60 cm ³	14	4	6	6	3
50. chart of human nervous system	14	3	6	3	6
51.* chart of heart	14	5	5	2	7
52. model of heart	14	3	6	3	7
53. periodic table wall chart	14	0	7	3	9
54n. spatulas	14	1	5	12	1
55.* force measurers	14	1	5	7	6
56. spotting tiles	13	6	8	1	5
57. battery charger	13	3	9	3	4
58.* chart of skin	13	3	7	3	7
59. mortars and pestles	13	3	5	10	1
60. asbestos mats	13	1	8	7	4
61. crocodile clips	13	1	2	8	8
62. Boyle's Law apparatus	12	6	9	0	6

Item	A	B	C	D	E	
63.	plotting compasses	12	6	4	4	6
64.	deflagrating spoons	12	2	7	7	4
65.	beehive shelves	12	2	5	10	3
66.	converging lenses	12	0	1	15	4
67n.	magnets: bar, cylindrical, circular, horseshoe	12	1	1	15	4
68.	polystyrene spheres	11	6	11	3	1
69.	pulley with clamp	11	5	10	3	3
70.	ripple tanks and accessories	11	7	6	2	7
71.	copper wire, bare and cotton covered	11	3	8	4	6
72.	pendulum bobs	11	4	6	8	4
73.	scalpels	11	4	6	6	6
74.	dissecting needles	11	1	8	6	6
75.	ball and ring	11	4	6	5	7
76.	Liebig condensers	11	3	4	12	3
77.	scissors	11	1	4	10	6
78.	pulley sets	10	4	6	9	3
79.*	chart of kidneys	10	5	6	3	9
80n.*	circuit boards and components	10	0	5	7	10
81.	specimen tubes	9	5	12	1	5
82.	G-clamps	9	12	4	3	4
83.*	skeleton of frog	9	4	12	1	6
84.	cavity microscope slides	9	3	12	4	4
85.	small disposable syringes	9	2	9	7	5
86.	rubber tubing, thick-walled for vacuum work	8	6	9	7	3
87.*	skull of dog	8	7	11	2	5
88.	entomological pins	8	6	11	3	5
89.*	carbon electrodes and holder	8	6	8	5	6
90.	PVC covered connecting wire	8	6	7	5	7
91n.	magnetic needles on stands	8	4	9	4	8
92n.	resistance wire, bare and silk covered	8	1	6	8	9
93.	balance, lever type	8	3	1	17	4
94.*	preserved rat	7	8	11	1	6
95.*	butterfly and pond nets	7	2	15	3	5
96.*	skull of rabbit	7	7	11	1	7
97.*	cell holders for flashlight cells	7	4	13	3	6
98.	model of kidney	7	4	13	0	9

Item	A	B	C	D	E	
99.	anatomical model, skull of man	7	4	12	1	9
100.	Y-tube connectors	7	6	5	10	4
101.	skeleton of human	7	3	8	0	14
102.	microprojector	6	6	16	2	3
103.	NiFe (alkaline) accumulators	6	9	10	1	3
104.	oscilloscope	6	8	11	1	6
105.	model eye kit	6	5	13	3	5
106.	aneroid barometer	6	7	10	2	7
107.	cellulose acetate and polythene strips for production of electrostatic charges	6	8	8	5	6
108n.	electrolysis cell	6	6	10	5	6
109.	fractional distillation columns	6	5	7	4	11
110n.	stopclocks, stopwatches	6	0	6	11	10
111.*	skull of cat	5	8	15	1	4
112.	skull of sheep	5	9	12	0	7
113.	l.t. power supply	5	11	8	4	4
114.	chart: anatomy of hen	5	7	12	0	8
115.*	human teeth chart	5	4	15	1	8
116.	compact light source	5	9	8	2	8
117n.*	tooth structure and decay chart	5	3	15	1	9
118.	lampholders, SBC	5	8	7	5	8
119.	transformers	5	4	8	4	11
120.	bar and gauge	4	17	9	1	1
121.	MES battenholders	4	18	8	0	3
122.	asbestos paper	4	11	13	2	3
123.	nutrition chart	4	4	16	1	8
124n.	cutter for glass tubing	4	1	18	5	5
125.	thermal conductivity kit	4	11	8	0	10
126.	model of skin	4	5	13	0	11
127.	gas syringe 100 cm ³ and holder	4	7	8	2	12
128.	Bourdon gauges	3	17	10	0	2
129.	polystyrene beads	3	10	14	1	4
130n.	magnet suspension stirrups	3	14	10	0	5
131.	metallised polystyrene spheres	3	13	10	0	6
132.	silica tube	3	10	13	2	5
133n.	convection in air apparatus	3	12	11	0	7
134.	electric vacuum pump	3	5	18	0	7
135.	quadrats	3	10	10	2	7

Item	A	B	C	D	E	
136.	absorption tube, CaCl ₂	3	9	12	2	7
137.	rocks and minerals set	3	8	11	1	9
138.	filter pump	3	8	10	4	8
139.	lamps, 12 V SBC axial filament, 24 W	3	11	6	3	10
140.	chinagraph pencils	2	17	9	1	3
141.	Malvern energy kit	2	14	12	1	3
142.	microphones	2	11	13	1	5
143.	jig for sodium chloride crystal lattice	2	12	13	0	6
144.	induced currents apparatus	2	15	7	1	8
145.	Visking tubing	2	8	12	1	9
146.	diamond structure	2	9	12	0	10
147.	model of kidney pelvis	2	6	15	0	10
148.	atom model	2	7	12	2	10
149.	4 mm plugs	1	16	11	2	2
150.	demonstration meter and dials	1	14	13	0	4
151.	calcite crystals	1	15	10	0	6
152.	Nuffield materials kit (solids)	1	13	12	0	7
153.	bicycle dynamo	1	14	10	2	6
154.	skeleton of cat	1	4	19	1	7
155.	rabbit dissection chart	1	7	16	0	9
156.	combustion tubes with hole 150 x 25 mm	1	13	9	1	9
157.	engine models	1	12	10	1	9
158.	combustion tubes, Nuffield type	1	11	10	3	8
159.	electromagnetic kit power supply	1	12	8	0	12
160.	Westminster electromagnetic kit	1	8	11	2	11
161.	kinetic theory model	1	4	12	1	15
162.	Nuffield combustion spoons	0	14	12	1	6
163.	convection in water apparatus	0	11	15	1	6
164.	foot pump with gauge and adapter	0	14	12	0	7
165n.	crystals kit	0	8	17	0	7
166.	2-dimensional kinetic theory kit	0	9	16	1	7
167.	dog whistle	0	8	16	0	8
168.	Ishihara colour blindness test book	0	5	13	1	13

Notes

54. Disposable plastic spoons are readily available and may be considered more satisfactory than ordinary spatulas, simply because they are disposable, reducing the risk of contamination of chemicals in bottles.
67. Scrap magnets can be obtained from radio repair shops and old refrigerators, and are much more interesting than the standard bar magnet polarised at the ends.
80. While circuit boards are made reasonably quickly in a teachers' workshop, and are bulky and therefore expensive in freight costs, the opposite is true of the accessories. Where there is some money available, consideration might be given to importing the components, even the pegs and cell holders of the boards if they can thus be brought in duty-free.
91. The Guyana Report (p.10) mentions a marble and steel strip magnetic compass. (The same principle can be used for the provision of simple electroscopes.)
92. Resistance wire is needed for purpose-built heaters and resistors, and for repairing metre bridges and potentiometers. The inadequate stocks reported may be a consequence of the bewildering variety offered in the catalogues, and it is likely that teachers could do with some help in the ordering and use of wire.
108. Combining approaches from Hubert Alyea of Princeton University, and C G Campbell in School Science Review, vol. 60, no. 212 (March 1979), pp. 528-530, Dr Dyer Narinesingh of the Chemistry Department, UWI St Augustine, has used test paper boxes on an overhead projector in effective demonstrations of chemical principles.
110. Given the spread of digital watches, laboratory stopclocks may become hardly necessary.
117. While tooth structure and decay charts have been observed in even primary schools, the impact of the dentist's X-ray would seem hard to beat.
124. Every home in the Caribbean has a triangular file for sharpening the domestic cutlass. Teachers do not appear to know how to use this file for cutting glass tubing.
130. When teachers have to suspend magnets, they commonly tie them up with string. The torsion in the string interferes with the behaviour of the magnet, and suspension stirrups can be easily made from 18 swg copper wire hung from nylon fishing line or very fine eureka wire. This is only one of many examples of the value of a good stock of wires.
133. Convection in air apparatus provides among the least of challenges in a region where kerosene lamp chimneys are so much a part of domestic life.
155. The ASEP (Australian Science Education Project) unit, Males and Females, which provides large photographs of rat dissection

stages, suggests how any teacher who knows a good photographer could arrange for any illustrations needed.

165. Most schools have nearly all of the items in the crystals kit. The unusual item is the baseboard which, however, is readily constructed in a few minutes by glueing any kind of strips into a square on a baseboard to suit the dimensions of the spheres chosen (these spheres could be spherical fruits of uniform size).

FOOD AND CORROSION

Everyone is probably familiar with the metallic taste of canned juice. The average tin of canned orange juice contains copper 20 ppm, iron (ferrous) 30.40 ppm, iron (ferric) 100 ppm, aluminium, chromium, nickel and tin over 100 ppm.

Although iron and copper are absolutely essential for growth: iron fortification of food is always recommended to deal with iron deficiencies. Iron and copper result in nutrient destruction.

It is difficult to have canned orange juice with vitamin C. Copper and iron catalyse, the direct loss of vitamin C with copper being much more active.

If the minimal loss of vitamin C in beverages is to be obtained, control

of copper and iron is necessary.

The destruction of vitamins A, E and K can be a direct process involving iron and copper but most often it is an indirect process coupled to rancidity formation (oxidation of fats).

The common reason for rancidity is the presence of metal; as most housewives are aware, if a metal spoon is dipped in peppersauce, the spoon corrodes, leaving a trace in the bottle and rancidity steps in.

Drinking water which is mixed with sea water and corrosive in the water mains may contain cadmium, leading to cardiovascular disease, to hypertension, and may also cause kidney

damage.

Generally in foods, there is a minimum problem of metal - iron toxicity. Specific cases of toxic concentrations in foods have been reported with fish. Mercury accumulative in swordfish and certain large tuna pose a health hazard.

The leaching of lead by acidic beverages from improperly glazed pottery such as mugs represent a continuing problem. The problem occurs mainly with pottery from small enterprises.

Children playing with gasoline or paint are affected by lead which leads to brain damage.

Cooking acid food in an aluminium pot could lead to problems because of corrosion products.

Article from Trinidad Express Catholic Supplement, 25 November 1979.

Questions

1. One of the duties of a scientist is to present work in a clear manner so that it may be easily read. Re-write paragraph 2 ('Although iron and copper') and paragraph 6 ('The common reason for') so that they can be more easily read.
2. Describe the chemical reaction that occurs between the pepper sauce and the spoon that is described in the article as 'corrosion'.
3. The article states that canned orange juice contains copper, iron (ferrous), iron (ferric), aluminium, chromium, nickel and tin.

What is inconsistent about this statement and how could it have been expressed more accurately?

4. Do you think that it is possible to test for corrosion of a tin by orange juice by using the methods of qualitative analysis normally used in a chemistry laboratory? Support your answer.
5. Discuss the importance of vitamin C to human growth. List some of the richer sources of vitamin C available to babies in the Caribbean.
6. In the light of what you have read in this article, what advice would you give to your mother if she were about to make some guava jelly or to set some sorrel wine?

This specimen text is taken from Science in the Press 5: Technology 1 by Patricia Isaacs, School of Education, UWI Mona, Jamaica, and June Alfred, St Mary's College, Trinidad.

GLOSSARY OF ABBREVIATIONS

APPIL	Advanced Physics Project in Independent Learning
ASETT	Association for Science Education of Trinidad and Tobago
ASTJ	Association of Science Teachers of Jamaica
BASE	Barbados Association for Science Education
CARICOM	Caribbean Community
CASME	Commonwealth Association of Science and Mathematics Educators
CDB	Caribbean Development Bank
CEDO	Centre for Educational Development Overseas
CIDA	Canadian International Development Agency
CISC	Caribbean Integrated Science Curriculum
CLEAPSE	Consortium of Local Education Authorities for the Provision of Science Equipment (UK)
CROASE	Caribbean Regional Organisation of Associations for Science Education
CRSP	Caribbean Regional Science Project
CSE	Certificate of Secondary Education (UK)
CXC	Caribbean Examinations Council
DAYM	Schools Materials Manufacturing Centre (Turkey)
GCE	General Certificate of Education (UK)
ICASE	International Council of Associations for Science Education
NCERT	National Council of Educational Research and Training (India)
NSTA	National Science Teachers Association (USA)
OAS	Organisation of American States
PSSC	Physical Sciences School Curriculum (USA)
REAP	Rural Education and Agricultural Project (Belize)
RECSAM	Regional Centre for Science and Mathematics (South East Asia)
SAPATT	Science - a Process Approach for Trinidad and Tobago
SDSP	Secondary Departments Science Project (Guyana)
SEPU	Science Equipment Production Unit (Kenya)
SLAST	St Lucia Association of Science Teachers
SSP	Secondary Science Project (Kenya)
STAG	Science Teachers' Association of Guyana
StVAST	St Vincent Association of Science Teachers

TVC Teacher Vacation Course (Guyana)
UG University of Guyana
UNESCO United Nations Educational, Scientific and Cultural
Organisation
UNICEF United Nations Children's Fund
USAID United States Agency for International Development
UWI University of the West Indies
WISC West Indies Science Curriculum
WISCIP West Indies Science Curriculum Innovation Project (WISCIP/B
and WISCIP/C were intermediate generations between WISCIP
and WISC)

© Copyright Commonwealth Secretariat 1982

Printed and published by
The Commonwealth Secretariat

May be purchased from
Commonwealth Secretariat Publications
Marlborough House
London SW1Y 5HX

ISBN 0 85092 212 7

