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ABSTRACT

Proceedings of a Workshop organized by the Unesco Regional Office for Education in Asia and Oceania and with the Science Education Center of the University of the Philippines are presented. The primary purpose of the workshop was to review biology education at the secondary level, focusing on: (1) environmental aspects; (2) molecular and genetic aspects; and (3) applications to health, nutrition, and agriculture; and to propose teaching competencies for biology teachers. The workshop was conducted in nine plenary sessions and fifteen group sessions; an agenda of the workshop is presented in Annex I. Contents include six chapters which review biology education in Asia and cover the main aspects listed above. Four appendices include information on strategies and methods for teaching and learning biology for general education; notes for discussion on content of secondary school biology; tables from papers showing content, practical experiences, methods and skills in three aspects of biology teaching; and an inventory of science teaching competencies at the secondary level. (CS)

APEID ASIAN PROGRAMME OF EDUCATIONAL INNOVATION FOR DEVELOPMENT

BIOLOGY EDUCATION IN ASIA

Report of a Regional Workshop
Quezon City, Philippines
18–23 August 1980

UNESCO REGIONAL OFFICE FOR EDUCATION IN ASIA AND THE PACIFIC
Bangkok, 1980

APEID Regional Workshop to Review Biology Education in Asia, Quezon City, Philippines, 18-23 August 1980

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The General Conference of Unesco, at its Twenty-first Session (Belgrade, 23 September-28 October 1980) adopted a resolution that the name of this region be changed from 'Asia and Oceania' to *Asia and the Pacific*. The new name appears on the cover and title pages of this report.

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Secondary school students in Indonesia studying plants and rocks in the sea surrounding Padang, West Sumatra. (UNICEF)

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The APEID Regional Workshop to Review Biology Education in Asia
was organized jointly by

The Science Education Center, University of the Philippines
and
The Asian Centre of Educational Innovation for Development (ACEID)
Unesco Regional Office for Education in Asia and the Pacific, Bangkok

INTRODUCTION

In pursuance of Resolution No. 1/4.4/1 of the General Conference of Unesco at its twentieth session, the Regional Workshop to Review Biology Education in Asia was held, within the framework of the Asian Programme of Educational Innovation for Development (APEID), at the Science Education Center, University of the Philippines, Quezon City, from 18 to 23 August 1980.

The Workshop was organized by the Unesco Regional Office for Education in Asia and Oceania through its Asian Centre of Educational Innovation for Development (ACEID), jointly with the Science Education Center of the University of the Philippines, which is an Associated Centre of APEID.

The Workshop was attended by 12 participants, one each from Afghanistan, Bangladesh, India, Indonesia, Japan, Malaysia, Nepal, Republic of Korea, Sri Lanka, Thailand, and two from the Philippines. In addition, two observers from the Philippines attended the Workshop. Dr. Dolores F. Hernandez, Director of the Science Education Center of the University of the Philippines, was the Director of the Workshop. The Workshop was assisted by a resource person-participant, Prof. V. Basnayake, Professor of Physiology, University of Peradeniya, Kandy, Sri Lanka, and by two local specialists: Dr. Fredegusto G. David, Department of Psychology, and Dr. Ruben Umaly, Department of Zoology, both of the College of Arts and Sciences, University of the Philippines, Diliman, Quezon City. Three staff members from Unesco (two from the Unesco Regional Office in Bangkok, and one from Unesco Headquarters in Paris) attended the Workshop. A list of participants, observers and resource persons is in Annex II.

The main purpose was to review biology education at the secondary level, focusing on three main aspects: (a) environmental aspects; (b) molecular and genetic aspects; and (c) application to health, nutrition and agriculture, and to propose the teaching competencies for biology teachers.

The discussions were directed toward identifying the key concepts, attitudes, values, methodologies, approaches and teaching competencies of biology teachers. The agenda of the Workshop is in Annex I.

The Workshop was conducted in nine plenary sessions and fifteen group sessions. In the first plenary session, the Workshop elected two Rapporteurs: Miss Amy J. Gonzalves (Bangladesh) and Dr. Arun K. Mishra (India). The Group Chairmen were elected by the group members themselves. The composition of the groups is in Annex III.

The Organizing Committee consisted of the staff of the U.P. Science Education Center.

In the closing session, the Workshop considered and adopted the report with modifications, which have been incorporated in this final report.

Chapter One

REVIEW OF BIOLOGY EDUCATION IN ASIA

AFGHANISTAN

Immediately after the great Saur Revolution in April 1980, the Government of Afghanistan started innovating the education system to make it not only available to all, but also to meet the demands of the country. Efforts are being made to include science and technology in the education system so that the learners may utilize them in their daily lives.

The school structure is as follows: (a) pre-school, which consists of nursery (3 months -2 years old) and kindergarten (3 years - 6 years old); (b) primary (grades I-VIII); and (c) secondary (grades IX-X).

Primary science education

In the primary school, science is not taught as a specific subject in grades I and II, but as part of the science dealing with healthful immediate surroundings. In grades III and IV, biology is taught in the form of nature studies, for two hours a week. In grades V to VIII, biology is taught as a specific subject, in a spiral approach, for two hours a week. In grades IX and X, it is taught for three hours a week.

The science programmes are related to real-life situations of the learners, so that physical and mental powers are equally trained.

The textbooks are designed so that each lesson contains at least one practical experiment. Each teacher is provided with a teacher's guide. Books for the various science subjects are being prepared. Grade V biology is ready for publication. The syllabuses in Dari for the science programmes for primary schools have been completed up to grade VII. Soon they will be prepared in other national languages.

Informal education is being actively promoted.

Secondary science education

In the secondary schools, the terminal classes are branched into social science and natural science streams. The subject of skills development is not included in the syllabus for boy students; but there are vocational schools for students to learn the trades. For girl students, skills development is infused in home economics subjects.

Of the three hours of science subjects taught in grades VIII to X, one hour is devoted to practical work in laboratories. The theoretical parts of the lessons are taught

mostly by lectures delivered by the teachers. Teaching aids are mainly blackboards, chalk and some charts.

Evaluation

There are two examinations per year, one at mid-year and the other at the end of the academic year. Primary school examinations are oral, while secondary school examinations are both oral and written.

Integrated Rural Development Department (IRDD)

The Department carries out a rural development project which aims at improving the living conditions of the masses. It uses an interdisciplinary approach, and the project covers, among others, education and social welfare, agriculture and animal husbandry, and health and sanitation.

Graduates of secondary schools are employed as village workers and trained through an orientation course of from two to four weeks' duration. Their basic knowledge of science subjects is useful in carrying out their community work.

Environmental education

The present Government is taking steps to identify and solve environmental problems and conserve natural resources. An environmental education project was recently tested. The target population was grade VII students. For implementation, three modules were designed and developed dealing with such issues as conservation of natural resources (soil, forest and wild-life), safe drinking water, community health, air and water pollution, use of chemical fertilizers and radioactive waste.

In the new biology programmes of grades IX and X, environmental education is infused into the general biology subject. The subject matter of environmental education for grade VII has already been tested, and the modules will form a regular subject in grade VII. They will be further expanded and used in grade VIII. Eventually it is envisaged to include environmental education in the school curricula *throughout Afghanistan.* The subject is also included in grade XII curriculum for laboratory technicians.

BANGLADESH

Educational structure

There are five years of primary education, followed by three years of junior secondary, two years of secondary, and two years of higher secondary education in Intermediate College or intermediate sections of degree-granting colleges.

Students in Bangladesh begin studying biology at the high-school level, though in a very concise way. This includes preliminary theoretical knowledge about plants and animals.

At the college level, the subject is more elaborate. The specific topics include, for example, zoology, economic biology (e.g. fisheries, silk industry, insects as affecting agriculture), theories of evolution and genetics. Field trips are seldom included.

Students belonging to the science group in the college usually study biology as one of their major subjects, particularly those in the premedical group.

Very little of the environmental aspects of biology is included in the syllabus. The general mass have little or no idea about health care and proper nutrition. Very little importance is attached to the molecular and genetic aspects of biology.

INDIA

Educational structure

The new educational structure in India is described as a 10 + 2 pattern. It consists of five years of primary, three years of middle and two years of secondary school, followed by two years of higher secondary stages. This system is now in effect in many states of the country, and many others are in the process of adopting this new pattern. Some variabilities in terms of structure still exist.

History of biology education

During the 1950s biology was introduced as an elective in formal science disciplines in many states and boards of examination. With the establishment of the National Council of Educational Research and Training (NCERT) in 1961, major innovations took place in science curriculum development. The American series, Biological Sciences Curriculum Study (BSCS) was widely publicized and distributed. At the same time the need for truly Indian curriculum in biology as well as in other science disciplines was being intensely recognized. The NCERT initiated a programme of preparing textbooks for the higher secondary grades IX, X and XI.

After the visit of a Unesco Planning Mission on science education, separate courses for physics, chemistry and biology were prepared for the middle stages instead of the existing arrangement of teaching general science. Today all high-school science courses are taught with the experimental component.

Science education in general, and biology education in particular, have undergone a drastic transformation in India, from a totally foreign curriculum to a curriculum which is a product of self-reliance. The evolution of biology education has reached a remarkably advanced stage as far as the concept and the curricula are concerned.

Objectives of science education

In the policy document of the NCERT "The Curriculum for the Ten-Year School - A Framework" it is mentioned that:

1. Science should help in reducing obscurantism and prejudices based on sex, caste, religion, language or region. By emphasizing a rational approach, science should help the development of a democratic, secular and socialist state.

2. At the secondary stage, laws and theories should be gradually introduced. Open-mindedness and scepticism should be encouraged.

3. The basic principles of chemistry, physics and biology should be taken up. The investigatory or experimental approach is suited to this (secondary) stage of learning. Science club activities can be introduced to encourage innovation and improvization.

Instructional materials

a) Lower secondary stage: The "Life Science" textbook published by NCERT in 1975 was modified. The Committee for the review of the "Curriculum for the Ten-Year School - A Framework" recommended a general science course and a separate course as two alternatives for examination. While for the general-science course a sequence of topics from the existing textbooks was given, for the other alternative, syllabus frames were recommended for greater elaboration by the textbook writers. NCERT has recently converted its three separate courses into a single multi-disciplinary or combined science course.

b) Higher secondary stage: The biology textbook was developed through the Editorial Board, which assigned units and chapters to authors, with guidelines to maintain uniformity of standard, objectives and points of emphasis.

There are some mechanisms for feedback and revision of the textbooks.

Content

The biology courses at both the secondary and higher secondary stages are richly represented with the content, and principles in the environmental aspects, the molecular and genetic aspects, and the health, nutrition and agricultural aspects.

Problems

1. The examinations basically concentrate on evaluation in the cognitive domain, while the development of attitudes and values is often incidental.

2. Fewer practical experiments are actually conducted than those prescribed in the curriculum due to laboratory constraints, large number of students, heavy load of teachers, and prevalent mode of evaluation.

3. The low-priced keys, notes, guides to textbooks unfortunately play a more significant role than the textbooks.

4. The public examinations reflect the contemporary social values, while the curriculum aims at social transformation.

5. Investigatory projects have been introduced in the elective course of biology at the higher secondary stage. However, the execution of these projects in schools leaves much to be desired, and more intensive follow-up-supervisory work is called for.

6. At the lower secondary stage, the approach of instruction as reflected through the textbook is quite conventional. The facts have over-riding superiority over the methods of science. At the higher-secondary stage, similar trends continue also, but the situation is somewhat improved in view of biology being an elective subject and due to the inclusion of investigatory experiments and projects in the course.

7. The curriculum is more a principle or fact-oriented one for nearly all the stages. There is only a secondary concern for the problems which could be solved through the knowledge of biology, or the problems which could be exploited for the understanding of biological concepts.

8. As to the question of "Science for Action", although students are capable of organizing action programmes on the basis of their understanding, they are handicapped because there are no forums or organizations through which they can assert; and they are too concerned with the public examinations to think of translating their understanding into action.

9. The biology curriculum is too prescriptive and rigid to allow for the exercise of freedom on the part of the teacher. However in the area of projects and investigatory experiments the position is different.

10. There is some linkage of the biology curriculum with the outside world for the learner but a great deal more can be brought in with reference to many of the topics.

Teacher training

The biology teacher of a secondary school in India is the holder of a Bachelor of Science degree from one of the over 200 universities in the country. Besides, more than 75 per cent of the secondary biology teachers have a professional degree in education (B.Ed.). About 25 per cent of the total lot, and a large percentage of the younger teachers, in addition, possess M.Sc. degree in Botany/Zoology or Life Science.

The B.Ed. training does not help the teacher to develop an ability and aptitude to lower the content to the intellectual level of the school pupils, nor does it equip him or her with proper aptitude and insight to develop higher mental abilities through the principles of biology and processes involved in biological enquiry.

The Regional College of Education, Mysore, offers integrated degree course in science education. In this four-year course, general education, science content and professional education are integrated together in a proper sequence. For students opting for the biological sciences group the major subjects are botany and zoology. The course content of biology closely parallels that of the other universities of the region.

The Regional College of Education, Bhubaneswar, has recently started a M.Sc.Ed. course in Life Science with a limited enrolment (20 students each year). The course is of the duration of four semesters with a total work-load of eight content papers and four papers in education distributed equally in each semester. Besides, there is also an investigatory project to be completed by each student in the fourth semester.

Various strategies for the in-service training of biology teachers (also other science teachers) have been adopted for a large-scale upgrading of their content knowledge.

Summer institutes of three and four weeks' duration were organized for the teachers of the schools taking up the new biology curriculum.

Greater emphasis was placed on environmental, cellular and molecular aspects. The teachers generally performed all the prescribed and additional experiments, and conducted investigatory projects. The faculty of each summer institute consisted of well qualified teachers from local universities and research institutes under close supervision of the NCERT faculty.

For the benefit of the teachers of the State Government schools a new programme of 'Centres for Continuing Education' has been initiated. The objective is to establish one such centre in each district of the country to be run by a part-time local faculty.

INDONESIA

Educational structure

There are six years of primary education (starting at the age of 7), followed by another six years of secondary schooling (three years of lower secondary, and three years of upper secondary).

Objectives of biology education

1. To develop understanding and curiosity among pupils towards living organisms by developing their basic concepts in biology;
2. To develop basic understanding about scientific processes and the problem-solving methods;
3. To develop values of life among children.

It is mentioned in the Outline of State Objectives in the current stage of the Five-Year Development Plan that the emphasis will still be placed on the development of the agricultural sector, although light industry will also be given attention. Biology education can therefore contribute to national development through the improvement of human environment, community health, hygiene and nutrition.

Biology in the secondary school curriculum

Biology is taught as a separate subject to 13-18 year-old students at the secondary level, but there is now a movement in the lower secondary schools to offer biology as an integrated subject with other disciplines, as in the primary schools.

For the non-science group of students in the senior high schools, biology is emphasized because "every citizen should be aware of his existence in the environment in which he lives." It is offered as a popular science dealing with knowledge taken from daily life with biological implications.

Environmental aspects

Through scientific explanation and real-life exemplification of the biological processes and ecological interdependence, attempts could be made to develop in the students the awareness of Man's crucial role in tipping the critical balance of nature's various components. Ecological principles, as a basis in the management of human environment, should enter the biology curriculum.

The 1975 curricula for lower and upper secondary schools include instructional objectives relating to environmental aspects. The ecological approach to the study of biosphere and environmental aspects are given emphasis.

There are three volumes of textbooks in the 'biology package' for lower secondary schools, and also three for upper secondary schools. The biology education in the upper secondary schools is carried out through an analytical approach. Clearly the environmental aspects constitute the main topics in the curricula and the accompanying textbooks.

Application to health, nutrition and agriculture

In Indonesia, health and nutrition are integrated and combined. The main problem is how to strengthen the co-operation between the health centres and the schools.

In the 1975 curriculum, there are no instructional objectives about skills development, especially in agricultural education. But there are possibilities of relating the school activities of a biology course to skills development in agriculture. The teachers, however, have little interest in extra-curricular activities, because they think that practical skills development should constitute a part of other subjects such as applied chemistry and skill subjects. They consider biology a pure science; it should therefore be distinguished from applied science.

School facilities for biology education

All state upper-secondary schools have relatively well-equipped laboratories. Private upper secondary schools in cities usually have laboratories, but only a few in small towns have special rooms for laboratory work.

The Government has launched a 'textbooks package project' to ensure that students can use the textbooks throughout the year by either borrowing them from their school, or buying them. However, private schools and schools in small towns do not receive sufficient copies, and textbooks at local stores are either expensive or at times out of stock.

Teachers

The 'creativity' of biology teachers is essential in getting the students interested in the subject. Teachers in upper secondary schools exhibit greater creativity than those in the lower secondary schools. Similarly, teachers in industrial areas show more creativity than those in small towns or rural areas.

JAPAN

Educational structure

There are six years of primary education, followed by three years of lower-secondary education and three years of upper-secondary education (or four years of part-time upper secondary), then four years of university and college education. There are also junior colleges (two years) and technical colleges (five years) for secondary school graduates.

Biology education in elementary schools

In elementary schools, biology is not a separate subject, but integrated in science in general. From 1980 onwards, science is taught for two periods a week in grades I and II; and for three periods a week in grades III to VI. Science for grades III and above is divided into three parts: (a) living things and their environment; (b) substance and energy; and (c) the earth and the universe.

Biology education in lower secondary schools

At the lower secondary level, biology is again not a separate subject, but is integrated in science. From 1981 onwards, science will be taught, at this level, for three periods a week at grades I and II, and for four periods a week in grade III. It is divided into two areas: the first covers the content of physics and chemistry; and the second covers the content of biology and earth science.

Biology education in upper secondary schools

Biology is taught as a separate subject in upper secondary schools. Students in the first year of the upper secondary school have to study 140 periods of science per year.

Then in the second and third years, biology becomes one of the elective subjects (the others are: physics, chemistry, earth science, and science II).

There is a provision for the purchase of science equipment and apparatus at school in the Science Education Promotion Law. The Government subsidizes half the cost of science equipment at school.

Environmental aspects

At the elementary (primary) level, only the influences of the environmental factors on living things are dealt with. At the lower-secondary stage, the subject of science is organized as a whole from the point of view of 'science of the environment'. As for the upper secondary level, at present, the environmental aspects are covered mainly by Biology II, but from 1982 they will be covered by Science I, Science II and Biology.

Molecular and genetic aspects

These are not given in the elementary schools. At the lower-secondary stage, the fundamentals of molecules and atoms are taught in the content of physics and chemistry, but not so with reference to biology. In the upper-secondary schools, a significant proportion of learning in biology deals with the molecular and genetic aspects; but the higher sophisticated molecular-biological content makes it very difficult for students and teachers. Therefore, in the revision of the course of study, this particular content has been drastically reduced.

Application to health, nutrition and agriculture

At present these aspects are covered by other subjects, and only the basic principles are taken up in the teaching of biology, for example, health is given in hygiene which is a part of physical education; nutrition is covered by homemaking, and partly by health and physical education; agriculture as the cultivation of plants and the breeding of animals at the elementary level, and as 'cultivation', included in handicraft, at the lower secondary level. In upper secondary schools, this aspect is not covered except as specialized courses in upper secondary agricultural schools; and as a part of co-curricular activities.

Teaching strategies utilized

The teaching methods used are: laboratory work, experiments and observations, field work, "transfer classes" (classes to stay out in a given area for a few days of study, observation and field trips), nature survey road, educational technology, modules, programmed instruction, and a response analyser (a gadget that enables the teacher to get immediate feedback on answers of the students).

In-service teacher education

There exists a system of long-term attachments at universities and research institutions. There are also in-service training programmes organized by science education centres located in each prefecture. The training is normally of one day to one week's duration. In addition, municipal science education centres are being established throughout Japan.

MALAYSIA

Educational structure

There are six years of primary education, followed by three years of lower-secondary and two years of upper-secondary education. The post-secondary or pre-university education is of two years' duration.

Science curriculum changes

The integrated science programme started in the late 60s. At present all the lower-secondary schools (Forms I to III) offer integrated science as a subject. The change logically took place in the courses at the upper secondary level.

The Physics, Chemistry and Biology courses (Malaysian syllabus) were introduced in 1972. Careful selection of the topics was made so that the courses could be completed in two years.

The General Science course (Malaysian syllabus) for arts students was also introduced. The syllabus developed was new, local and implemented in stages with a few trial schools in 1974.

All the courses underwent phased implementation, with a continuous period of formative evaluation.

Teaching and learning strategies

The teaching/learning strategy recommended is based on the discovery and inquiry approach. Conceptual understanding is given prime importance, coupled with students' ability to apply acquired knowledge and skills to real-life situations. The spirit of investigation is highlighted.

At the lower secondary level, worksheets are used to enhance further investigation and discussion.

At the upper secondary level, the teaching and learning strategies used in biology and general science are advocated to further improve the understanding of principles and concepts through classroom activities and experiments.

Biology education in secondary schools

The new biology courses have been adapted to the Malaysian context. In the integrated science curriculum, the approach has been to interlink various concepts. The

environmental aspects are introduced in a very general form. Concepts on health and nutrition are introduced with emphasis given to functions of different organs, balanced diet and body systems. Agricultural topics are treated in more detail in the upper forms. Also at this level, pupils are required to study health education as a non-examination subject, separately.

In the general science (biology section), the three areas are treated in more depth.

In the biology course, units are arranged in a sequence to ensure that appropriate foundations are built up for later learning.

Teacher training

In-service and pre-service courses. In the integrated science programme, by 1979 some 8,673 teachers had been initially orientated to the new curriculum. For the general science course and the pure science courses, 1,498 and 2,978 teachers respectively attended in-service courses organized by the Schools Division. In addition, the Faculties of Education at the three universities of the country have programmed methodology studies towards the new curriculum.

NEPAL

Educational structure

There are three years of primary education, four years of lower secondary, and three years of upper secondary education.

Science curriculum

Science is introduced only from grade IV as one of the compulsory subjects. At the primary level, some science concepts are integrated in social studies. At the secondary level, science continues to be one of the nine compulsory subjects.

The science curriculum gives first priority to knowledge, skills and attitudes that will be of direct use to the students in their daily lives.

In the general secondary school, 12 per cent of the total school time is allotted for general science. Biology in the secondary school curriculum is treated under two main areas: (a) structure of living things; and (b) life processes and maintenance. Environmental aspects are included in the second area. There is no reference to molecular aspects. There are separate curricula for health, nutrition and agriculture at the secondary level. Health is a compulsory subject for all levels, and not integrated in biology. Nutrition and agriculture are vocational subjects, and are offered only in vocational schools. However, some introductory concepts on these three areas are treated under various units of general science.

Science equipment and materials

One set of required equipment and materials is distributed free to every school by the Ministry of Education. In most of the schools there is no separate science room or laboratory.

Teaching methods

Due to lack of physical facilities and trained teachers, the method of teaching biology is still completely lecture-oriented. Only in a few schools is the demonstration method used.

PHILIPPINES

Educational structure

The formal system of education in the Philippines provides for six years of primary education, and four years of secondary education. Both primary and secondary levels are compulsory.

Biology education in the school curriculum

In the first three grades of primary education, science is integrated in health education. Then, in grades IV to VI, science is taught as a separate subject.

At the secondary level, the natural-science course consists of integrated science courses, with emphasis on a particular area at each year level. In Science II (second year), the emphasis is on biology, with a time allotment of three hours per week.

The science courses for the vocational and technical schools are similar to those offered on the general curriculum, with emphasis on the practical aspects.

In special science high schools, the curriculum is much richer in terms of science and mathematics and intended to provide gifted students with the optimum learning experience.

Concepts, relevance and flexibility

The important and relevant concepts are clearly brought out in the curriculum. But ecological concepts are relatively new, and genetic concepts, especially at the molecular level, are doubly difficult. There is therefore a critical need for the proper sequential presentation of concepts and the blending of factual but relevant examples.

To promote relevance, a biology curriculum may allow some degree of flexibility in the use of available materials. Modular exercises might offer this flexibility. A well-trained teacher is expected to utilize indigenous or any available materials which can best present the concepts.

REPUBLIC OF KOREA

Education structure

The system of education in the Republic of Korea is composed of six years of primary education, three years of middle-school education, and three years of high school education.

Biology in the school curriculum

In grades I-IX, biology is integrated in the science curriculum. In grades X-XII, it is taught as a separate subject. Students at this high-school level are required to complete two subject areas in science, on an optional basis. A student must get ten credits of science over a three-year period (one credit is one hour per week for 18 weeks).

The biology content at the primary level consists of the relationship between organisms and their environments, and the basic concept of the ecosystem. What is unique is the intensive treatment of the ecosystem, which is dealt with in biology in the high school.

Instructional materials

The Korean Educational Development Institute (KEDI) has developed a unit called "Man and the Environment" for grade VIII. This unit was tried out, and is favourably considered for integration into the science subject for the middle school. The unit is accompanied by a teachers' guide and student learning materials.

SRI LANKA

Educational structure

The formal educational structure in Sri Lanka is composed as follows: five years of primary school, five years of junior secondary school, two years of senior secondary school, and tertiary (higher) education.

Science curriculum

At the primary level, the pupils learn science informally as environmental studies. The curriculum is mainly based on nature. The child is confronted with very simple problem interactions, and is given simple assignments.

At the junior secondary level, the curriculum consists of integrated science which is a compulsory subject. Teaching is mostly accompanied by practical activities. About 16 per cent of the weekly workload for a pupil is on science. Nearly 40 per cent of the integrated science curriculum deals with biology. The teacher and the pupil work together to improvise the equipment made of locally available low-cost materials. Field work is given a very prominent place. The curriculum materials for this level is prepared at the Curriculum Development Centre in Colombo. Pupils are supplied with textbooks free of charge.

At the senior secondary level, science is taught as four separate disciplines; physics, chemistry, botany and zoology. Only about 15 per cent of the student population at this level get a chance to study science. During the past few years, drastic revisions in the science syllabuses have taken place, particularly in chemistry and zoology. Human biology is one of the latest additions in the new advanced-level zoology syllabus. Other new areas are: animal diversity, ecology, industrial aspects and technology (as economic zoology), genetic engineering, genetic counselling.

The Field-Studies Centre programme

This is a science environmental programme to serve the needs of science students of the G.C.E. Advanced Level. A Field-Study Centre is developed, taking into consideration a natural resource as the nucleus of activity. The programme provides facilities for first-hand study of the environment, and makes the young people aware of the need for conservation of the natural environment.

Two Field Study Centres were set up in 1979. Several study camps have been held, and teachers and school principals have been trained for field study work. These centres have contributed greatly to the development of science education in Sri Lanka, and have developed a large number of projects for the general public too.

Teacher training

Teachers of science at the junior secondary level are mostly untrained, but they are given vigorous in-service training.

THAILAND

Educational structure

The schooling pattern in Thailand is as follows: six years of compulsory primary education, followed by three years of lower-secondary and three years of upper-secondary education.

Biology curriculum

Corresponding to the concerns of the Workshop, the biology curriculum aims at:

1. Helping students to acquire biological knowledge applicable to their lives; making them observant of local environment and people's way of life; stressing the values of conservation of natural resources and natural habitats;
2. Recognizing the relationships between biological knowledge and other disciplines;
3. Helping students to acquire skills in applying biological knowledge to problems in their personal lives and public welfare;

4. Helping students develop certain attitudes; e.g. love of nature and appreciation of the value of conservation of natural resources.

At the primary level, biological topics are incorporated in other subjects which are grouped together as *subjects for the promotion of life experiences*. Science as such is not a subject at the primary level.

At the lower secondary level, general science is a separate subject, in which all the science disciplines are integrated. Biological aspects deal with the environment and occupations of the people.

At the upper-secondary level, biology is taught as a separate subject, for three hours a week. Students selecting the science programme must study six courses in biology. The content of these courses deals with basic knowledge in biology which will prepare students for further study. Non-science students then also have to study a special course which deals with biology for everyday life.

At all three levels, the environmental aspects, as well as those of health and nutrition are incorporated in the biology curriculum. The genetic aspects and the application in agriculture are taught from the lower-secondary level upward. The molecular aspects figure in the curriculum for the upper-secondary classes only.

School facilities

Most of the secondary schools have adequate science equipment and apparatus. Schools without laboratories can give practical work by adapting classrooms for the purpose. Simple instructional aids are made from local materials. There is still a shortage of audio-visual materials for biology teaching.

Teacher training

Pre-service training for biology teachers is given by the teachers' colleges and universities. Student teachers (of biology) must take at least three groups of subjects: biology, education and teaching methods. Teachers of biology at the secondary level are generally holders of a bachelor's degree.

In-service training is given by the Ministry of Education in collaboration with the Institute for the Promotion of Teaching Science and Technology (IPST). The investigative approach is used in the teaching-learning method.

Chapter Two

BIOLOGY AND OUR ENVIRONMENT

Environment can be defined as *the sum total of all factors (biotic, abiotic and socio-cultural) interacting with life.*

The areas of ecology and environment, with particular reference to man, have assumed a place of great significance in the last decade or so. Nearly all countries have introduced a unit or two in their curricula of general science and/or biology highlighting the principles of ecology and environment; the role of man as a factor acting upon the environment and in turn being influenced by all changes taking place in it. In addition, the realization of problems, hazards and crises is often emphasized for proper management and survival of the human race with greater comfort on this small 'spaceship earth'. This is in contrast to the notion of fear and despair evident a few years ago regarding the damage to human population and its possible extinction in view of the environmental deterioration.

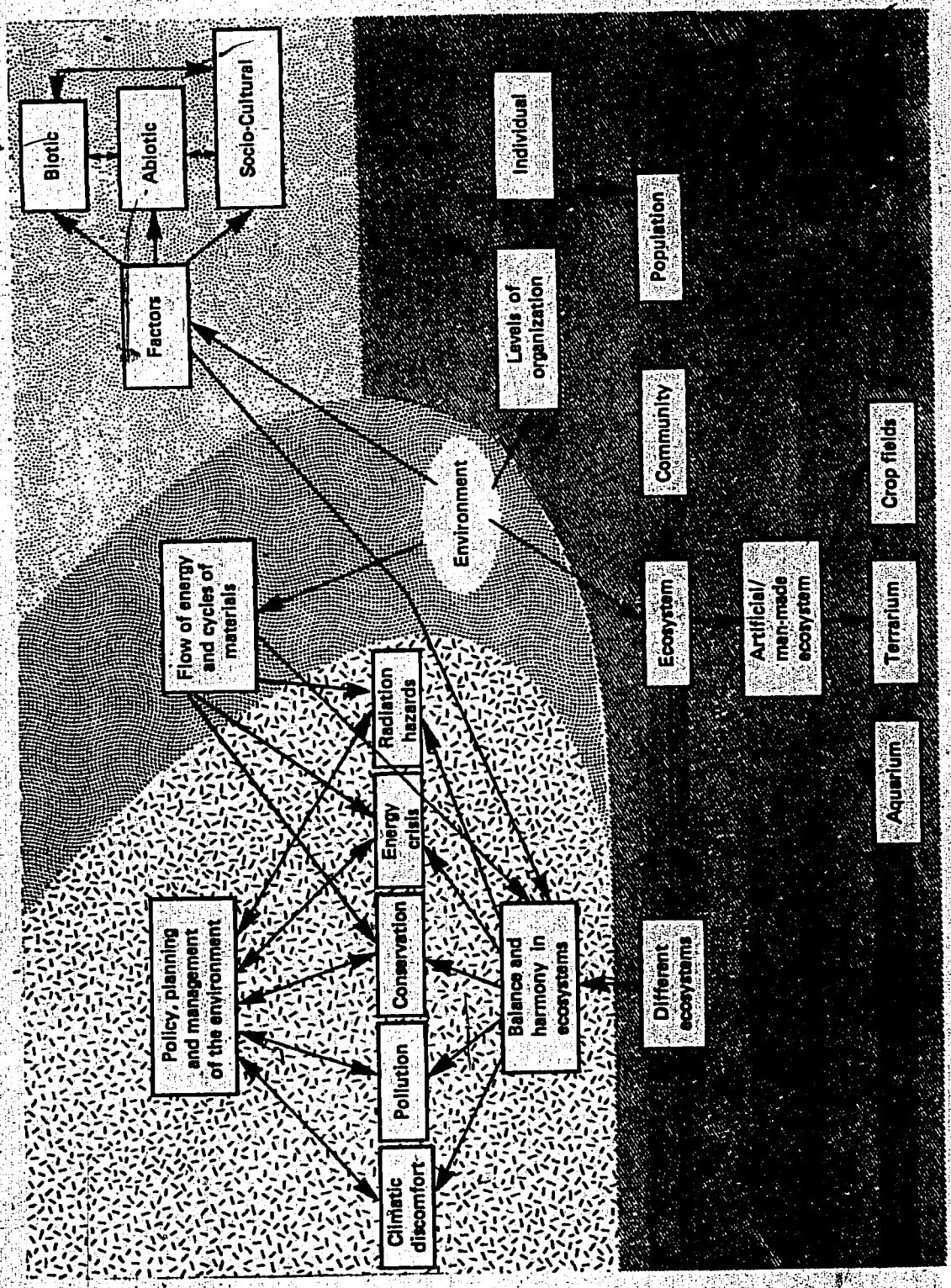
The environmental aspects assume still greater importance in the Asian context. These countries are predominantly agricultural and being tropical in climate possess great productive potentials for their population. An ecological imbalance, besides having effect on the human race directly will also interfere with productivity for support of the population. Another factor in this connection is the rapid urbanization and development being undertaken recently. This calls for caution in urban and industrial planning so that the mistakes of the West do not recur. The rapid population growth which places greater demand on the environment is another reason for better environmental awareness.

The diagram on the next page depicts the various areas of environmental concern and their inter-relations. It is presented to simplify the complexities so as to achieve better understanding of the tables that follow.

The ideas and experiences of the participating countries have been synthesized in these tables. It is suggested that reference be made to the country experiences in the various sub-areas for better understanding of the implied ideas. The detailed country experiences are in Appendix C of this report.

During the synthesis it has also been kept in mind that the practical experiences and teaching strategies that have been listed have been actually tried out and are in vogue in one country or the other at the concerned levels of school education. Others which could possibly have been included, but have not been experienced in schools, have been omitted.

It is not intended to give a prescriptive curriculum guide for any particular country nor a model to follow or imitate. Instead, the concepts, practices, values and attitudes, and learning strategies provide an elaborate list from which to draw for framing new syllabi or revising the existing ones and developing other related instructional materials.



Area of concern	Concepts / Principles	Practical experiences	Teaching/Learning strategies	Developing values/ Intellectual skills	Levels Lower	Levels Higher
I. Factors						
A. Biotic	Plants, animals, micro-organisms – socio-economic aspects – diversity	Field study of diversity in natural conditior – collection – preservation – identification	– Lecturette* – Discussion* – Field trip – Laboratory examination – Audio-visual aids*	– Appreciation of aesthetic value – Appreciation of conservation laws	✓	✓
	– interaction predation parasitism commensalism mutualism competition, aggression scavenging	Case study	– Games on interaction – Audio-visual aids – Making models from local materials	– Implication to social inter-relation		
B. Abiotic	Influence of the following on the organisms – air – water – soil – temperature – humidity – pH – light – salinity – climatic comfort	Measurement of air composition Physical and chemical analysis of soil (moisture, pH, water retaining capacity) Experiment on effect of light and temperature on plants and animals Measurement of factors affecting thermal comfort - temperature, humidity, air movement, radiant heat	– Lecturette* – Discussion* – Field trip – Use of local materials – Audio-visual aids* – Experiments	– Sharing of the same environmental factors by all – Equality, social justice – International understanding – Application to real life situations – Drawing of inferences	✓	✓

Note: * These are to be used when necessary in relation to each topic in the following pages.

Environmental Aspects of Biology Education (cont'd)

Area of concern	Concepts / Principles	Practical experiences	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
C. Socio-cultural aspect	– Man as a social being – Interacting influences between man and his environment – Attitudes, traditions and practices in relation to environment	– Beautifying the environment	– Collection of and discussions on local traditions, practices	– Realization of the potentialities of man vis-a-vis environment – Realization of the interactions of the biotic, abiotic and socio-cultural factors	✓	
II. Levels of organization – individual – population – community – ecosystem	Population and species – characteristics of a population, population growth, population density, birth rate, death rate, immigration rate, emigration rate (with special reference to human population) – effect of environment on population, nutrient supply, available space, weather, community. – characteristics of a community: trophic organization, stratification, dominance, succession	– Field study of the density of plant and animal population including man – Laboratory study on increase in population of certain organisms (*Drosophilla*, bacteria etc.)	– Field study in and out of school. – Simulation – Experimentation – Use of research findings conducted by scientists – Use of facts and statistical data: local and global	– Implication to population growth and consequences, social interrelations – Awareness of the importance of population control	✓	✓
III. Ecosystem – structure	Structural components of an ecosystem: producer, consumer, decomposer	– Field study of local ecosystems (components and related factors affecting the ecosystem)	– Field study in and out of school	– Dexterity in outdoor experimental skills and science process skills	✓	✓

Area of concern	Concepts / Principles	Practical experiences	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
			– Use of information related to student's real life situations – Use of illustrations from various sources	– Observation, classification – Measuring, recording, – Hypothesizing, inferring		
– Different types of ecosystem	Major ecosystems of the world Aquatic biomes: Marine – seas, seashores, mangroves, estuaries Freshwater – streams and rivers, ponds and lakes, marshes and swamps Terrestrial biomes: Forest – tropical, temperate, taiga Grassland – tropical, temperate Desert Tundra	– Model-building	– Use of models – Project work	– Realizing the significance of local ecosystems to the society – Awareness of conservation principles		
– Artificial/man-made ecosystem	Aquarium Terrarium Crop – fields, etc.	– Construct an artificial ecosystem using an aquarium, terrarium, school and home gardens	– Use of man-made situations			
IV. Flow of energy	Source of energy, trapping of energy (including quantitative aspects), food chain, food web, food pyramid	– Model building for food chain, food web – Experiments on production rate – Depiction of data through charts, graphs	– Use of models – Experimentation – Use of data and illustrations from various sources	– Awareness of abundance of solar energy and its potential for utilization – Development of correct attitudes towards harnessing of the biomass	✓	✓
V. Materials cycles	Carbon cycle, water cycle, oxygen cycle, hydrogen cycle, nitrogen cycle, cycle of other elements – P, S, Ca		– Use of information and illustrations from various resources	– Realization of the significance of recycling and its application in daily life	✓	✓

Environmental Aspects of Biology Education (cont'd)

Area of concern	Concepts/ Principles	Practical experiences	Teaching/ Learning strategies	Developing values/ Intellectual skills	Levels Lower	Levels Higher
VI. Harmony and balance	– Interdependence and interrelationships of one component on another – Examples of disturbance in components resulting in imbalances with emphasis on the role of man – Homeostasis and steady state		– Use of information and illustrations from various resources: local and global	– Awareness of the delicate balances in the ecosystem – Development of global perspective	✓	✓
VII. Environmental problems and management	A. Pollution: 1. Air – Main sources of air pollution, main air pollutants, the effects of air pollution on environment	– Tests for air pollutants – Simple statistical representation of data – Case studies on index plants	– Experimentation – Use of local data – Case study – Use of current literature – Use of community resources – Project work	– Recognition of pupils' roles and identification of actions for minimizing pollution (applicable to pollution as a whole)	✓	✓
	– Preventive measures and quality control		– Use of resource persons	– Developing proper attitudes for urban and industrial planning – Developing reasoning power and establishing cause and effect relationships – Development of environmental ethics		
	2. Water – Main sources of water pollution, main water pollutants, effects of water pollution on environment	– Measurement of BOD / COD levels	– Use of information and illustrations from various sources: local and global	– Realization that not all flowing and apparently clean water may always be potable	✓	✓

Area of concern	Concepts / Principles	Practical experiences	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
	– Preventive measures and control, quality criteria – Accumulative effects of pollutants	– Study tour to water treatment plants – Turbidity tests for water pollution – Experiments on effects of water pollution on aquatic organisms	– Experimentation – Study tour – Use of current articles – Project work – Use of resource persons			
	3. Soil – Main sources of soil pollution, main soil pollutants, effects of soil pollution on environment – Preventive measures, control and remedies	– Extraction of soil organisms to compare polluted and unpolluted areas (Tullgren and Baerman)	– Use of local information – Experimentation – Use of related articles in literature – Project work – Use of resource persons		✓	✓
	B. Conservation: – Nature of renewable and non-renewable resources – Methods for – preventing soil erosion – retaining soil fertility – maintaining water cycle – Knowledge about wasteful methods in tree cutting – Prevention of destruction of forests – Endangered species of plants and animals – Marine resources, ocean as an alternative source of food, medicinal plants and industrial products	– Experiment on roles of plants in preventing soil erosion – Visit to national parks, zoos and sanctuaries	– Experimentation – Use of local information – Use of related articles in literature – Use of resource persons – Use of audio-visuals – Study tour – Project work	– Realizing the need for conservation and wise use of natural resources – Realizing that every development project must give appropriate consideration to its environmental implications – Awareness of legislations and development of the desire for their implementation – Appreciation for the traditional notions of environmental protection and management	✓	✓

Area of concern	Concepts / Principles	Practical experiences	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
	— Austere and judicious use of non-renewable resources and search for the alternatives					
	C. Energy crisis: — Depletion of sources of energy — Austere use of energy — Search for alternative resources — Energy consumption pattern of selected nations — World energy prospects	— Use of solar driers, solar cookers, water heater, biogas, etc.	— Use of related articles in literature — Use of community resources — Use of data and illustrations from various sources — Project work	— Developing proper attitudes towards the use of energy resources	✓	✓
	D. Radiation and chemical hazards: Harmful radiations — Ultra-violet radiation — Ionizing radiations and their biological effects Chemical hazards associated with nuclear fallout — Main elements of nuclear fallout and their effects on human health — Protective measures against UV, nuclear wastes		— Use of related articles in literature — Use of community resources — Use of data and illustrations from various sources — Project work	— Awareness of the hazards of nuclear energy		✓

Chapter Three

GENETIC ASPECTS OF BIOLOGY

Genetics and molecular biology are often said to occupy centre stage in contemporary world biology. The concepts involved, however, may be mostly unsuitable for school level (though not at university level) because of their complexity and because they may not be able, in the Asian scene, to displace some of the other materials which are desired to be retained. Even a technologically advanced country as Japan advises the teacher that "the emphasis should be on the relation between DNA structure and gene mutation, between hereditary phenomena and enzymes, and between DNA and the appearance of characteristics. However, it is not necessary to sacrifice student comprehension by presenting more facts than they are able to understand."

Reviewing the present biology education in the participating Member States, the Workshop felt that for the detailed listing of the concepts/principles/topics the content of genetics in secondary school biology need not, at present include molecular biology than the basic mechanism of DNA replication, transcription and the translation.

Terms such as the following are perhaps suitable for discussion only at teacher training and enrichment seminars and not for school students:

gene isolation	repressors
gene regulation	RNA-directed DNA synthesis
gene transfer	supercoiled DNA

The framework used was to start at the macroscopical level (such as everyday life evidence of inheritance and of variation), to pass on to the microscopical level (cytogenetics) and finally to the molecular level (DNA, translation and transcription for protein synthesis). The use of this particular framework was simply a matter of convenience. It does not in any way mean that it is the best. An equally logical framework could be made by turning the present framework upside down. In any case the workshop was not concerned with the order in which the topics are listed for the purpose of the report.

The workshop confined its work in 'molecular biology' to 'molecular genetics'. This was done because of time constraints and not because of strong pre-conceptions about the meaning of the term 'molecular biology'. It was noted that a broader interpretation could be given to the term, so as to include the molecular aspects of photosynthesis, energy liberation, and hormonal actions on cellular processes. It was however not possible for the workshop to find the time to consider this vast area of molecular processes.

Also no attempt was made to grade the topics into categories such as 'highly recommended', 'recommended' and 'recommended for use in certain circumstances only'. This omission was in accordance with the workshop's policy of concerning itself only with the whole range of topics which are suitable for school biology courses, and not with any further selection of topics for teaching in any given school or province or country. The Workshop considered that such choices of individual topics was a matter for each country and school system to decide for itself. The Workshop's business was only to provide a 'shopping list' of topics which it considered to be suitable for general education purposes through biology in Asian secondary schools.

Apart from the teachability of topics the choice was influenced by a concern to emphasize relevance of biology education to the actual current interests and needs of the individual student, the community, and the nation.

The Workshop took note of the fact that the criterion for inclusion of topics for general education include not only the customary body of traditional biological knowledge but also the growing use of terms such as (XX) which are popular with the mass media so that total ignorance of them may not be desirable, and related topics which may have a considerable attitudinal flavour (such as 'race').

The Workshop would have liked to document each topic, with examples of school systems in Asia which actually do teach the topic, and with examples of teaching procedures, particularly in regard to practical work. It therefore recommends to Unesco that steps be taken to provide such documentation. This will help to convince curriculum developers and teachers that these topics can in fact be taught, and taught well. Appendix C of the report however gives in some detail the attempts being made in various countries to teach the concepts.

The Workshop felt that there may be a need to lay increasing emphasis on the relationship between biology and human values. The importance which the workshop attached to this viewpoint arose from various considerations, including the dangers to individuals and societies arising from certain traditions, from the breakdown of certain other traditions; and from the various other forces such as commercialism and racism. These concerns, are, it is hoped, reflected in the column on skills and attitudes.

However the topics listed by the Workshop do not include all the items suggested by the participants. The omitted concepts were those which were rather controversial or/and vague, belonging mostly to areas loaded with values. The Workshop took note of the two working papers prepared for the Workshop (Appendices A and B). They emphasized the need to consider the relationship between biology and human values. The Workshop wishes to recommend to Unesco that mechanisms be devised to study these problem areas in depth.

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values Intellectual skills	Level	
					Lower	Higher
I. Variations	Introduction and definition: The types of variation, modes of expressions, cellular and molecular basis and its pattern of inheritance from one generation to another among individuals and populations.		Motivational examples of inheritance – parents and children – diseases – abilities – plant/animal breeding Class discussion Audio-visual	(Intellectual/Psychomotor) Relevance to national development, community development and personal development.	✓	✓
	Variations: Types of variation – morphological, physiological – behavioural	– Study differences of students in the class e.g., hair, fingerprints, leaves, flowers from same species.	Observations, measurements, (sizes, frequency, counts)	Inferences on adaptations based on observations of characteristics. Relevance to personal interests	Behavioural and external morphology only.	✓
	Role of heredity and environment in producing variation. – The phenotype as the product of interaction between genes and environment.	– Experiments to show environmental effects, like effect of covering mango seedlings with a box.	Observations/measurements of trees, selected plants in schools	Relevance to idea of 'race' or groups of people. Similarities between different peoples are much greater than differences.	✓	✓
		– Experiences on the effect of curlers or chemicals on genetically straight hair; a fair-skinned individual exposes himself to the sun; he becomes dark.	Practical work/demonstration. Use as examples: hair colour/eye colour (mainly genetic)			
	– Phenotypic characteristics can be classified into four groups: 1. characteristics due mainly to genetic origin		– development of learning potential is environmentally influenced			
	2. characteristics due mainly to environmental origin		– miracle rice only works with fertilizer	Internationalism Evaluation on improvement of breed		

Genetics (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels	
					Lower	Higher
	3. characteristics due mainly to genes but requiring specific environments e.g., use of fertilizer		– pre-disposition to specific diseases like most infectious diseases (mainly genetic but with specific environment)			
	4. characteristics due to environment but will require specific genes		– traditional rice if heavily fertilized lodges (environment but requiring specific genes)			
	– the biological significance of variation is chiefly in providing materials for natural selection and evolution				✓	✓
II. Methods of studying genetics	– hybridization and other breeding experiments	– Survey of inherited traits in family of class members, e.g., tongue rolling, left-handedness, ear wriggling etc.	Special project, hybridization, e.g., varieties of beans, mango, corn, *Drosophila*	Appreciation for the methodology of genetic research	✓	✓
	– pedigree analysis	– Collection of medical data for analysis of heritable traits, pedigree				
	– twin study – others	– Crossing *Drosophila* and observing traits				
III. Applications	– breeding experiments – genetic engineering – eugenics				✓	✓
IV. Genetics and society	– improvement of crops – selective breeding – conservation of gene pool – genetic counselling – protoplast fusion – legal implications – improvement of crops through mutation	Examination of as many varieties of rice/coconut/corn, dogs, cats, horses, chicken, cows if possible to illustrate concepts of breeds (var).	Field trip to breeding station. Special projects; breeding plants/animals to produce desired characteristics	Relevance to national/community goals, self-sufficiency	excluding genetic engineering eugenics and legal implications	

Genetics (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
V. Cytogenetics	– review of cell theory – cell and viral structures – the role of the nucleus	– Building models of chromosomes, nucleus, cells, virus – Examination of nuclear materials in plants like onion root tip; in protozoans	– laboratory work – discussion – audio-visual – use of text material	– Interpreting abstract models – Inferring models (chromosomes) from evidence		✓
	– the chromosome theory of inheritance	– Building of clay/wire models	– laboratory work – discussion – audio-visual – use of text material	– Interpreting abstract models – Inferring models (chromosomes) from evidence		
	– chromosome structure – karyotyping of chromosome – role of chromosomes in genetics	– Microscopic examination of chromosome using plant materials (onion root tip), animal material (grasshopper testis), *Drosophila* (giant chromosomes)				
VI. Cell cycle (Cell Division)	A. Mitosis – historical basis of mitosis – structure of nucleus – process – implications of mitotic division	– Microscopic examinations of different stages of mitosis using onion root tips – Building of clay or wire models showing the different mitotic stages – Squash preparation of onion root tip, corn pollen – Examination of chromosomes undergoing cell division in *Drosophila* – Vegetative propagation	– laboratory work – discussion – audio-visual	– Interpreting microscopic appearances – Recognizing unity in life Relevance: understanding the biological implication of mitotic division – appreciation of the mechanisms and implications for applications of cloning	✓	✓
	B. Meiosis – types of cells involved in meiosis	– Microscopic examination of prepared slides of grasshoppers/ mouse testis, etc.	– laboratory work – discussion – audio-visual	Relevance: understanding the biological implication of meiotic division – introduction of variation in plant and animal species		✓

Genetics (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
	– process – implications – increasing the chances of variation through crossing-over and random assortment of chromosomes – segregation of sex chromosomes – sex determination – chromosomes as carriers of hereditary traits	– Microscopic examination of egg and sperm, e.g., mouse testis, frog egg		– Valuing certain traditional customs which prevent in-breeding and promote out-breeding		
VII. Chromosomal aberrations	– deletion, duplication, or re-arrangement of genetic material	– Interpreting the existing data from humans	– laboratory work – discussion – audio-visual	– Relevance: to certain diseases, e.g., leukaemia mongolism, sexual aberrations		✓
VIII. Patterns of inheritance	– laws of probability – role of chance – binomial expansion	– coin, – dice } tossing	– Problem-solving – Games to illustrate probability laws	– Appreciation of the role of chance in reproduction and transmission of genetic traits	✓	✓
	Mendelian inheritance – definition of terms: dominant/recessive traits, hybrid, alleles – introduction to Mendel's work on pea – rediscovery of Mendel's work	– Crossing of wild and mutant *Drosophila* – Survey of family traits and construction of family trees – Observation in poultry, cows, dogs	– Discussion – Simulation games – Analysis of results of family tree – Problem solving – Audio-visual	– Relevance to understand differences between people – To internationalize science – Appreciating its historical aspects	✓	✓

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
	– laws of segregation and independent assortment – review of cytological basis – review of mathematical basis – examples in plants, animals, etc.					
	Limitations of Laws of Mendel – multiple alleles – Rh factors – histo-compatibility genes – ABO groups – immunity	– Trip to the health centre to have blood types taken and correlate with parents' blood type if possible	– Discussion on results of blood typing test – Use of models to explain antigen-antibody relationship	– Relevance to health matters such as blood transfusion, tissue and organ transplantation and Rh factor problems		✓
	– incomplete dominance and co-dominance – intermediate dominance (blending inheritance)	– Trip to botanical garden/school garden to observe certain characteristics especially of flowers e.g., four o'clock plant and *Hibiscus*; shapes of fruits in squash, water melon	– Discussion on the result of the trip; games; pedigree analysis	– Recognizing the limitations of certain laws and principles e.g., Mendel's laws		✓
	Linked genes and gene mapping – linkage in *Drosophila*, corn – chromosome mapping work on *Neurospora*	– Cross between wild and mutant *Drosophila*	– Audio-visual – Laboratory work – Class discussion – Problem-solving	– Interpretation of experimental data		✓
	Polygenes examples: – quantitative inheritance – skin pigmentation – cob length in maize	– Measurement of stature of children of same age to show continuous variation – Estimation of skin colour – Counting number of seeds in the pods from the same plant	– Laboratory work – Introduction of simple statistical concepts	– Valuing the concept and commonness of continuous variation including the shape of normal distribution – Interphase with simple biostatistics – Valuing individual differences leading to tolerance of such differences		✓

Genetics (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values/ Intellectual skills	Level: Lower	Level: Higher
	– Gene interaction – epistasis – complimentation – production of new phenotype	– Observation of comb-shape in poultry	– Discussion and interpretation of results of observations			✓
	– Sex-related inheritance – X or Y linked-genes – sex-influence – sex-inherited traits	– Survey of colour blindness baldness, hypertrichosis of the pinna, etc. – Cross between wild and mutant *Drosophila*	– Discussion and interpretation of results – Case studies	– Relevance to certain health problems such as haemophilia; genetic counselling		✓
	– Lethal and sub-lethal genes – Cytoplasmic inheritance – Others	– Survey of families with haemophilia	– Class discussions – Case studies – Discussion of concepts			✓ ✓ ✓
IX. Population genetics	– Definitions – population – gene – gene pool – gene frequency – random mating		– Calculation of gene frequencies from data on blood groups – Comparison of phenotypic characters in two populations – Applications of biostatistics	– Application of mathematics to biology – Value in recognizing that the average differences between two populations may be very small in comparison to individual differences,		✓
	– Hardy-Weinberg Law – meaning – application	– Survey of community members who are tongue rollers; human blood groups – Getting data from hospitals, blood banks	– Class discussion of concepts	– Application of this to the "race concept" – Valuing the tendency to stabilization of certain characteristics in a population		✓
	– Changes in gene frequency due to: – 1. migration – 2. mutation – 3. selection	– Data gathering on number of migrants in a country	– Class discussion on results of data gathered – Enumeration of country statistics of migration e.g., Indochinese refugees – Audio-visual	– Appreciating that mankind is getting increasingly mixed up genetically – Valuing the occurrence of differences between population groups		✓

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values Intellectual skills	Levels Lower	Levels Higher
	– Genetics and society – Eugenics – Genetic counselling – Concept of race – Evolution – Others		– Problem solving – Role play (genetic counselling) – Contrast of differences between the so-called races of man on the basis of skin colour etc. and the very different pattern seen when hidden heritable characteristics such as blood groups, and enzymes are used or considered	– Valuing the use of reason in making personal decision – Considering not only oneself but also others and their future in making decisions about marriage etc. – Promoting tolerance between population and racial groups – Weighing arguments before making decisions – Improvement of socio-economic, educational and other environmental conditions which would permit full expression of gene potentials	✓ Awareness level only	✓
X. Molecular genetics	– Protein as phenotype determinants – curly hair - product of the type of keratin – albino - absence of enzyme melanin – diabetic - due to absence of hormone insulin – haemophilia - absence of protein for blood clotting – sickle-cell anaemia - wrong haemoglobin which is a carrier protein		– Lecture – Discussions	– Valuing the creativity of the human brain to formulate mental models of complex chemical structures as in the molecular structure of protein and DNA – Valuing the ability to device experiments to test the validity of these concepts		✓

Genetics (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values/ Intellectual skills	Level Lower	Level Higher
	– Structure of proteins and their functional specificity – primary structure – secondary structure – tertiary structure – Co-linearity of proteins and DNA – DNA as a genetic material	– Paper chromatography of amino acids – Interpretation of models of proteins	– Use of examples – Use of models – Class discussion – Audio-visuals			
	– Structure of DNA – nucleotide – nucleoside – bases – phosphate – bonds	– Model building – Demonstration of presence of DNA in cells by the Fuelgen-reaction	– Use of examples – Use of models – Class discussion – Audio-visuals	– Valuing the ability to see the fit between observed facts and propose theoretical models – Appreciate relationship between structure and function		
	– Proofs that DNA is the genetic material – Griffith experiment – Avery-McLeod experiment – Transduction of bacteriophage – Proof that DNA can replicate – Messelson, Stahl and Taylor's work – Properties of genetic material – stability – coding – mutability – mechanisms of mutation – examples of mutagens – molecular explanation of mutation – translatability	– Use of Models – Experiments on mutagens in *Drosophila* – Experiments on effects of radiation in plants	– Motivational examples and case studies from drug abuse, alcoholism and radiation damage – Class discussion of concepts – Discussion of experiments mentioned in column 2	– Appreciating of the experimental methodology as applied to genetic experiments – With regards to the effect of mutagens – judging the claims of some commercial ads of some products – developing an aversion for callous commercial promotion and warfare		

Genetics (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values/ Intellectual skills	Level
				– Awareness of forces at work which encourages the production of some health damaging products and discouragements of production of other beneficial products	
	– RNA – structure – role in protein synthesis – Control of gene expression – Operon concepts – Genetic recombination – transformation – transduction and conjugation – recombinant DNA – genetic engineering	– Use of models of DNA, RNA, protein synthesis	– Discussion of models for synthesis of proteins – Audio-visual – Discussion of concepts	– Appreciation of the Operon concept – Building of mental models to explain facts – Awareness of the great potential for both desirable and undesirable effects of genetic engineering	

Chapter Four

HEALTH, NUTRITION AND AGRICULTURAL ASPECTS OF BIOLOGY EDUCATION

The Asian countries share a number of problems in the broad area of health, nutrition and agriculture. Ignorance about the principles of healthful living, proper nutrition and the scientific basis of modern farming for a vast majority of the uneducated rural population is a major drag for the developmental activities in nearly every country of the region.

Malnutrition, undernutrition, improper food habits, and superstitions in the area of food and health are prevalent in all countries in one form or the other. In view of this it is not surprising that education in health and nutrition as an integral part of biology curriculum has been given its rightful place in most of these countries.

Agriculture is another very important applied area of biology. Nearly all the countries of Asia have a predominantly agrarian economy. Scientific agriculture presently holds the key to development of these countries and will continue to do so for many decades to come. In the scheme of general education the place of agricultural principles, processes and technologies cannot be underestimated. This is true for rural poor or the urban elite alike. Nearly all countries of Asia have accepted this proposition and have either included - or are in the process of including - these concerns in their secondary stage courses.

It can be seen (Appendix C) that many countries in their reports have made an explicit reference to such areas as balanced diet, nutritional requirements, deficiency diseases, communicable and non-communicable diseases, crops - their diseases and pests, human biology, poultry, fishery, animal husbandry, irrigation and soil conservation. Many of these are recent inclusions in biology curricula. This reflects a definite, conscious effort to bring the elements of greater social relevance into the biology curriculum. It may, however be borne in mind that besides these areas giving explicit coverage, nearly all the areas of traditional and modern biology contain principles which find applications in health, nutrition and agriculture. These range from morphology and taxonomy to molecular genetics, bio-chemistry and bio-physics. An attempt to identify all such principles would have resulted in an account too elaborate and inclusive of all biology. For the present work the areas of nutrition, health and agriculture as contained in various biology curricula with explicit reference have been covered. The tables in the following pages have been developed on the basis of a synthesis of country experiences. The general considerations given in the preambles of the two other aspects, namely, environmental and genetic, also apply to the presentation that follows:

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Level Lower	Level Higher
					✓	✓
I. Health and nutrition						
a) Basic life processes	The basic life processes that determine to a large extent the nutrition and health condition of an individual:				✓	✓
	1. Digestion and assimilation	– Simple tests for food materials	Lecturette (follow-up)	– Appreciating the action of enzymes on digestion		
		– Trace pathway of food and changes it undergoes in human body	Discussion Visual aids (models, charts, illustrations)	– Awareness of the presence of several substances in foodstuffs		
	2. Respiration and energy metabolism	– Trace pathway for gas exchange; simulate action of diaphragm; test for gas exhaled; test for effect of CO_2 and O_2 on blood characteristics (physical); factors affecting rate of breathing (ex. strenuous activities)	Visual aids (charts/ models) Simulation Model construction Discussion Lecturette	– Appreciation of importance of 'clean' air	✓	✓
	3. Transport of materials	– Determine factors affecting pulse rate – Observe blood flow in tadpoles and other biological specimens (lower forms) – Dissection of mice, frogs – Survey incidence of heart ailments – Effect of smoking	– Use of student's own body for practical work – Discussion – Visual aids – Surveys – Medical resource person	– Awareness of a healthy heart condition – Appreciation of blood banks and donors	✓	✓
	4. Excretion: – importance of removing waste products from living things	– Use of model or diagram of human excretory system if available	– Class discussion – Audio-visuals – Motivation by use of examples i.e.			

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching/Learning strategies	Developing values/ Intellectual skills	Levels Lower	Levels Higher
	– In higher organisms wastes are removed through specialized structures	– Microscopic examination of contractile, vacuole of amoeba, flatworms, paramecium or other lower forms of organisms	– effect of strenuous activities on excretion of waste – one with fever feels warm – perspiration is salty – drinking water after profuse sweating	– Awareness of why kidneys should be kept healthy – Appreciation of what science and technology can do to repair destroyed body organs	✓	✓
	5. Reproduction (pregnancy) – a well-nourished mother during pregnancy is more likely to have a normal pregnancy and a healthy baby than one whose diet is poor	– Cite examples or collect data of healthy parents and healthy offspring – Identification of food requirements of nursing mothers and newborn infants	– Discussion of statistics – Survey – Discussion; use of food charts	– Awareness of proper nutrition on mother and growth of fetus – Awareness of proper nutrition on growth of infants	✓	✓
	Malthusian theory	– Maintain a population of mice (etc.) and determine the amount of food consumed, and consequently, survival and reproductive capacity of the population	– Discussion on data gathered – Decision-making	– Realization that higher population demands more food (implications on family planning)		✓
	6. Adaptation – short-term and long-term adaptive mechanisms	– Field trips – Case studies (ex. temperature and atmospheric gas, absence of enzymes to digest milk on some people)	– Lecture – Discussion	– Awareness of man as an integral part of the environment – Appreciating biological adaptation	✓	✓
b) Micro-organisms and diseases	Many diseases are caused by micro-organisms Natural immunity system of the body (anti-bodies) Artificial immunity vaccines and other preventive measures	– Visits to health centres/hospitals for diseases and causative organisms – Culturing and studying harmless microbes – Test antibacterial properties of local medicinal plants	– Charts for life cycles of micro-organisms – Discussion (discoveries like pasteurization, small pox, vaccines, antibiotics) – Demonstration – Medical resource person	– Awareness of role of micro-organisms – Appreciation of the discoveries of scientists – Realization of the potentials of herbal medicines for diseases control/prevention	✓	✓

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values/ Intellectual skills	Levels Lower	Levels Higher
	– Food production and preservation – Some micro-organisms cause food spoilage – Industrial micro-biology	– Simple methods of food preservation – Plan realistic preventive/ control methods for spread of diseases using local situations (ex. malaria, dengue fever)	– Small-group discussion (for action plans) 'What would you do if . . .' – Decision-making	– Improving attitudes on environmental sanitation		
c) Nutritional requirements	– Nutrition refers to food eaten and how the body uses it – Malnutrition (over and under-nutrition) results from improper intake of the recommended food groups – Food, its value and functions in the body – Criteria for a healthy individual – Balance diet	– Relate possible malnutrition to incidence of diseases – Evaluate food intake according to nutritional values – Plan and prepare a balance and economical menu – Interpret graphs on nutritional requirements based on age, sex, activities, height and weight	– Analysing case studies (Asian region) – Discussion – Resource person (medical, nutritionist) – Demonstration by students – Using a model – Individual instruction – Charts	– Recognize value of nutrition – Reorientation of attitudes on proper nutrition – Awareness and patronizing of local foodstuffs which are economical and nutritive	✓	✓
d) Food and food habits	– Variability on food preferences of different peoples (due to religion, customs, upbringing); effect of commercial factors including food additives and adulteration	– Collect data and basis of food preferences of different regions (or on house to house basis whenever applicable) – Prepare palatable and nutritious diet	– Surveys, interviews – Project work – Discussion – Demonstration – Decision-making – Charts on food groups	– Respect for individuality for food preferences – Reorientation of faulty food and eating habits	✓	✓
e) Water and life	– Water and its importance to life	– Cite criteria for 'good' drinking water and for hygienic purposes – Survey of drinking water resources in the community	– Discussion – Assessment of village resources – Field trips – Use local statistics – Resource person – Reporting	– Awareness of the multi-faceted uses of water to daily life – Improving the quality of community water resources	✓	✓

Health, Nutrition and Agricultural Aspects of Biology Education (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
		– Collect and examine water samples – Simple methods of purifying water – Collect information on water-borne diseases – Suggest ways of preventing spread of water-borne diseases	– Writing up results of surveys – Group project work – Small group discussions – Decision-making (action plan) – Analysis of state laws/ rules on water quality management			
f. Accumulation of pollutants	– Pollutants in the environment directly or indirectly impinge on the health of an individual, family, community and nation, as well as the economy – Fecal pollution	– Survey concepts/ideas on pollution – School-level monitoring of pollution – Analyse data on pollution index board – Compare health statistics between rural and industrial areas – Test for presence of pollutants in the environment – Survey of biological indicators of pollution in the local setting (ex. lichens)	– Interviews, questionnaires – Decision-making on house planning (citing) – Field trips/field work – Project – Group work	– Awareness of the presence of pollutants in the environment and its possible effects on health and economy – Realization of the quality of the environment based on pollution load	✓	✓
II. Agriculture						
a) Factors affecting crop production	– Biotic factors and interaction – Concepts of limiting factors – Concepts of tolerance – Carrying capacity	– Case studies – Field work – Designing remedial experiments – Identification of visual symptoms of limiting factors	– Project work – Games – Lecture – Discussion	– Awareness of conservation of soil and water resources – Appreciating the need for proper management of soil and water resources – Awareness of production limits of ecosystems	✓	✓

Health, Nutrition and Agricultural Aspects of Biology Education (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower	Levels Higher
b) Varietal improvement c) Use of non-conventional food sources	– Breeding – Asexual reproduction – Mutation – Genetic conservation – Introduction of new species	– Field trip – Performing asexual propagation methods – Setting up school nurseries – Actual breeding experiment in plants and animals	– Lecture – Discussion – Audio-visual aids – Case studies	– Skills in analysis of pedigree – Skills in breeding asexual propagation of plants – Awareness of new role of heredity in development of organisms – Awareness of negative and positive effects of breeding	✓ ✓	✓ ✓
d) Pest and diseases control	– Biotic relationship – predator prey – host specificity – competition – allelochemics – Development of resistance to biocides (pesticides, weedicides, herbicides)	– Field work – Case study – Experiments – Familiarity with biocides (pesticides, weedicides, herbicides) and their uses – Collection – Preservation of specimens	– Decision-making – Games – Lecture – Discussion – Audio-visual – Use of biological specimens – Use of resource persons including farmers	– Awareness of important biotic relationship – Develop attitude for conservation and maintenance and proper biotic relationship – Skill for developing proper agricultural practices for pest and disease control and management (intercropping, multiple cropping, biological control)	✓	✓
e) Pollution (including biocides and agricultural waste management)	– Food chain relationship – Hydrologic cycle – Material cycling	– Case studies – Monitoring studies using ecological indicators – Field collection/preservation – Identification of ecological indicators – Collection and separation of biodegradable/non-biodegradable farm waste materials		– Develop proper attitudes towards the use of pesticides, weedicides and fertilizers – Appreciate value of farm waste as a source of energy and fertilizer – Develop proper methods of agriculture waste disposal	✓	✓
f) Integrated farming systems for efficient resource utilization and management	– Energy flow and material cycling – Ecological efficiencies – Homeostasis and steady state	– Case studies – Field work – School projects on recycling	– Audio-visual i.e., charts, slides – Lecture – Discussion	– Appreciate the value of diversified production system		✓

Health, Nutrition and Agricultural Aspects of Biology Education (cont'd)

Area of concern	Concepts / Principles / Topics	Practical experiences for students	Teaching / Learning strategies	Developing values / Intellectual skills	Levels Lower Higher
		– Practical experiences in the farm	– Need resource assessment	– Appreciate the value of farm waste as alternative source of energy and fertilizer – Develop proper management strategies for integrated farming	

Chapter Five

BIOLOGY TEACHER COMPETENCIES

During the last decade all the participating countries have made a number of curricular innovations in their biology education programmes. Central to these efforts is the demand for more socially relevant curricula, for orienting education to the goals of national development. Another equally important concern is to present the most up-to-date concepts, techniques and applications. These new curricula also exhort teachers "to teach not about science, but to teach science itself" which in turn, has resulted in the inclusion of a number of activities and experiments in the new curriculum materials so as to involve students in doing something, rather than reading and listening only.

To be meaningful, biology has to be taught as 'inquiry', as a 'problem-oriented activity' (problem solving - problem finding). This would demand the acquiring of new skills on the part of a biology teacher. These skills cannot be learned apart from the biology concepts with which they will be used. Hence a sound understanding of the concepts and clusters of skills should enable the teacher to be competent in 'doing' science.

The Workshop had the benefit of examining the inventory of basic science teaching competencies for secondary school teachers prepared by the Science Education Centre, University of the Philippines (from which extracts relating to the biology teacher are given in Appendix D) and, assuming that the development of these basic competencies will be included in biology teacher training programmes, has recommended in the following pages additional competencies related to the three main areas of concern for the Workshop.

Another assumption made by the Workshop is that the biology teacher would have the basic knowledge of the various concepts, principles and topics suggested under the three areas of concern for possible inclusion in the secondary school biology courses.

Concepts / Principles / Topics	Practical experiences	Teaching strategies	Values / Skills
Has sufficient knowledge and understanding of the following: 1. Environmental factors 2. Levels of organization 3. Ecosystem 4. Energy flow and material cycles 5. Harmony and balance in ecosystem 6. Environmental problems and management 7. Healthy environment	Is capable of conducting: 1. Field-study on – diversity in natural conditions – density and population of plants and animals (man included) – local ecosystems – local polluted areas – natural conservation 2. Case study on – interaction – pollution 3. Experiment to – measure the composition of air – analyse physical and chemical components of soil – study the effects of light and temperature on organisms – study the increase in population of certain organisms – study production rate – test for air pollutants – measure BOD and COD levels – test the turbidity of polluted water	Has the ability to: – identify and utilize environmental resources to the maximum so that teaching becomes more meaningful and relevant – improvise (whenever possible) the enhancement of the learning situation – utilize innovative evaluation tests, both for student evaluation and teaching effectiveness – use process skills and educational technology - audio-visual aids – plan and execute field study, case study and experiments effectively – relate the principles to values and intellectual skills and highlight social relevance to each topic – use short lectures, demonstrations and group discussions at appropriate places in the scheme of instruction – organize project work, games and simulation studies – organize self-study and individualized instruction	Has the awareness of the: – necessity of population control – solar energy and its abundance – balance and harmony in ecosystem – environmental legislations – hazards of nuclear energy Development of: – dexterity in outdoor experimental skills – correct attitude towards harnessing biomass – global perspective of environment – reasoning power and establishing causality – ability to draw inferences from facts – environmental ethics – proper attitudes towards the use of energy resources Realization of the: – implication to social interrelations – potentialities of man vis-a-vis the environment – interactions of the biotic, abiotic and socio-cultural factors – implications of the levels of organization to population growth and consequences as well as social interrelations

Environmental Aspects of Biology Education (cont'd)

Concepts / Principles / Topics	Practical experiences	Teaching strategies	Values / Skills
	– compare the amount of soil organisms in polluted and un-polluted areas – study the roles of plants in preventing soil erosion Construction of – models showing different types of ecosystem – an artificial ecosystem – models showing food chain, food web Depiction and interpretation of data/ information through graphs, tables, diagrams, illustrations, charts		– significance of local ecosystems for the society – significance of recycling and its application in daily life – roles of the students in minimizing pollution – need for conservation – need for every development project to give appropriate consideration to its environmental implications Appreciation of – aesthetic values – conservation laws

Genetics

Concepts / Principles / Topics	Practical experiences	Teaching strategies	Values / Skills
Has sufficient knowledge of the following: 1. Variations 2. Methods of studying genetics and their application 3. Cytogenetics (cell theory – cell and viral structure; role of nucleus in genetics; chromosome theory of inheritance; chromosomal aberration) 4. Patterns of inheritance (laws of probability, mendelian inheritance) 5. Population genetics (definitions; Hardy-Weinberg law; changes in gene frequency; genetics and society) 6. Molecular genetics (protein as phenotype determinants; DNA as genetic material)	Has been exposed to: – current methods of studying genetics – plant experimental breeding – pedigree analysis – statistical analysis – karyotyping – microbial and molecular genetics – computer science and population genetics Is capable of: – identifying the right type of locally available material for chromosomal studies – preparing slides to show chromosomes – preparing models from different materials – preparing tissue culture – arranging breeding experiments – conducting surveys and study trips to collect relevant data – dealing with probability problems – conducting relevant surveys – developing short case studies – calculating gene frequency from raw data – collecting and utilizing local research papers with data on blood groups – conducting Feulgen-reaction as specific for DNA – electrophoresis experiments – using paper and column chromatography – conducting experiments on mutagenesis	Has the ability to: – apply the scientific process – use appropriate educational technology – conduct and guide experimentation – arrange demonstrations – organize simulation activities (games, role-play, etc.) – apply skills in group dynamics and group methods of teaching – collect, organize and interpret data – use of simple algebra – organize role-play (genetics-society) on current problems bearing on genetics and society – use models – set up experiments and analyse experimental data	– Appreciation of the methodologies of genetic research and its role in development – Acceptance of the fact that some characteristics can be changed while others cannot be changed – Appreciation for quantitative data – Developing intellectual skills of inferring, interpreting, making mental mod – Appreciation of the unity as well as the diversity of life – Patience in looking for chromosomes – Appreciation of the discovery of natural laws as well as of their limitations – Use of critical thinking in relation to population problems which often arouse emotions and intolerance including race, drugs, commercial advertisements, etc. – Valuing the occurrences of differences between population groups; recognizing the average differences between two groups may be very small in comparison to individual differences within a group – Probing into the molecular level of organization vastly expands human understanding of genetic process

Teaching competencies applicable to health, nutrition and agriculture

Concepts/Principles/Topics	Practical experiences	Teaching strategies	Values / Skills
Has sufficient knowledge and understanding of the following: I. Health and nutrition 1. Basic life processes 2. Micro-organisms and diseases 3. Nutritional requirements 4. Food and food habits 5. Water and life 6. Accumulation of pollutants	Is capable of designing and conducting experiments on: – simple chemical tests for food materials – effect of CO_2 and O_2 on physical characteristic of blood – factors affecting rate of breathing and pulse rate – arthropod dissection – the study of the circulatory system – natural population study – culture of micro-organisms – simple methods of food preservation – water purification (simple methods) Collecting, preserving, identifying – important food resources – food requirements – medicinal plants – micro-organisms – ecological indicators and pollutants – planning and conducting field trips – basic life processes – conducting surveys – conducting population studies – identifying food groups and requirements of different age groups	Has the ability to: – prepare interview and survey instruments – process and analyse survey data – interpret and apply data – isolate and culture micro-organisms – plan and conduct field trips – design and conduct games and simulation exercises – use and prepare visual aids, i.e., models charts – design and evaluate projects – identify sources of available resource persons and information	Awareness of: – presence of several substances in foodstuffs – proper nutrition on mother and growth of fetus – proper nutrition on growth of infants – role of micro-organisms – patronizing of local foodstuffs which are economical and nutritive – use of water in daily life – importance of a healthy heart condition – the presence of pollutants in the environment and its possible effects on health and economy Appreciation of: – blood banks and donors – clean air – discoveries of scientists – the role of science and technology in repairing body organs – role of transport system for distribution of food nutrients and gas exchange – action of enzymes on digestion – role of the excretory system in maintaining balance in the body – intricacies of the respiratory process Realization of: – that higher population demands more food (implication on family planning)

Teaching competencies applicable to health, nutrition and agriculture (cont'd)

Concepts / Principles / Topics	Practical experiences	Teaching strategies	Values / Skills
			– potential of herbal medicine for disease control and prevention – quality of environment based on pollution load – importance of improving community water resources (if found faulty) for drinking and hygiene Improving attitudes on : – environmental sanitation; the values of breeding, asexual reproduction, mutation, genetic conservation and – use of new species in improving crop production Recognizing the value of: – nutrition – the importance of pest control and disease management Reorientation of attitudes on: – proper nutrition – faulty feeding habits
II. Agriculture 1. Factors affecting crop production 2. Varietal improvement and use of non-conventional food sources	– From a set of factors, identifying which affect crop production such as: – biotic factors – limiting factors – tolerance of an individual – carrying capacity – Suggesting ways to improve crop varieties, capable of performing asexual propagation in plants to increase yield	– identify visual systems of limiting factors – recognize tolerance and carrying capacity – design experiments to remedy crop diseases – conduct surveys and field work on non-conventional food sources – set up school nurseries – demonstrate asexual reproduction such as budding, cutting, grafting, marcotting, inarching	Awareness of factors affecting crop production Awareness of importance of soil conservation Appreciation of the need for proper soil and water management Awareness of production limits of ecosystems Awareness of the presence of non-conventional food sources

Teaching competencies applicable to health, nutrition and agriculture (cont'd)

Concepts / Principles / Topics	Practical experiences	Teaching strategies	Values / Skills
3. Pest and diseases control	– Know common pest problems – Identify biotic relationships in diseased crops – Knowledge of biocides and proper care	– conduct field work – discriminate use of biocides – test plants for allechemic properties	– Awareness of biotic interactions which bring population dynamics in disease-curing organisms/pests
4. Pollution and agriculture waste management	– Know agricultural pollution – Plan workable solutions to solve pollution – Capable of introducing biological content in agricultural farms	– prepare solutions to fix and preserve collected specimens – monitoring field studies – set up experiments to monitor pollution studies	– Awareness of pollution in agricultural farms – Realization of values of tree nurseries – Realization of importance of proper waste disposal
5. Integrated farming systems for efficient resource utilization	– Make action plans to remedy pollution – Explain homeostasis in integrated farming system	– classifying degradable from non-degradable farm wastes – survey and supervise school projects on recycling – perform work in the field	– Appreciation of the value of the farm in the village economy – Appreciation of values of diversified production systems – Appreciation of the value of farm work as a source of energy and fertilizer

Chapter Six

SUGGESTIONS FOR REGIONAL CO-OPERATIVE ACTION AND NATIONAL FOLLOW-UP ACTIVITIES

To Member States

1. As teacher-training programmes have not kept pace with curriculum development efforts, Member States should undertake a study of teacher training with reference to current school biology curricula, with a view to making improvements for relevance to life today (including relevance to national development goals) and for competency-based training.
2. Evolve mechanisms (for example, meetings, journals, newsletters) to promote investigational work (project work, research work) by students and teachers in secondary schools.
3. Organize training workshops for development of teaching/learning materials based on exemplars that may be co-operatively developed by the participating Member States.
4. Study the ways of evaluating the cognitive, psychomotor, and affective domain aspects of the three concerns of the workshop and develop tools for improving learning and teaching strategies.
5. Assure the linking of biology education with environmental education and all environmental concerns.

To Unesco

1. Undertake the preparation of a school biology curriculum guidebook for the Asian region with special attention paid to documentation of the guide with actual examples of good classroom, laboratory and field practices in the teaching/learning of biology in Asian schools, including an annotated bibliography.
2. Organize a workshop for training in more difficult techniques of practical work, including field work, which could be widely applicable in school biology teaching/learning in the region.
3. As a follow-up to the present workshop, organize a workshop for the development of learning materials, modules, units, and the like at national level with reference to identified concepts.
4. Organize a Sub-regional Workshop to review the outcome of the above national workshops and develop exemplar instructional materials based on the experiences of the national workshops.
5. Unesco should establish a study group to study the ways in which human values can be introduced as an important and pervasive part of school biology teaching/learning in the region, with special attention paid to values which promote national peace and internationalism (including the biological aspects of race, language, and human behaviour).
6. Undertake studies of the ways in which school biology education can be linked with social activities, including community development, industry and work experience.
7. In all of its work in biology education, Unesco should seek ways to bring to demonstrate to learners the essential function of biology in protecting the earth's environment.

Appendix A

STRATEGIES AND METHODS FOR TEACHING/LEARNING BIOLOGY FOR GENERAL EDUCATION

Part I - INTRODUCTION

Rationale for a diversity of teaching/learning strategies

In a recent conference held in U.K. the point was made that elitism in education has resulted in isolating pure science from society and its citizens, so much so that to the man in mass media the term chemical is associated with the dangerous, harmful, noxious or distasteful. When a choice of local or imported technology and equipment is to be made the local is equated as inferior. This view was expressed in the context of European countries but it could well apply to this country, and other Asian countries especially in the area of teaching and research. It is these adverse attitudes that elitism brings about which urgently calls for making science - or at least portions of it - understandable, practical and relevant for the masses of the people.

In a study on the effect of culture on learning, Ramirez and Castaneda (1974) have identified characteristics of field-independent behaviours and field-sensitive behaviours, and correspondingly have described field-independent and field-sensitive teaching styles. Certain field-independent behaviours tend to promote success in the classroom (individual competition, independence when working on tasks, use of discovery approach in learning and ability to deal with science and mathematics abstractions). Field-sensitive behaviours which promote success are co-operation, sensitivity to peer feeling, sensitivity to a wide variety of cues, and learning by modelling and imitation. Ramirez and Castaneda recommend teaching children towards bicognitive development so that they can function within both field-sensitive and field-independent cognitive styles. Although these studies and recommendations were made in the context of American society and addressed to the assimilation problems of Mexican Americans, they have implications for educators who are faced with a variety of cultural communities who are to be educated in one educational system. Furthermore, field-independent teaching styles lend themselves very significantly to science and mathematics teaching.

This paper was prepared by Dolores F. Hernandez, director, University of the Philippines Science Education Center, for the Regional Workshop to Review Biology Education in Asia, sponsored by ACEID/Unesco and University of the Philippines, 18-23 August 1980.

A study of the in-school, off-school (ISOS) approach revealed that this programme exposes the student to opportunities for learning various skills, concepts and values by providing academic, physical, social, pre-vocational and out of school experiences. (Hernandez and Gavino, 1979). However, it was also noted that although the programme offers rich possibilities for self-directed learning the achievement of this objective leaves much to be desired. It was further revealed that the student participants involved in this case study exhibit field-sensitive behaviours.

In the area of cognitive development, educators and teachers have become familiar with Piagetian studies and are aware of the various stages of cognitive development and the implications of these for teaching, learning and the curriculum. Local studies on cognition are being conducted here and in other Southeast Asian countries, many of them based on Piagetian tasks. See for example Acuna and Villavicencio (1980) and A. Sia (1980). There is now a more pronounced awareness that the students in our classrooms may not be on the cognitive level required by the learning materials we provide. Hence, along with studies on cognition, there have been some attempts made to match the cognitive expectations and requirements of the curriculum with the actual cognitive stage of the students. This becomes an important new aspect of evaluation in the 1980s. See for example Shayer (1979).

The current national and political demands for more socially relevant curricula, for orienting education to the goals of national development, for inclusion in the curriculum of work experience and other government thrusts, for a return to the basics and to the teaching of values toward the unification of the country as a nation are pronouncements which have remained unresolved. These are issues and developments which are shared among developing countries.

Finally, the statistics on school population reveal a disappointing picture of the holding power of our schools. In spite of the high rate of participation in schooling especially at the primary level of education (in the Philippines it is over 95 per cent), the survival rates reveal a different story. Only 66.40 per cent of our pupils complete grade VI of the first level of education and only 33.84 per cent complete grade IV of the secondary level. Similar conditions prevail in most developing countries.

All these developments point to the need to re-examine what is going on in our classrooms (and out of them) to help teachers and administrators determine what measures for improvement can be undertaken. It is not within the scope of this meeting nor this paper to consider various pertinent factors that affect learning in and out of the classroom. The major issue addressed here is that of teaching/learning strategies.

The conditions described in the preceding paragraphs make imperative the need for using varied teaching methods suitable to various groups of students, to the new experiences

being introduced and to the achievement of certain currently emphasized objectives.

The State of the Art in the Philippines*

To determine the state of the art in the Philippines and to provide some information about what biology teachers in the field do in relation to their strategies and methods, and what they think about some of the areas of concern which are to be discussed in this meeting, a questionnaire was fielded to some key training institutions in geographical areas - Luzon, Visayas and Mindanao. The questionnaire drew information on techniques more frequently used by most secondary and college teachers, models and teaching aids most frequently and least frequently used and the teachers' reactions to topics, such as nutrition, human ecology and environment, molecular biology and genetics.

Respondents

There were 102 biology teachers who responded, 28 per cent are college teachers teaching general introductory biology and 72 per cent are secondary biology teachers. The basic degree for the majority (75 per cent) of the secondary teacher is B.S.E, with majors in biology (69 per cent) and other science areas (26 per cent). The college teachers have B.S. degrees with majors in biology (60 per cent), zoology (17 per cent), and botany (24 per cent). Most of the teachers of both levels do not have their minor areas of specialization in biology or in any science area. These teachers teach adolescence with age ranging from 14-18 years old. In the Philippine context, this group includes those taking biology courses in high school at grade VIII level and first or second year college students who take a science course to fulfil a science requirement in the general education programme. Many students select biology to meet this requirement.

Responses

As to the state of the art regarding the use of strategies and methods for teaching biology, the following are significant information:

A. On the use of strategies/methods

A majority of the secondary teachers frequently use the textbook and blackboard method, the least frequently used are recordings and games. Other strategies and/or methods used include laboratory work, classroom recitation, small group discussion, lecture, discussion entire class, charts, living organisms. In college, the most frequently used is lecture and blackboard. The least frequently used: discussion small group and community resources. Other techniques ranked in decreasing order of use are: books, discussion entire class, charts, living organisms and laboratory.

* Acknowledgement is made with thanks to the biology team of UPSEC for help in preparing the questionnaire: R. Villavicencio, L. Gregorio and N. Villanueva and to research assistant, M. Dimayuga, for collating the data.

B. On models and teaching aids

Secondary teachers most frequently use in the classroom laboratory as teaching aids the following: shells and other preserved collections and growing plants. The least commonly used is live animals. Others include models, pictures, bottled specimen, terrarium and aquarium. In school yard premises, most frequently used are potted plants; least commonly used are ponds. College teachers most frequently use bottled specimens, models and bottled specimens in the laboratory. In school premises they maintain potted plants.

C. On topics related to rural communities

Surprisingly, more college teachers (86 per cent) are of the opinion that topics related to rural communities be included in biology teaching but only 62 per cent claim to be doing something about it. Actually, it is the secondary teacher who is more involved in community-school projects particularly in rural areas. Most of the topics teachers would include relate to food and agriculture.

D. On health and nutrition

Both groups agree that health and nutrition should be included in biology teaching, and a high percentage in both groups claim they are incorporating in their teaching some topics in this area of concern. But when asked to give the topics they include, few topics were given by the college teachers; the secondary teachers gave a more diversified list. The topics most mentioned are: hygiene and sanitation, disease prevention and medicinal plants.

E. On human ecology and environment

The secondary school teachers and college teachers were almost unanimous in their opinion that human ecology and the environment should be included in their courses. The percentage of teachers who indicated they were actually incorporating these topics was quite high (95 per cent of the total group). Population control stands out as the topic most mentioned by both groups.

F. On molecular biology

Ninety-two per cent (92 per cent) of high school teachers and 93 per cent of college teachers agreed that molecular biology should be included in biology courses. However, considerably less of them are doing it. Only 56 per cent of high school teachers claim to include molecular biology topics in their teaching and 79 per cent of college teachers do it. This discrepancy between beliefs and reality may indicate the need for appropriate materials which could be used at this level and for this target group.

G. On genetics

Eighty-five per cent of the secondary teachers and 93 per cent of college teachers think that genetics topics should

be included in biology courses at this level (14-17 year olds). However, only 74 per cent and 86 per cent of secondary and college teachers respectively, are incorporating such topics in their courses. For the secondary teachers the topic incorporated is mainly Mendelian patterns of inheritance; more teachers in the college group include topics like: hereditary disease, genetic engineering, patterns of inheritance.

To teach the topics under areas mentioned in Sections C to G above, about nine techniques were frequently mentioned in association with them. These are: (1) lecture; (2) laboratory, and (3) class discussion as the most commonly mentioned, followed by (4) field trips and (5) charts, and then (6) student panel/reports, (7) buzz session and (8) use of resource persons. Note that books, blackboard, living organisms are not mentioned although these were among the first ten techniques ranked by the teachers when they were asked to respond to a given list. For the information contained in Sections C to G, the teachers were asked open-ended questions; no lists of topics or techniques were prepared. Under this condition, it is possible that teachers do not normally consider the textbook or blackboard as a teaching technique; that they consider them as common teaching aids which are taken for granted, hence they were not mentioned in an open-ended situation. The same questionnaire however contained the checklist of techniques, in the first part of the instrument to which they have earlier responded. What this little study reveals is that teachers tend to use over and over again the same teaching techniques or methods. These are underlying reasons for this behaviour; it is possible that the teachers are not aware of other methods which they can use, or being aware are hampered by constraints in their environment, not comfortable with other methods, having just heard or read about them and never having tried using them. There is also the possibility that many prefer to take the easy way out.

It seems suitable then that as a first step, an awareness of a variety of methods be made available to teachers in in-service programmes, that they be given practical experiences on these methods and that they be helped in the utilization of these methods in a manner that will facilitate them to achieve specific objectives beyond the acquisition of knowledge. Towards this end, a description of strategies and methods has been prepared and is in fact the core of this paper. Another list which is relevant to the theme of this conference is one prepared by Rex Meyer (1980) for Unesco. He worked out a scheme which rates the effectiveness of each method in achieving specific aims and established an effectiveness index for each of the methods on his list. Admittedly, the list is subjective; nevertheless, it is an excellent paper and a novel contribution to this little studied subject area.

A caveat should be made at this point; the list presented in Part II does not cover all the possibilities. The specific techniques like laboratory techniques and other needed professional competencies of science or biology teachers have not been included. For such specific skills one could refer

to a competency list (see for example UPSEC inventory of science teaching competences). Also, the analytical papers presented by the participants are expected to amplify this list.

Furthermore, this paper deals with only one side of the coin, the other face of which is content. Ideally, strategies should be discussed within the context of content. But since both topics are now so vast, it was decided to limit this paper to strategies mainly, using as examples topics from biology appropriate to the themes of this meeting. Another paper (Dr. V. Basnayake) as well as the participants' papers, will present the content of biology relevant to our three areas of concern: environmental aspects, molecular and genetic aspects and their applications to health, nutrition and agriculture.

Part II - STRATEGIES AND METHODS

This part deals with descriptions of various methods which are useful for teaching biology for general education purposes. No attempt is made to include all known strategies and methods. Neither is it intended to describe all the methods mentioned in this paper. Rather, the focus is on those methods we hear about but have not used, or have used minimally. Thus, the categories may seem rather unconventional. It will be noted that some methods are not included or are merely mentioned briefly such as those related to the processes of science, problem solving skills, and practical skills. This does not mean that they are not useful or not relevant to the theme of this paper but they are richly covered in the literature, and most science educators and teachers are quite familiar with them. The focus of this paper is really on the nonconventional strategies and methods in science teaching.

Actually all methods of teaching may be classed into either group methods or individualized methods. Learning however, is very much an individual matter. This is a principle on which few will disagree. The teaching methods, have been grouped here arbitrarily. There can be a great deal of overlap. The categories used for grouping these methods are arbitrary and not mutually exclusive; the categories themselves may overlap; as one teaches for learning in a social context and social relevance, it certainly is possible to attend to social values and use group methods in the process. In brief, these categories have been used for certain purposes: to focus on some current aims of science teaching that are as yet not widely implemented, and for easy reference. For example, one who has not included values, social relevance in teaching can raise questions like: "How do I go about teaching values? social relevance?" or, "What other group methods can I use?"

In this paper the term categories may be referred to as strategies, and the various ways of executing the strategies, may be referred to as methods.

Using Group Methods

This category includes conventional classroom teaching methods known as recitation or question answer cum discussions in which the entire class participates, and other methods which involve teaching either large or small groups. One reason for placing all these together is that in large classes one can easily divide the large group into smaller groups for better interaction, or to enable the teacher to provide more attention to one group that needs it while other groups are learning on their own or pursuing other topics or activities, and so on. We have observed secondary school teachers who are skilled in shifting from large group to small group and back again to large group teaching within a single class period. Groups in a class should be kept flexible so that no one student finds himself with the same team members every time the group method is used. This allows for broadening of experiences and more heterogenous interactions among the students.

Group methods include: laboratory work, student demonstrations, field experiences, panel discussions, buzz or brainstorming sessions, discussion group, tutorial groups, peer tutoring, and lectures. The less commonly used methods will be briefly described.

'Buzz' sessions

This method can be effectively utilized when a controversial issue, a question or problem of current concern arises, or when a question excites students to contribute their opinion, experiences, or knowledge that can be related to the topic under study. The class breaks up into groups of 3-5 students to discuss the question on hand. The 'buzz' session may take only 3 to 5 minutes. No disruption in the class seating arrangement is necessary. Two students in front merely turn back and discuss with the two seated immediately back of them. After a few minutes each buzz group reports back to the class (in large group session now) and the teacher collects their suggestions, answers and queries by writing these on the board. The acceptable answers are then checked. Such brief breaks during a large group's entire class discussion, lecture, or question and answer period can be refreshing and involve more students in interaction. A graphic or visual aid can be used to start the discussion. For example, data from an experiment that is open to various possible explanations is presented and students are asked to offer several interpretations. Some questions that lend themselves to this method are: Would you endorse scientists' adding or removing genes to change human characteristics when and if this ability becomes possible? Should we use live animals for experimenting in our lab work?

Discussions

Discussion sessions may be either in larger or small groups, led by the teacher or by students. Research studies

seem to support the idea that the more highly one values outcomes beyond acquisition of knowledge the more likely one would prefer student centred methods. At the secondary level, in Philippine schools, student led discussions in science are not commonly observed though they are more frequently used in other subjects such as social studies. In classes using off-school-in-school approach this method is used quite often even in science classes where it is mainly used for reporting on some small group or individual experiment or experience which is often followed by a brief question-and-answer or discussion session.

Tutorial groups/peer tutoring

Often the secondary school teacher resorts to using small tutorial groups for remedial teaching, meeting the group after class or giving a group special attention while the rest of the class is given other work. Advanced students are sometimes asked to help weaker students on a one to one basis or in small groups. Some authorities recommend that students take turns tutoring; all students should at times be tutors at other times, tutees. The usual case is to have students within a classroom tutor each other, but it is also possible to have students of a higher grade level tutor those in a lower grade level. In either case, it is important to establish a positive set for peer tutoring, work out procedural details carefully and organize the programme creatively. If it degenerates into routine procedures for tutoring say only on skills learned through drills, students consequently lose interest. It is important to provide for variety.

Lecture

Although the lecture method has been much maligned lectures do serve useful purposes if properly used. At the secondary level lectures should be brief - 10 or 15 minutes - interspersed with other activities. The question really is "when should the lecture method be used?" Some guidelines are: (a) when the needed information is not readily available to the students; (b) when the unique experiences of a teacher, resource person enables him to give a lecture that clarifies certain issues; and (c) when time is important and the needed data are widely scattered.

Individualizing Instruction

These methods are also referred to as mastery, contract or individualized methods. In large classes (say 50 or more students to a class) individualized instruction has been utilized in a modified form. At the secondary level in this country because of overcrowded classrooms, minimally provided with facilities, teachers have used individualized methods for small groups rather than for individuals. Within the 'individualized study' method distinctions are made by some educators between individualized personalized systems on the basis that the former is automated and the latter humanized. For

most developing countries this distinction is academic since the great majority of schools cannot supply the necessary hardware for automated instruction.

According to Kahle (1979) an instructional system is individualized when:

1. The characteristics of each student play a major role in the selection of objectives, sequence of study, choice of materials and procedures.
2. The time spent by each student in a given subject area is determined by his performance rather than by the clock.
3. The progress of each student is measured by comparing his performance with his specific objectives.

Among the individualized learning systems are the following: audio-tutorial, individually prescribed instruction (IPI), computer assisted instruction (CAI), contracting, personalized self instruction (PSI). Some individualized systems are simply called individualized instruction (I.I.). Some schools in the Philippines use I.I. relying mainly on printed material to which each student has access.

Audio-tutorial

This learning system is based on audio-mediated materials which may be sequential or independent. It also includes quiz sessions, large and small group discussions.

Computer-assisted instruction

In CAI, a student interacts with a computer terminal through sequenced materials. The computer records his responses, presents branching programmes, scores his work, reports results and prescribes the student's next unit.

'Personalized' Self Instruction (PSI)

An example of PSI is the Keller method. Students pace themselves within a given time frame. The system includes learning units with specific objectives and suggested learning procedures. The student selects options from among those suggested in the unit.

Lecture and demonstrations are non-compulsory and serve purely motivational purposes (there may be 8-10 lectures throughout a semester's work). The Keller Plan includes analysis and organization of subject matter (careful selection of the basic textbook is important) specification of objectives, provision for individualized progress as each basic step is mastered, feedback to the instructor at every step which enables him to improve his programme. The steps in the programme are not frames as in programmed instruction. They are more inclusive, better described as reading assignments or laboratory exercises. Advance within the programme is not based on a confirming word but follows personal approval (by proctor) of larger samples of behaviour. The instructor of

PSI is aided by an assistant and some proctors (number depends on class size).

Programmed instruction

This is either linear or branching. The learning unit is broken down into a series of steps (frames). A linear programme progresses logically from frame to frame. A branching programme allows a student to proceed by one of several routes depending on his response. P.I. materials may be presented by teaching machines audio-tapes, films, etc. The printed format has been found the most practical.

Contract

A contract is made between the teacher and the student which includes learning objectives, activities to be undertaken and the assessments to be made. Any kind of learning materials may be used. The contract may also specify the kind of grade the student may expect. Although the contract is an individual agreement, it may in effect turn out to be small group instruction, if several individual students pick the same options.

Using Simulation in Teaching

"The child in the savage and barbarous tribes plays with miniature imitations of the implements used by adults. His amusements and games are similar but imitations of the implements used by adults." This, in the words of Paul Monroe (1928), describes the early phase in the practical education of primitive peoples. It is an unconscious imitation of life.

Play activities and games have survived as pedagogical vehicles for learning but they are now used consciously to simulate experiences which otherwise would not be possible to introduce into the classroom. Game experiences are still much used in education but other terms have also cropped up to include the earlier notion of games as an educational experience and other learning situations. Perhaps the earliest conscious use of the term simulation in relation to teaching can be traced to the 'Link Trainer' of the United Kingdom's Royal Air Force (Taylor, 1972). This was a dummy cockpit which allowed a trainee pilot to experience a model of actual flying situation. This allowed him to make mistakes without paying dearly for them.

Some major features of simulation include (Taylor, 1972):

1. It is an informal activity in the classrooms in which both students and teacher participate. The players take on roles simulating the real world. They make decisions according to their assessment of the situation in which they find themselves. They experience simulated consequences of their decision and reflect upon the relation of their decision and resulting consequence.

2. It is problem-based; it is open to multidisciplinary approaches. For example, social skills directly related to the real world may be involved.

3. It is dynamic; it deals with situations that change requiring flexibility in thinking and responding.

In this paper, we shall include under simulation the following methods: role-play, using situations, educational games, machine or computer simulation.

Role-play

The participant is given a (hypothetical) situation; he is expected to assume a new identity and act or react in accordance with his new identity. The 'play' is very instructional and the outcome unpredictable. Given the basic information as background each participant acts and reacts according to his role but in the process of interacting, he gains better insights into relationships with others and what they are doing.

This method has not been used much in biology teaching but with the current interest in 'humanizing' science and the trend towards social relevance, there is greater possibility of its expanded use in teaching. Included in this category of role-play are similar dramatic methods such as: drama, skit or play. Before role-playing starts the teacher provides the background for the situation and gives the stand or views (pertinent to the problem on hand) of each individual involved whose roles are to be played by the students.

Samples of role-play: (1) a meeting of government officials (National Power Corporation); two or three leaders of affected barangays (villages) in Mountain Province; adviser of the barangay (an 'outsider' e.g., a religious leader or a lawyer). Situation: a dam is being proposed which will inundate two villages. The villagers are farmers who know no other way of life. The villages are traditional pre-Hispanic tribal lands of the people. The people refuse to be relocated. (This situation of a dam being proposed on what is claimed as tribal property has actually occurred in this country). (2) evolution is taught in biology. A parent who claims the teaching of evolution is against his religion, confronts the teacher. The teacher, child and parent meet.

Using situations in teaching

This method is useful in teacher training, particularly as exercises in decision-making relative to objective, content, methods and materials to be used in teaching in a given situation.

Samples of situation: (1) One group of 14 year olds in your biology class obtained the following data (of approximate values) from a nutrition centre:

Approximate values of certain foods

Food	Portion (serving)	Weight (grams)	Protein (%)	Carbohydrates (%)	Fats (%)	Iron (grams)	Calcium (grams)	Phosphorus (grams)	Energy calories
Banana	1 medium	100	1.3	22	0.6	.000 64	.0091	.0313	100
String beans	1/3 cup	44	2.3	7.4	0.3	.000 48	.0202	.0228	18
Bread, white	bakery slice	27	9.2	53.1	1.3	.000 243	.00729	.0251	68
Cabbage	1/3 cupful	61	1.6	5.6	0.3	.000 26	.0211	.0174	15
Cauliflower	1/3 cupful	73	1.7	4.5	.45	.000 68	.0894	.0443	18
Chicken	1 leg or equivalent	148	21.5	–	2.5	.004 8	.0185	.3473	139
Corn	1/3 cupful	57	2.9	19.2	1.2	.000 457	.0034	.0590	58
Meat, lean beef	2 slices, 7.5 cm x 7.5 x .6 cm	150	21.3	–	10.4	.005 94	.0209	.3381	240

How will you use this data in teaching?

(2) A supervisor comes around and notes that you have no live animals in your class-laboratory, nor in the school yard except for one small aquarium. Being a great believer in the use of living organisms in teaching biology, she gives you a lecture on its advantages and usefulness. How will you handle this criticism?

Educational games

Games, even educational ones, are best learned by playing. A teacher introduces a game by playing the game with the students after a brief introduction about what the game is about. She demonstrates the rules of the game as playing progresses. Then the students can play by themselves. Games can be introduced at any appropriate time, e.g., when a topic being learned is related to the game. Or, it may be used as review for groups of students who need additional time for learning or by fast learners who finish their work ahead during lab or activity periods.

Samples: (a) Rumigen is a card game (prepared by UPSEC staff) on Mendelian inheritance which helps the student understand the meaning of genetic cross, genotype, phenotype and ratio. The game is played in a manner similar to gin rummy. The game starts by giving each player seven cards. The principle on which the game is based may be stated thus: If the parents have a given characteristic (genotypes for one trait are given), then the offspring should have genotype _____. The game proceeds with each player drawing a card, and discarding the card on his hand which he thinks has little probability of giving him the right set of parents and offspring for a given characteristics. In a series of draws and throws each player attempts to complete a suit (made up of two cards representing male and female P_1 and one card for each of the possible offspring from P_1). The game ends when a player succeeds in putting down all his cards in completed suits. Each player then gives the phenotype and genotype of each

P_1 and F_1 in his completed suit. He also gives the ratios of the genotypes and phenotypes of F_1 individuals in his completed suit/s. (b) Incomplete Dominance is taught in another game that reinforces learning of related concepts like intermediate character, filial generation. In one pack of cards there are seven complete suits showing inheritance of intermediate traits from P_1 to F_2. The number of suits to be used depends on the number of players to be involved. All cards are distributed randomly, one to each player. Those players holding cards of the same organism come together (they can call attention to their cards by holding up their cards or calling the name of the organism). Each group of players then determines what trait is involved in their suit and works out the inheritance of the trait from P_1 to F_2. After completing a suit one member of the team describes the phenotype and genotype of each organism in the suit (from P_1 to F_2).

Computer simulation

The computer is rarely or not used at all in secondary school teaching in Asian countries except in Japan. But this is not a reason for teachers to be unaware of its possibilities. There is also, the possibility of including some experience in computers in the in-service training of teachers.

Samples: (a) population games for mathematically-inclined biology students can be used to teach experiential and logistic variations of population size. The theoretical form of the population growth can be plotted by the student and this can be compared with the empirical results he gets after doing the game. (b) simulation using random generated DNA and RNA sequences. Students use the sequences to perform a variety of simulated events: predicting complementary sequences, translational products, evaluating base compositions, determining frequencies of triplet codons and suggesting possible secondary structures.

Improving Reading

This is a category used by Meyer (1980). Printed materials are still the most common learning aids available in most classrooms. If we accept the notion that reading and study skills should be the responsibility of every teacher (at pre-university level) then biology teachers should take a more active role in improving the student's reading and study skills.

If we know the types of reading skills needed in science learning, it should not be difficult to plan learning activities that tend to develop these abilities. Shepherd (1960) had identified these as:

a) skill in varying the rate of reading according to the purpose for reading and the nature of the material;

b) skill in using parts of a book;

c) skill in locating and using sources of information;

d) the ability to use correctly the vocabulary of science;

e) the ability to understand and use formula and scientific symbols;

f) the ability to gain accurate information from graphic arts;

g) the ability to read for exact meaning; noting the main ideas and supporting details;

h) the ability to organize ideas from reading;

i) the ability to read directions accurately;

j) the ability to evaluate science materials and to draw conclusions;

k) the ability to apply data from reading to practical problems.

Some methods which may be used to enhance reading abilities are: independent study, reading assignments, preparing essays, book reports, projects, analysis of case studies.

Focusing on Values

Values education is a current controversial issue in education judging from the literature. But all would agree that values, attitudes and beliefs are essential components of learning, thus the belated recognition after the cognitive emphasis of the previous decades. This is not to say that we are de-emphasizing cognitive aspects of learning; what is being expressed is that learning (in science) has other components equally important as cognition. The idea that one does not learn concepts in isolation from other associations (mostly affective) has been expressed repeatedly by Schaefer (1979).

Admittedly the teaching of values is a complex undertaking in any classroom situation; for values are acquired in many ways and often sub-consciously from various social groups like the family, peer group, the church and adult models, and so on. However, values are also products of reflection and it is this aspect which interests us as teachers. It is now recognized that values have both cognitive and affective dimensions.

Enough is known about values to give some assurance that it can be taught; some teaching procedures have been developed and are presently being used as part of teachers' teaching repertory. Values are intimately associated with emotions hence, more than usual attention and precautions on part of the teacher are necessary when handling them.

What 'values' do we include in classroom teaching? There are many statements made by students which reveal his stand on an issue, his preference, his prejudices, his ambitions. Value lessons of the incidental type may start with such statements, by turning them into problems for discussion. For example:

1. "It is a bother to try to remember some English units, some metric, and some of our own (indigenous) units of measure."
2. Should the people in Ramon town, Isabela, be educated about progress so they will understand the importance of constructing Magat Dam?
3. We keep growing tobacco and subsidizing it, yet we know it is bad for the health.

Questions like the following may be raised, from which brief stimulating discussions may ensue:

1. Our Bureau of Standards is now finalizing a system of measures based on the metric system and international standards. How do you think this should be implemented so there is least confusion among all the people (e.g., the vendors, the small sari-sari store owners, students, etc.)?
2. How would you organize an educational campaign (relative to the dam for the people of Ramon town in Isabela)?
3. What measures would you suggest to change or minimize the growing of tobacco in the Northern provinces?

More systematic ways of teaching values have been developed and studied. Some are briefly described in the following paragraphs.

Value analysis as a teaching strategy (Coomb and Meaux, 1971) includes the following tasks: identifying and clarifying the value question; assembling the purported facts; assessing the truth of purported facts; clarifying the relevance of facts; arriving at a tentative value decision and testing the value principle implied in the decision. These tasks obviously involve decision-making. A comprehensive discussion of these strategies is found in Metcalf (1971).

Harriman et al. (1973) propose three levels of teaching: facts, concepts, value which they claim can be done in almost all subjects. Taking biology as an example, a study of a frog on the factual level might include: parts of the body, how it feeds, its life cycle, how it reproduces; on the concept level: contribution of frogs to the balance of nature, similarities and differences between the development of a frog and a human individual; characteristics of social behaviour of frogs (observed in a terrarium). On the value level: which would you rather dissect: a frog, a worm, a dog? Why? Would you eat a frog, worm, dog, if you were starving? Would you draw a line about what you would eat if you were starving?

Teaching of scientific attitudes has been and is being accomplished by teachers using several well-tried methods like: using a model, biographies of scientists, stressing some of these attitudes as incidents arise in the laboratory or classroom discussions which demonstrate such attitudes.

A novel way has been used by Crawley and Krockover (1979). They defined the attitudes: curiosity, inventiveness, critical thinking, persistence and inquiry by citing observable behaviours for each of these attitudes. Then the student teachers were asked to observe their own classes while the pupils were engaged in an activity, or to observe their class while it was being taught by another teacher. They then tallied each behaviour observed at predetermined time intervals. They also prepared slides of teaching episodes exhibiting some of the scientific attitudes (curiosity, inventiveness, critical thinking and persistence). These were shown to their student teachers who were asked to classify them according to the dominant attitude demonstrated by each slide. Reasons explaining the choice may be given for each slide.

Closely related to values education is the method of decision-making. This has been much utilized in drug education, and environmental education. Decision-making is much influenced by many and often differing points of view of individuals concerned; it is also influenced by the situation and circumstances obtained at the moment of decision.

Blum (1979) and others suggest the inclusion of decision-making as a topic in environmental education. He mentions the following as some techniques useful for training in decision-making: cost/benefit analysis, case studies, exercises of the "What would you do?" type, games, role playing, real situation and action, and kits. The latter is a packaged learning kit which includes both print and nonprint materials which deal with environmental problems like pest control, oil spills and so on. It is noted that simulation methods lend themselves to teaching decision-making and values.

The Biological Sciences Curriculum Study (BSCS) efforts along this line are worth noting. In their programme entitled, "Quality of Life and the Future," an exercise in decision-making is provided by a role-play presenting a national crisis on water in the year 1999. Representatives of five (5) different power groups present their views. A discussion follows with a set of questions provided to focus the discussion. Then each student 'votes' on the various recommendations given by each group representative. (A prepared worksheet is given for voting on the different recommendations).

In another exercise, an article is given which shows how one community changes its life style in order to reduce energy consumption. A discussion follows with a given set of questions provided. Then the students are asked to complete a worksheet which asks them to name the life style choices made by the citizens of the community; the corresponding consequences in the community regarding growth; the possible future choices the people might make and possible future consequences of these choices.

Another exercise on decision-making in a BSCS publication: *Land Use*, uses opinion poll on which students react by indicating agreement, disagreement or don't know on each of a hundred items. The class selects several statements on

which there are about equal numbers of respondents in the three categories. Then, the class divides into three groups, one group lists down all the reasons they can think of for agreeing with the statements, a second group does the same for those disagreeing and the third group lists the facts, the undecided need to know for them to form an opinion. The whole class also identifies all the items in the poll which are opinions and those which are facts.

A fourth method used is the use of a value analysis scale on a given land issue, e.g., should a downtown vacant lot be converted to a parking lot? This asks the student to list all positive consequences and all negative consequences and to rate them on a ± 10 point scale with + 10 very good and - 10 very bad; 0 rating means the respondent is not sure of the consequences.

The Bio-medical Interdisciplinary project (1976), is a notable example of an interdisciplinary project for secondary school students. It has developed sequenced teaching units which deal with various social issues related to bio-medical sciences. A look at the one such unit on decision-making and health reveals the extent of the content coverage and the strategies used to teach them:

1. Values and decision-making (lessons 1-7)

   Methods used: role-play - a situation in which it is the students' responsibility to decide allocation of certain health care resources - identify value statements; identify value principles underlying value statements; analyse value statements in their own resource allocation decisions; discuss the importance of values and internal value conflict in relation to decision-making.

2. Allocation of responsibility (lessons 8-11)

   Methods used: games - students participate in a game that simulates six different ways of allocating responsibility for decision making within a group. They describe allocations of obligations and responsibility and identify allocations of responsibility.

3. Responsibility for decision-making in the American systems of Government (lessons 12-17)

   Methods used: analysis of the allocation of responsibility for government decision-making - gather information in government-related domestic issues.

4. Bureaucratic and informal decision-making (lessons 18-21)

   Methods used: making posters (to encourage the public to avoid factors that increase

risks of coronary heart disease) — simulation of informal decision-making and bureaucratic decision-making; discuss advantages of each style; identify instances in real life.

5. Analysing community opinion about health (lessons 22-25)

   Methods used: design questionnaire to assess opinions about health care — analyse data; generalize from data.

6. Cost of health care in the United States (lessons 26-28)

   Methods used: analyse data on national health care — discuss market forces particularly health market; consider controversial questions about allocation of health care resources.

7. National health care policies (lessons 29-36)

   Methods used: identify value conflicts in two alternative national health care proposals — discuss roles of interest groups; role-play congressional hearings.

Teaching for Social Relevance

James Rutherford (1979) has defined "socially relevant science instruction to be that kind of science education, the content of which presents a broad cultural perspective of science and that also deals with at least some contemporary science-related social issues." A broad cultural perspective of science, Rutherford further suggests, "is science in its manifold philosophical, historical and social character."

In Southeast Asia, in the Philippines at least, we are much concerned about social relevance which we interpret basically in economic and developmental terms geared to national development goals. This is by no means popularly implemented for much of the teaching in our classrooms remain much like what it was in the 50s and the 60s when the concepts and inquiry were the catchwords. Yet, the emphasis remains, constantly reiterated by leaders in government and education and all are exhorted to do something. For developing countries, the drive for self reliance, for an improved economy, better quality of life and other socio-economic goals are timely and necessary. The question facing educators and science educators in particular is, "how can we help in these national movements? What can we do?"

Our attempts at involvement in the practical and often necessary and very basic science-related needs of our people should not be taken to mean that we reject the teaching of concepts and science skills relevant to the discipline. But the seeming over-attention at the moment may be an attempt

to redress the imbalance in our curricula, especially at secondary level which by tradition has for so long addressed itself to the needs of the discipline appropriate to college-bound students rather than to the needs of the large majority of our people.

Teaching for social relevance is emphasized in both formal and non-formal education. The latter efforts directed towards development goals are designed to bring new knowledge, skills and attitudes to a target group outside the formal system. The involvement of this group depends on their willingness to participate which in turn depends very much on their perception of the benefits they will derive from such participation. The ultimate test of non-formal education is the extent to which the knowledge gained and favourable attitudes acquired are translated into practice (Castillo, 1977). Involvement of academicians and educators from the formal sector in non-formal education benefits both system – it brings to one much needed expertise and to the other it opens up his view of education and the needs of the population thus reinforcing the notion of the need of real life experiences and more practical content in formal education.

The following paragraphs describe some methods used by the University of the Philippines Science Education Center (UPSEC) staff in conducting community based science education projects. These methods could well be introduced in in-service training of teachers. It has in part been done by Ministry of Education and Culture in some of their programmes.

I. Preliminary studies

A. Assessment of village needs and resources

1. The following parameters are generally included in the assessment:

- economic activities
- use of indigenous technology
- community structure
- health and sanitary conditions
- community resources: natural, human (in terms of skills)
- beliefs and practices, associated with nature, occupation, life environment
- aesthetic and leisure time activities
- constraints in the community
- expressed needs of the village folk

2. Methods used to make the assessment include:

- indepth interviews
- questionnaires
- group sessions
- ocular inspection

B. Analysis of data to identify problems and implications for the curriculum and non-formal education. This analysis will be specific to the community which is being

studied. An outline of the various topics can then be developed to guide curriculum developers. An earlier paper by Dr. Dolores F. Hernandez (1979) provides an example of this aspect of the analysis.

C. Experimentation. This phase includes finding and trying out substitute materials or methodology, or developing appropriate methodology/apparatus for a given situation, e.g., identifying and using medicinal plants, building and maintaining a fish pen. This phase may also include trying out activities in a laboratory at the Center for the purpose of testing its feasibility before it is written up and tried in actual situations.

II. Community participation

This phase starts right at the beginning of a project, even at the planning stage. A briefing is usually made to which the community leaders and interested citizens are invited. Ways by which the village folk get involved are through:

A. Village seminars. The coverage of these seminars are determined by the villagers themselves. Our projects have consistently shown that the village folk are concerned mainly with their livelihood and any economic activity which will help improve their economic conditions. Secondly, they are interested in the health of the family particularly children. Within these areas some science related topics are identified and included in the seminars.

B. Action projects. These include such activities as: providing space for reading centres (one or more for a community), making water sealed toilets, digging wells, all of which are done by the villagers themselves. Or, in an agricultural area, experiments on farming practices are done in the farms of the participating farmers.

C. Organizations. The activities in this category may involve organizing a co-operative (after a seminar on co-operatives has been conducted), organizing sports teams e.g., basketball teams among the men, volleyball for the women; organizing mothers' teams to help at the daycare/health centre.

III. Developmental phase

Preparation of modules on topics selected from the identified areas of interest of the adults, testing the modules, revision and finalization. Development of apparatus and equipment follow a similar pattern. These modules and facilities are used in the village for which they were developed and in other similar villages.

Teaching for Intellectual and Cognitive Development

Research studies indicate that providing students with specific experiences improves or fosters intellectual development. Among the intellectual skills developed are: recognizing variables, controlling variables, interpreting experiments and understanding experimental design (Thier, 1974) logical connectives e.g. negation, quantifiers, if ... then ... (Eisenberg and McGuity, 1975), divergent thinking (Schaefer, Nov. 1979 and others). In brief, many of these skills are what are commonly recognized as skills related to problem-solving, critical or logical thinking.

The methods used to foster the development of these skills include inquiry approach (McKinnon and Renner, 1971); personalized approach: individualized, independent, open instruction (Thier, 1974); experiences in investigations including: observation, measurement, interpreting, prediction, and other scientific processes (Linn and Thier, 1975); problem solving (Dirkes, 1975); independent study (L. Gregorio, 1980); questioning, inquiry, games, and cybernetics (Villavicencio and Tayko, 1980).

Ramirez and Castaneda (1974) have identified field-independent and field-sensitive teaching strategies which would help teachers match teaching styles with learning styles of the students in the classrooms. The field-independent instructional behaviours are:

- encourages independent student achievement, emphasizes importance of individual efforts
- encourages competition between individual students
- adopts a consultant role
- encourages learning through trial and error
- encourages task orientation (focus attention on assigned tasks)

The field-sensitive instructional behaviours are:

- expresses confidence in child's ability to succeed; is sensitive to children having difficulties
- guides the students, makes purpose and main principles of lessons clear; sequence of steps towards a "solution" is clearly delineated
- encourages learning through modelling
- encourages co-operation and development of group feeling, to think and act like a unit
- holds informal class discussions, helps students see relation of learned concepts to students' experiences.

We note here a great deal of overlap in the methods used to develop intellectual skills or higher levels of cognition. The crux of the matter lies in the creative or imaginative use of methods or techniques for a purpose, in this case intellectual and cognitive development. But before we can expect the teaching towards intellectual development to flourish at the secondary school level, teachers and

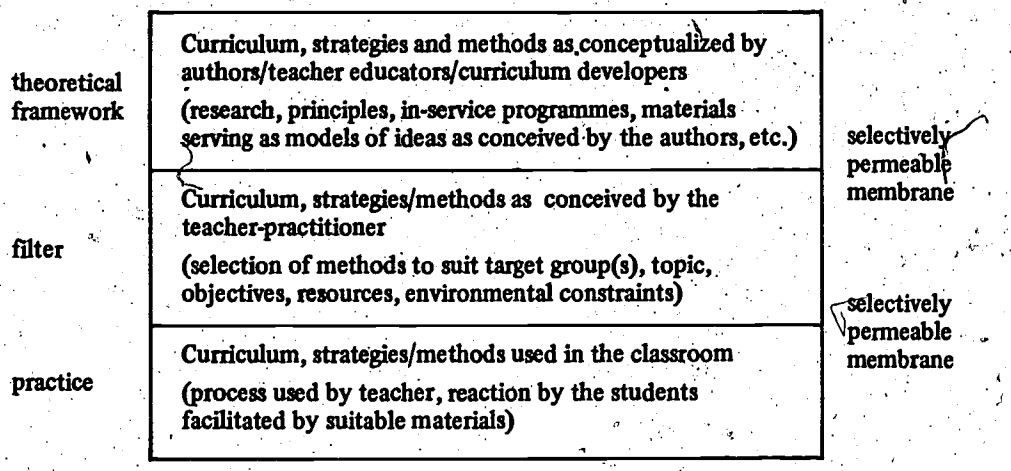
prospective teachers of this level must know how to teach towards this objective. This means that teacher education must offer substantial experiences on this topic; it further implies that those responsible for the education of teachers in college and universities must themselves practise inquiry teaching and utilize other tested methods that tend to develop intellectual skills. This applies to both science and education professors. The other problem is the availability of a variety of materials specially designed to develop intellectual skills in students. These two problems cry for attention; workshops and meetings like this should contribute towards the solution of these problems.

CONCLUDING REMARKS

A good way to end this paper is to raise certain issues. It was brought out earlier that though there exists a vast array of teaching methodologies teachers still use only a few of them. It also has been observed that the content of a new curriculum (the topics) may be used by teachers but not the strategies associated with the content.

If we adapt Roberts' filtering mechanism (cited in Connelly, 1979) we can view this problem as illustrated in the figure below. The strategies and methods (implied or explicitly associated with a new curriculum or with new materials, e.g., environmental education, science in society, etc.) is filtered through a boundary which can be compared to a selectively permeable membrane. Some of the ideas originally conceived by the organizers or authors of the curriculum and strategies pass through, others do not. Those that pass through and are actually used by the teacher may bear little likeness to the original idea.

Figure 1. A filtering mechanism



It is obvious that the key figure is the teacher for it is the teacher who selectively filters the content to be included and the strategies to be employed. It is equally obvious that the availability of appropriate materials (which include content and strategies) is important. How can teachers of biology be encouraged to use new materials and strategies?

A second issue which could be raised is: How much of a course in biology at secondary level or at college general education level should be transformed in response to the current demands (brought out in Part I)? Should the entire course be changed, or only a portion of it? If only a portion, how much? Why?

Some of us have experienced both types of changes. In the 1960s the former took place in the Philippines when we introduced an ecologically-oriented book and slowly, the older books oriented to taxonomy and physiology were replaced. Now, faced with the call for social relevance, national development goals, values education and so on, we are once more faced with a dilemma.* To date, the reply has been to introduce these new requirements via modules. Eventually, these modules may find their way into the curriculum. The question is: How much of the existing course should be oriented towards these new needs? Should the entire biology course be oriented towards them or should only part of the course address these needs. Decidedly there is no single answer to these questions. A centrally organized system may respond one way, a decentralized system may respond in varied ways, including as we have seen (in U.S. for example) entirely new courses addressing the problems. In the Philippines so far the trend has been to maintain the current biology textbook(s) as the basic core but to introduce the new materials via modules. But this does not answer the question: How much? Why? to what extent? Why? Perhaps this meeting could provide some guidelines and insights on issues which eventually can bring about a reasonable decision by the classroom teacher or someone involved in policy-making in the educational system's hierarchy depending on the degree of centralization in the system.

These issues point to the need for examining the process of change and reforms in this case the teaching of biological topics which strongly stress applications, which may at times be far removed from the discipline, which has a strong multidisciplinary flavour and which necessarily brings to the teaching of biology the methodologies of the social sciences. This may or may not be a good thing. Its value perhaps should be assessed more from the viewpoint of the good it will do for the end consumer - our students rather than what it does

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* Ecology-orientation - environmental biology - is as socially relevant as ever, increasingly so. 'Development goals' cannot once again throw conservation out of the window. Appendix B, in fact gives concise suggestions for vital new environmental, health and agricultural orientation for biology education. *Editor*

to the discipline. But it is not within the scope of this paper to explore these possibilities.

In a recent BSCS newsletter, Paul de Hart Hurd set forth his ideas of the teaching of biology as part of the liberal education of the future world:

1. Be taught in a social and human context, perhaps as a science of human beings.
2. Include values and ethics as goals, recognizing that these are moral and aesthetic as well as scientific answers to human problems.
3. Have courses organized more according to biological events and problems that have meaning for the quality of life, rather than according to the logic of biological disciplines.
4. Consist of subject matter selected for its task, action and applied values that can serve real life and practical ends.
5. Be taught from a holistic and integrative point of view with a curriculum that is transdisciplinary in concept and structure.
6. Make sure that a substantial fraction of laboratory investigations include individual and community-based problems, issues or policies.
7. Encourage additional cognitive skills such as decision-making, valuing processes, knowledge-validation, problem resolution, concept of risk, and ecological thinking.
8. Orient biology teaching toward the future giving students opportunities to consider various alternatives for the future course of human efforts.
9. Use more individualized and personalized teaching to accommodate established learning styles of different students as well as different learning needs.
10. Recognize that the biology teacher is an interpreter of biology concepts, theories, and research and serves as the intermediary between scientists and the lay public.

The above perceptions make explicit some of the underlying assumptions in this paper. We may also take comfort in the thought that the developments in biological education which raise the questions above are shared concerns of biologists and educators not just in the third world but also in developed countries.

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Incomplete dominance
Rumigen
Good chain
Biological classification
Karerahan sa Gubat (Race to the forest)
Ang Bahay ay Galing sa Gubat (The house is from the forest)

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Appendix B

NOTES FOR DISCUSSION ON CONTENT OF SECONDARY SCHOOL BIOLOGY

This is a working paper for assisting the Workshop discussions on content of secondary school biology. It seeks to give an account of Asian material. It also advances a few topics which may not at present be generally included in school biology curricula in Asia. It does not seek to deal with standard textbook content which is undoubtedly familiar to all the Workshop participants.

A. Environmental biology

1. Asian acceptance. It is widely and wholeheartedly accepted almost everywhere in the Asian region that the environment should have a prominent place in the content of school biology. A number of reports, studies and guides bear witness to this (13, 108, 114, 115,191,192,197). One report spoke of beginning science education "in the soil,. . . . in their natural surroundings in Asia, the ideal starting point for science learning." [188] Even in so highly an industrial country as Japan the guidelines for senior school biology include those for "a true appreciation of nature" and "observations and surveys of ecosystems." [83] In Thailand it is declared that curricula "must be seen as an instrument for helping the students cope more effectively with their environment and improve the quality of life. Thus the new curricula are being designed to be both functional and relevant." [180]

2. Curriculum. Practically all curricula for secondary school science give a notable place to environmental biology. The integrated science course for lower secondary schools in India has environment as its 'integrating factor' i.e., the focus around which the course is built.[195] In the Hoshangabad Science Teaching Programme, a special project for lower secondary schools in Madhya Pradesh, "a system of field trips to agricultural fields, rivers, rocks, forests and the village has been evolved and tested. Biology is primarily learned through this method." [196] The Philippines has a special project at a school (Jose Abad Santos Memorial School) in Quezon City, called "Project on utilization of the environment in developing viable life science curricula;" school facilities include one hectare of land, fish pond, animal house, and others.[140]

Many Asian countries have prepared their own curriculum materials for environmental biology. The materials generally form part of the textbook and practical guide. The Philippine adaptation of the BSCS Green Version, *Biology for Philippine High Schools*,[22] is based on an ecological approach. The materials, which first appeared in 1965, consist of a student's text, a laboratory manual and a teacher's guide. A complete revision of the work appeared in 1978, entitled *Interaction of living things and their environment*,[202] one section of which is on man and his role in the environment. The Republic of Korea too prepared an adaptation of the BSCS Green Version.[95] Malaysia chose to adapt British material to suit the Malaysian environment.[118] Thailand's Institute for Promotion of Teaching Science and Technology (IPST) has produced biology curriculum materials (in Thai) with attention paid to the ecological aspects.[28, 98, 181] India too produced its own textbooks, entitled *Life sciences*.[80] Apart from textbooks and teacher's guides for the textbooks, teacher resource materials have been produced, e.g., *Philippine environmental studies*.[195]

This paper was prepared by Prof. Valentine Basnayake, Professor of Physiology, Department of Physiology, Faculty of Medicine, University of Paradeniya, Paradeniya, Sri Lanka, for the Regional Workshop to Review Biology Education in Asia sponsored by ACEID / Unesco and the University of the Philippines, 18-23 August 1980.

3. **Inter-country curricula.** There are environmental biology curriculum materials which could be of inter-country applicability in Asia. The Regional Educational Centre for Education in Science and Mathematics (RECSAM) in Penang, Malaysia, has prepared prototype materials for lower secondary level integrated science, with Indonesian, Khmer, Laotian, Thai and Vietnamese translations.[167] RECSAM has also prepared a teaching unit for secondary schools on population biology, and one on a pond ecosystem;[168,169] it includes work sheets for students and guide notes for the teacher. The Unesco publication, *Teacher's study guide on the biology of human population: Asia* has sections on the environment (air, ecosystems, fauna and flora, genetics, health, nutrition, soils, water).[184]

4. Country handbooks and monographs. Each Asian country has its own handbooks and monographs on its fauna and flora and other environmental subjects. These materials should be of the greatest use for teaching environmental biology but they often remain inaccessible or even unknown to teachers.

The present Workshop might consider it useful to recommend to Unesco that an annotated bibliography, preferably with text, be prepared of such environmental resource materials for the region. It might be best to do so separately for each country before attempting a region-wide monograph.

5. Science clubs and science fairs provide opportunities for learning environmental biology. In India there have been annual National Science Exhibitions and state level science exhibitions since 1971.[195] Delhi has three science centres which encourage science club activity. APEID's third cycle of activities (1982-1986) is likely to include support for science clubs, exhibitions and fairs.[196]

6. School research projects by secondary school students and teachers are encouraged in many Asian countries and even made compulsory in some. Many of the projects come into the category of environmental biology.[37] In India the Central Board of Secondary Education has taken the innovatory step of prescribing that senior secondary science students shall do an investigatory science project as a course requirement. This is said to encourage interest and creativity in the science education system.[195] In Japan, senior secondary school biology students are expected to carry out a research project, preferably within school hours, choosing a problem of their choice with the teacher's guidance.[83] In Sri Lanka a project was compulsory for senior secondary students[172] but this is not the case now; individual bodies, however, do encourage environmental research by students and teachers in schools. The Asian Association for Biology Education (AABE), ever since its inception in 1966, has in its biennial meetings[49,50,51,154,164,182] encouraged school biology research. The emphasis at the third meeting (Third Conference, 1970)[182] was in fact on this. The fifth meeting (Fifth Conference, 1974)[49] had a paper which sought to evaluate the work of a school biology investigations group.[203] AABE school research papers have included environmental topics such as root nodules,[96] water pollution,[91] and weed ecology.[134]

7. Human community. Educational experiments based on the idea that school work should intermesh with the human community to which the school belongs have been taking place in Asian countries. APEID has had a continuing interest in this area.[191,193,195] India has innovatory programmes to bring school and community together.[81] So has Papua New Guinea with a Secondary Schools Community Extension Project.[5,137] The Philippine Science Education Center has projects in rural development.[64,195] Singapore[161] and Thailand[20] too have shown interest.

8. Environmental warmth and thermal comfort. Environmental warmth is one of the commonest causes of discomfort in everyday life in most countries in the region.

Knowledge of the causes of thermal discomfort can have application for everyday life in regard to clothing, building and human behaviour.

The concepts which might be suitable for teaching at secondary school level include:

a) The primary environmental factors affecting thermal comfort: temperature, humidity, air movement (ventilation and radiant heat);

b) The indices which have been devised to combine these factors into a single index (such as "effective temperature" and "equatorial comfort index");[157,189]

c) Application to clothing;[132]

d) Application to building:

Building, general [73, 74, 79, 129, 155, 204]
Building, schools [11, 200]
Cooling systems, passive [15]
Roofs [76, 93, 171]
Sun shading [7, 70, 120, 201]
Ventilation [31, 72, 77]

e) Application to landscaping: Shade trees [205]

9. Environmental light. Schools in most Asian countries work by daylight. Knowledge of the factors influencing daylighting may have applications to school work.[10, 71, 75, 128]

10. Ergonomics. The science of the working environment of man[123, 192] includes the topics of environmental warmth and light. Other ergonomic topics which could be of live interest in the biology class include desk and chair sizes,[8, 82] laboratory design (general l oratory,[9, 165] biology laboratory[6, 158]), furniture design,[12] and anthropometric data.[18

11. Internationalism in environmental biology. School education often has as one of its objectives that of cultivating the spirit of internationalism. In regard to biology education, there may be a case for arousing, some degree of awareness in students and teachers of international organizations which are concerned with the environment, e.g., *Ecology Newsletter for Southeast Asia* (published twice a year from 1972 by the Ecology Division/Group, University of Malaya);[107] IBP; IUCN; Regional Centre for Research, Training and Postgraduate Study in Tropical Biology, Lembaga Biologi Nasional, Bogor, Indonesia; SEAMEO;[166] UNEP; WWF.

12. Aesthetic education in biology. Every teacher wishes not only to communicate knowledge but also to cultivate feelings for values. Biology, and especially environmental biology, can have many aesthetic overtones. Respect and love for nature are often cited among the aims of biological education.

There is a Buddhist legend about a flower. Buddha held up a flower and said nothing. That was his sermon. In his audience of disciples, Mahakasyapa smiled. And the Buddha knew from his smile that Mahakasyapa had got his message.

In the Southeast Asian Utopia of Pala[69] the education of children used the same technique.

'We use this same kind of approach', she (the Principal, Mrs. Narayan) said to Will (visitor to Pala), 'in our science teaching, beginning with botany.'

'Why with botany?'

'Because it can be related so easily to.... the Mahakasyapa story.'

'Is that your starting point?'

'No, we start prosaically with the textbook. The children are given all the obvious elementary facts, tidily arranged in the standard pigeon-holes. Undiluted botany—that's the first stage. Six or seven weeks of it. After which they get a whole morning of what we call bridge-building. Two and a half hours during which we try to make them relate everything they've learned in the previous lesson to art, language, religion, self-knowledge.'

'Botany and self-knowledge—how do you build *that* bridge?'

'It's really quite simple', Mrs. Narayan assured him. 'Each of the children is given a common flower—hibiscus for example, or better still (because the hibiscus has no scent), a gardenia. Scientifically speaking, what is a gardenia? What does it consist of? Petals, stamens, pistil, ovary and all the rest of it. The children are asked to write a full analytical description of the flower, illustrated by an accurate drawing. When that's done there's a short rest period, at the close of which the Mahakasyapa story is read to them and they're asked to think about it. Was Buddha giving them a lesson in botany? Or was he telling his disciples something else. And, if so, what?

'What indeed?'

'And of course, as the story makes clear, there's no answer that can be put into words. So we tell the boys and girls to stop thinking and just look. 'But don't look analytically', we tell them, 'Don't look as scientists, even as gardeners. Liberate yourselves from everything you know and look with complete innocence at this infinitely improbable thing before you. Look at it as if you'd never seen anything of the kind before, as though it had no name and belonged to no recognizable class. Look at it alertly but passively, receptively, without labelling or judging or comparing. And as you look at it, inhale its mystery, breathe in the spirit of sense, the smell of the wisdom of the other shore. An education in the art of being receptive. First the gardenia as a botanical specimen, then the same gardenia in its uniqueness, the gardenia as the artist sees it, the even more miraculous gardenia seen by the Buddha and Mahakasyapa. And it goes without saying' she added, 'we don't confine ourselves to flowers. Every course the children take is punctuated by periodical bridge-building sessions. Everything from dissected frogs to the spiral nebulae, it all gets looked at receptively as well as conceptually, as a fact of aesthetic or spiritual experience as well as in terms of science or history or economics. Training in receptivity is the complement and antidote to training in analysis and symbol-manipulation. Both kinds of training are absolutely indispensable. If you neglect either of them you'll never grow into a fully human being.'

In Sri Lanka, 'Appreciation of the environment' has been introduced from 1978 as an option in the aesthetic group of subjects in junior secondary school.[202] Many of the topics naturally touch on environmental biology.

13. Trees are of interest and concern from the point of view of conservation, aesthetics, use of wood, and pure biology. Asian biology educators may wish to pay even more attention to them than before, including such topics as energy forests,[26,36,55,150,175,206] the shapes of trees,[47,67] the CO_2 question,[133] and shade trees.[205]

14. Environmental pollution

Syllabus. A proposed syllabus for teaching environmental pollution in secondary school has been described by a Singapore biologist.[99]

Water pollution. RECSAM has prepared a teaching unit on water pollution with respect to human population problems.[168,169]

Noise is one of the commonest forms of environmental pollution in many Asian schools. The human voice could be the commonest pollutant. A study of noise in Asian classrooms led to the conclusion that no child should be more than seven metres away from the teacher; noise levels in classrooms should not exceed 60 decibels; flexible partitions should have a noise reduction of at least 4 db; the partition height should be two metres when teachers are back to back, and 2.4 m when they face each other in adjacent classrooms.[33]

15. Asian Papers on environmental biology related to school curricula

Biological education[1,32,85,142]
Conservation education[43,163]
Ecology education[177]
Environmental education[125]
Marine ecology[42,153,176]
Nature appreciation[143]
Population biology, teaching of[46,53]
Tropical ecology[41,110]

B. Molecular biology and genetics

1. General observations. Genetics and its near relative, molecular biology, are often said to occupy centre stage in contemporary world biology. The concepts involved, however, may mostly be unsuitable for school level (though not at college level)[4] because of their complexity and because they may not be able, in the Asian scene, to displace other material which we wish to teach. Even so technologically advanced a country in the Asian region as Japan advises the teacher that "the emphasis should be on the relation between DNA structure and gene mutation, between hereditary phenomena and enzymes, and between DNA and the appearance of characteristics. However, it is not necessary to sacrifice student comprehension by presenting more facts than they are able to understand."[83] Perhaps the content of genetics in senior secondary school biology need not, and should not, at present include more molecular biology than the basic mechanism of DNA replication, transcription and the translation of the transcript into protein.

2. At the same time, many of the growing points are popular with the mass media. Total ignorance of them may therefore not be desirable. A possible solution to this dilemma may be to teach only definitions, or at most thumb-nail sketches, of the concepts. These are exemplified by terms such as the following:

Cloning[111]
External human fertilization[14,61]
Gene structure[48,117]
Genetic engineering[57,66,151,152]
Mapping of chromosomes[112,152]
Recombinant DNA[35,60,119,121,146,162,207]

Terms such as the following are perhaps suitable for discussion only at teacher training and enrichment seminars and not for school students:

Gene isolation[24]
Gene regulation[173]
Gene transfer[3]
Repressors[148]
RNA-directed DNA synthesis[179]
Supercoiled DNA[19]

3. Molecular biology topics of recent growth which may be considered for inclusion in teacher-enrichment seminars (but which are probably unsuitable for secondary school) include:

Cyclic AMP[139]
Molecular biology of the cell membrane[27]
Molecular biology of the immune system[34,38,84]
Molecular biology of viruses[25,48,170]
Neutral theory of molecular evolution[92]

4. There are larger matters, such as race, language, and aggression, which have genetical connections and which may be regarded as being so relevant to human life in the Asian region that some definite treatment of them may be worthy of consideration for a school biology course. These topics are discussed in the following sections:

5. Genetical aspects of race

1. The topic of 'race' is of lively importance to many Asian countries that are multi-racial societies. It is of national importance in such societies. A search for national identity is often expressed in national policy statements. 'Race' is of everyday life interest to individuals in such countries. The feelings aroused by race have often led to violent explosions of communal hatred.

If the educational process of a country should seek to promote understanding and peace,[30] a dispassionate examination of the biological aspects of race may be desirable in secondary school biology. It also provides a topic for the study of variation, genetics being the study of inheritance and of variation. One of the topics listed in the world survey of school biology curricula for relevance to everyday life[115] is "differences between races, cultures and individuals."

2. The following concepts may be considered for such a purpose:[135]

a) When one group of organisms seems to differ significantly from another group of organisms of the same species, it may be necessary to classify them as separate 'varieties' or 'races'.

b) When classifying organisms into biological varieties or races it would be advisable to do so on the basis of:

i) many characteristics (and not on the basis of one characteristic only);

ii) heritable characteristics.

c) When this is done for human 'races' it turns out that there is considerable overlap between any two racial groups; the differences between any two individuals (other than identical twins) of the same race are far greater than the average difference between two 'races'.[102]

d) Any other use of the term 'race' is non-biological. There is danger that such non-biological uses of the term might be exploited by interested parties for their own ends.[45]

e) The people of small isolated villages, all belonging to the same nation and 'race', may differ biologically much more from each other than does the 'race' to which they belong differ from other 'races'.[29]

6. Language. Along with 'race', language is of extreme importance in connection with national ideologies in multi-racial Asian countries.[106,136,142,160] As with 'race' there may be a case for teaching dispassionately the biological aspects of language.[2,101] Language problems also may arise in reading and writing in secondary school education in Asia.[52,56,89,94,104,136,142,168,185,203]

The main concepts to be taught could include the following:

a) Only the human species has a true language.[2]

b) The biological aspects of language include:

i) The physiological mechanisms (vocal tract, motor area of the brain, receptive and associative areas of brain, speech centres, dominance)

ii) Genetically programmed aspect (speech unfolds in the child in a way which suggests it)[113,116,122]

iii) The species specificity

c) All languages have certain universal features (with regard to phonology, grammar and lexicon)[116]

d) With the evolution of writing, the brain's evolution moved away from mere massive memory to more thinking and problem-solving. (This is speculative)

7. Aggression. Along with race and language, aggression between population groups is a topic of considerable importance in multi-racial Asian countries. There is a case for dealing dispassionately with the biological aspects of aggression in secondary school biology courses.

The following is a list of concepts on aggression[63] which may be introducible in the context of the genetics course:

a) Aggression can be defined as behaviour directed towards causing harm in another individual of the species;

b) A more general term which would include aggression is 'agonistic behaviour';

c) Aggressive behaviour often stops short of violence;

d) The objective of aggression is often to settle status, precedence, or access to some object or space;

e) The circumstances of aggression between individuals and small groups often include nearness of another individual, the physiological state of the individual, frustration, pain, and fear.

f) The aggression may occur towards an individual other than the one who aroused it;

g) Individual variation in aggressiveness depends on many factors including genetic factors, social experience during infancy and childhood, fighting experience, punishment, and observational learning;

h) Aggressive behaviour of groups of individuals is: Liable to spread rapidly, violence breeds violence. Not generalized but directed towards specific goals which usually represent some of the initially frustrating factors. Stimulated by reciprocal actions, and reduced by passivity, on the part of the subjects of aggression;

i) There is much loose thinking in the claim that aggression is biologically valuable;

j) Aggression can be re-directed into non-aggressive emotional channels.[54,103]

C. Application of biology to health, nutrition and agriculture

1. The applications of biology to everyday life and to social needs have been favourite topics in many Asian school biology curricula for decades. In India, curriculum development in science has as one of its objectives for secondary school students—"to acquaint them with the major applications of science and mathematics in industry, agriculture, civil engineering, transport, means of communication, health services, culture and everyday life."[81] The Philippines has a project[14] to build nutrition education into the secondary school curriculum with inclusion of the following topics—balanced diet, food habits, food preservation, nutritional survey, economic considerations, commercial propaganda regarding foods, solving nutritional problems, etc. An Israeli project[87] produced an agro-biology course for rural schools. The title of a paper[21] in Asia was 'Crops cannot be grown on a blackboard nor certificates eaten'. A recent world survey of school biology[115] noted that "during the 50s and 60s there was also a strong move to select biological concepts of greater relevance to everyday life. This was especially marked in the Third World. Content was related to issues such as personal health; conservation; agriculture; population control and economic management. At this stage, however, most syllabuses were still largely structured according to 'subject' criteria and the applied topics were 'grafted on' or treated as extensions."

2. Some topics of the 1970s which educators may wish to incorporate briefly into school courses may include the following:

Health: The world conquest of smallpox[19,61]
Prenatal diagnosis[50,131]
Non-invasive techniques (such as the use of ultra-sound) in medical diagnosis[40,183]

Nutrition: Food additives[90]

Agriculture: Pros and cons of such procedures as non-tillage agriculture[183] and intensive meat production[145]
High-lysine corn[62]
The use of artificially-induced mutations[156, 159]
Triticale (wheat-rye hybrid)[68]
Mode of action of a plant pathogen[174]

3. Asian educational investigations related to health and agriculture:

Health: Menarche[44, 127]
Myopia[138]

Agriculture: Earthworms and seed germination[59]
Fruits[100]
Grasses[53, 198]
Rice[53, 105, 199]
Vegetables, a genetical study[109]
Vegetative propagation from leaf[130]

D. Communicating to teachers the findings from biological research done within the teacher's country

Secondary school teachers would probably be happy and proud if they could use the findings from biological research done in their own country, for teaching biological concepts in their classrooms.

The research findings are, in practice, usually inaccessible to them in many Asian countries. This is due to a variety of reasons which include lack of library facilities, and difficulty in extracting suitable material even if library facilities are available.

A possible practical solution to this problem is for the curriculum development organization of the country to prepare the material and supply it to the teacher. The task would be rendered much easier in the case of countries that have a documentation centre which publishes an index of all the scientific publications in the country. This happens now in many Asian countries.

The task is wide in scope. The educator in charge of the programme must scan all the country's journals, with assistance from the documentation centre's science index. He must read the relevant papers and monographs, extract material which is suitable for teachers, write up the material, see it through press, and supply it to teachers with guidance regarding its use in the classroom. It would be desirable to collect information from the school teachers with regard to the usability of the material, and to revise the material accordingly. All this requires a separate person, or a separate small unit in the curriculum organization, for efficient handling.

Some cases of Asian efforts in this direction may be seen in reference nos. [17, 18, 41, 85].

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Appendix C: Tables from country papers showing content, practical experiences and skills in three aspects of biology teaching

Area of concern	Concepts/ Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values/ Intellectual skills
INDIA				
I. Environmental aspects:				
Lower Secondary				
A. Individuals, population and community	Population and species :characteristics of a population; population density; factors affecting population density—birth rate, death rate, immigration rate, emigration rate, effects of the environment on population, nutrient supply, available space, interaction with other organisms, weather. Community: characteristics of a community—trophic organization, stratification, dominance, variety of species, interactions between organisms such as predation, parasitism, scavenging, commensalism, mutualism, competition.	Study of the density of plant population Study of symbiosis, parasitism, through examples	Lecture/field visit/discussions/ examination oriented instruction	Population growth and consequences (by implications) Social relationships (by implications)
B. Ecosystem	Structural components of an ecosystem: producer, consumer, decomposer; major ecosystems of the world— Aquatic biomes: Marine — seas, sea shores, estuaries Fresh water — streams and rivers, ponds and lakes, marshes and swamps Terrestrial biomes: Forest — Tropical, temperate, taiga Grasslands — Tropical, temperate Desert Tundra Artificial ecosystem		Lecture /discussion/field trips examination oriented instruction	Awareness of variety of climates, flora and fauna—International understanding (by implications)

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values Intellectual skills
INDIA (cont'd)				
C. Biosphere	Flow of energy – solar energy, trapping energy pathway, food chains, food webs, trophic levels, amount of energy fixation Cycle of materials – carbon cycle, oxygen cycle, hydrogen cycle, nitrogen cycle, cycle of other ions		Lecture/discussions/ charts and diagrams	Conservation of energy (by implication), significance of recycling of materials; appreciation of balance and harmony in nature
D. Ecological crisis Maintenance of ecological balance; healthy interaction within biological community and between the biotic and physical components; Man will suffer if the ecological balance is disturbed; Man is capable of and has been changing the ecological balance; Population explosion; Technological and industrial advancements at cost of nature and environment.	Dependence of each part of a community on all other parts of it; crisis in the biological community: – destruction of forests, wild life – concept of natural habitat – disturbance of *cheetah→black duck→ grass* food chain causing soil erosion – pollution of water resulting in ecological imbalance – growth in human population, its rapid rate and consequences Crisis in the physical environment: – land and the loss of its fertility, soil erosion – water and imbalances resulting in flood and drought – pollution of meagre sources of water – universal effects of air pollution, sources of pollutants, types of pollutants, diseases due to air pollution – noise pollution	Local surveys, lab experiment to study water pollution, air pollution; chemical analysis of water	Lecture/discussion/examination oriented instruction	Students realize the nature and magnitude of ecological problems; Develop proper attitudes towards town planning, deforestation, reforestation, conservation of wild life, etc.; Appreciate the need for keeping population under control and can evaluate the environmental consequences of developmental efforts; Develop reasoning and the skill of establishing causality

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
E. Conservation of natural resources – judicious use of renewable and non-renewable resources, prevention of soil erosion, preserving soil fertility, conserving water resources, conserving forests and wild life	Nature of renewable and non-renewable resources; methods of preventing soil erosion; methods for retaining soil fertility (crop rotation etc.); steps for maintaining water cycle and for preventing water pollution; knowledge about wasteful methods in tree cutting; shifting cultivation preventing destruction of forests for urbanization and development Knowing about endangered species of plants and animals. Austere use of non-renewable resources and search for their alternatives Knowledge about the efforts of IUCN, UNEP, WWF, national legislations on environment, national parks and wild-life sanctuaries	Visit to national park, zoo and sanctuaries	Lecture/discussion/ examination oriented instruction	Realizing the need for conservation; organizing action groups for environmental concerns and actions; Awareness of legislations and development of the desire for implementing them; Realizing that every developmental project must give proper thought to its environmental implications
Higher Secondary				
A. Growth of human population – rapid increase in human population and its environmental consequences	Past, present and future of human population: – rise in population through ages – present growth rate and future trends – 'U' shaped and 'S' shaped curves – biotic potential and carrying capacity Factors controlling population density: – climate – location of water, soil, energy and mineral resources – transportation – urbanization – demographic factors		Lecture/discussion/ examination oriented instruction	Appreciating the need for limiting the growth rate of human population; developing positive attitude towards family planning; Realizing that an un-checked increase in population would lead to increased incidence of human miseries such as wars, epidemics, famine, etc. Realizing that an increase in population puts greater demand on the available resources

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
B. Soil, rainfall and temperature with reference to natural resources: – significance of water, soil and temperature for supporting life on earth	Role of water as a metabolic reactant; soil fertility and rainfall often determining the population distribution; temperature as a determinant of rainfall, soil formation and growth and density of plant and animal population: Soil – fertility, texture, structure, organic content, soil water and air Rainfall – Hydrological cycle, humidity Importance of water and temperature	Study of the population of plants or animals in a given area in two different seasons and representation of the data through graphs and histograms Chemical and physical analysis of soil moisture, pH, water holding capacity, chloride and phosphate	Lecture/discussion/ examination oriented instruction	Realizing the need for maintaining soil fertility
C. Our natural resources: – their use and abuse, conservation of forests and wild life – Limited stock of non-renewable resources such as minerals, fuels, and their abuses – abuses of renewable plant, animals and marine resources	Classes of earth resources (non-renewable): – minerals (metallic minerals in particular) – fossil fuels, their initial reserves and balance at hand – energy consumption pattern of selected nations – world energy prospects Renewable resources: – plant resources, grain crops, vegetables crops, oil crops, forests and forest based industries, forest management, wild-life conservation – water, its use and abuse, paucity of safe water, increase in per capita water consumption with the progress of civilization – marine resources, ocean as an alternative source of food, medicinal plants and industrial products – animal resources		Lecture/discussion/ examination oriented instruction	Developing proper attitude towards using the valuable renewable and non-renewable resources Realising the need for keeping pollution at minimum Developing proper attitudes towards forests as natural resources Developing concern for a sound and thorough environmental planning Developing awareness about various efforts and legislations about conservation

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
D. Environmental pollution: – living in polluted air and water – minimizing environmental pollution – recycling of waste for the longer use of resources	Environment, pollutant, environmental monitoring: Air pollution: – major air pollutants and their effects (sulphur oxides, particulates, aerosol, oxides of carbon and nitrogen etc.) – preventive measures and control – air quality standards Water pollution: – major pollutants and effluents (inert suspensions, poisons, inorganic reducing agents, oils, organic residues, hot water) by various industries by fertilizer application, insecticides etc. – biological oxidation demand (B.O.D.), chemical oxygen demand (C.O.D.) – treatment of waste water by reverse osmosis, recycling of waste Soil pollution: – pollutants and remedies		Lecture/discussion/ examination oriented instruction	Realizing the hazards of air, water, and soil pollutions Identifying actions for minimizing pollutions Developing proper attitudes for urban and industrial planning
E. Radiation and chemical hazards: – exposure of people, animals and plants to harmful radiations – nuclear fall out and associated hazards in the present nuclear age	Harmful radiations: – ultraviolet radiation – ionising radiations and their biological effects Chemical hazards associated with nuclear fall out – Iodine 131, Strontium 90 are the main elements of nuclear fall out and their effects on human health – protection measures against UV, nuclear wastes		Lecture/discussion/ examination oriented instruction	Realizing that nuclear energy should be properly used for peaceful purposes and not for war

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values/ Intellectual skills
INDIA (cont'd)				
II. Molecular and genetic aspects:				
Lower Secondary				
A. Molecular level of organization; cell theory; structure of cells; cell division	Various type of molecules constitute organelles, protoplasm as a complex, organized molecular aggregate; early cell studies – development of cell theory; structure of cells – plasmamembrane, cell wall, cytoplasm, cell organelles, centrosome, mitochondria, golgi, plastids, flagella, nucleus, nuclear membrane, chromatin, nucleolus (as seen under optical microscope); – cell and organelles as seen under the electron microscope; Cell division – mitosis (detailed) – meiosis (brief)	Examination of plant and animal cells Study of variety of cell types in various plant and animal tissues	Lecture/discussion/ charts and slides/ examination oriented instruction	Developing the skill of microscopic observation; international understanding (by implications)
B. Life processes: – role of molecules – molecules being broken down during digestion in man and their products – molecules being consumed and synthesized in photo-synthesis – intermediates in respiratory process – molecules in human blood – molecules being excreted – molecules for control and co-ordination	Digestion of food in man: enzymes, substrates and products Carbon-dioxide and water as raw materials, and carbohydrates and oxygen as final products of photo-synthesis Chlorophyll Energy rich molecules – ADP, ATP Process of respiration with the mention of important intermediates in glycolysis Molecular components of blood – haemoglobin, plasma proteins, electrolytes, etc. Water, CO_2, Urea, uric acid, salts as excretion products; hormones in animals and plants	Action of salivary amylase Oxygen evolution in photo-synthesis Essentiality of chlorophyll in photo-synthesis Experiment to demonstrate anaerobic respiration Tests for food constituents – protein, starch, sugar, fats	Lecture/demonstration/discussion/examination oriented instruction	Values of equality of man, international understanding through commonness in life; processes Development of reasoning through experimentation Inculcation of the spirit of working together through experiments

Areas of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values/ Intellectual skills
INDIA (cont'd)				
C. Molecules in genetics: – nature of genetic material (DNA, RNA)	Chemical structure of nucleic acids Reproduction of DNA		Lecture/discussion/examination oriented instruction	Values of equality of man, international understanding through commonness in life processes Development of reasoning through experimentation Inculcation of the spirit of working together through experiments
D. Variability in plants and animals	Causes of variation; genotype and phenotype; DNA structure	Experiments to show i) environmentally caused variations ii) genetically caused variations	Observations in the environment, on experimental plants Lecture/discussion/study of data to derive the ratios/visit to agricultural research institutes, etc.	Understanding of the variability in races of man as being superficial Development of insight into experimental methodology
E. Laws of transmission of genetic characters from parents to offspring: – application of the principles of genetics in many areas of agriculture and biology	Mendel's methodology; monohybrid cross and the law of segregation; concept of gene; dihybrid cross and the law of independent assortment		Lecture/discussion/study of data to derive the ratios/ visit to agricultural research institutes, etc.	Values of equality of man and international understanding through the knowledge of universal laws of inheritance
Higher Secondary				
A. Cell theory: – historical aspects of cell study and development of the cell theory	Definition of a cell, cytology and cell biology, early observations of Leeuenhoeck, Robert Hooke, Schleiden and Schwann, Dutrochet and Virchow, salient features of the cell theory		Lecture/discussion/examination oriented instruction	
B. Techniques of cell studies: – various experimental and instrumental techniques of cell studies	Microscopy, resolving power; electron microscopy; cytochemistry; auto-radiography; cell fractionalism; biochemical techniques; tissue culture	Paper chromatography enzyme cytochemistry	Lecture/discussion/examination oriented instruction	Appreciating the potentialities and limitations of various techniques

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values/ Intellectual skills
INDIA (cont'd)				
C. Detailed structure of cells (e.m. studies) and functions of cell organelles: – variety in shape, size and number – prokaryotic and eukaryotic cells – chemical composition – cell wall structure and function	Quantitative ideas of units and dimensions, sizes of cells and organelles, surface volume relationships, cell shapes in sperms, diatom, nerve cells, protozoan, muscles, liver etc.; nucleus, cytoplasm and organelles; percentages of various macromolecules of cells		Lecture/discussion/examination oriented instruction	Realization of the uniformity principles of life
– various models of plasma-membrane; pinocytosis and phagocytosis	Cell wall as protective cover and determinant of cell shape, matrix and fibrils of cell wall; unit membrane concept, plp sandwich, fluid-mosaic model, membrane transport; ingestion of liquid and solid particles by cell			
– endoplasmic reticulum, ribisomes – golgi structure and functions – lysosomes, peroxisomes and spherosomes	Rough and smooth ER, the network and lamellae components of ribosomes, polyribosomes and their functions, cisternes, enzymes of golgi, vesides etc.; primary and secondary lysosomes and their enzymes, lysosome cycle and function, enzymes of peroxisomes and spherosomes			
D. Energy transformation within the cell: – cellular energy and its roles	ADP, ATP, role of ATP in various cell processes		Lecture/discussion/examination oriented instruction	Appreciation of uniformity principles of cell energetics
– mitochondria as the power house of cell, its reactions – chloroplasts as transformers of solar energy	Structure of mitochondria, its compartments, cristae, elementary particles, oxidative phosporylation, details of glycolysis, Krebs cycle, mitochondrial electron transport, biogenesis of mitochondria; stroma, grana, thylakoids, light reactions – electron flow, chlorophyll molecule, Calvin cycle, C-4 pathway	Study of anaerobic respiration in yeast Paper chromatography for separation of plant pigments		

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
E. Interphase nucleus, enzymes and regulation of metabolic reactions	Ultra-structure of interphase nucleus, main functions of the interphase nucleus, chemical composition of the nucleus-DNA proteins and enzymes, nuclear pores; chemical nature of enzymes, mode of enzyme action, nomenclature and classification, factors affecting enzymes; regulation at the enzyme level, genetic level (operon concept)	Study of the hormonal regulation of alpha amylase synthesis in barley or maize	Lecture/discussion/ examination oriented instruction	Uniformity principles of regulation in organisms Making a mental model of a physiological process Appreciating the limitations of a hypothesis
F. Physical and chemical basis of heredity; role of nucleic acids	Nucleus as the carrier of genetic information: – Boveri's experiment – Hammerling's experiment in *Acetabularia* – nature of nuclear materials – Flemming's work on mitosis – meiosis and associated workers (Winiwater, Farmers and Moore) – similarity between the behaviour of chromosomes during division and characters during inheritance – establishing chromosomes as the carriers of hereditary characters; molecules in the nucleus, nucleoside, nucleotide, bases, phosphate, bonds in DNA and RNA molecules, DNA structures; Griffith's experiments, Avery, Macloed and McCarty's experiments, experiments with bacteriophages to establish DNA as the molecules of inheritance; Replication of DNA, Messelson and Stahl's work, Taylor's experiment; Transmission of genetic information, genetic code	Study of the chromosomes in grasshopper testis Preparation of DNA model	Lecture/discussion/ examination oriented instruction	Appreciating how scientific knowledge grows due to continuous experimentation, setting up of hypothesis, testing and contradicting or supporting a hypothesis Appreciating the uniformity principles of inheritance (equality and international understanding by implications)

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
G. Cell division	Details of mitosis and meiosis, amitosis	Study of mitosis and meiosis in plant and animal cells, study of permanent slides; preparation of mitosis and meiosis models	Lecture/discussion/examination oriented instruction	Equality and international understanding by implications
H. Principles of inheritance	Introduction to Mendel's work on pea, Principle of dominance, principle of purity of gametes, principle of segregation, principle of independent assortment, rediscovery of Mendel's work	Study of F_1 and F_2 ratios in monohybrid and dihybrid crosses	Lecture/discussion/examination oriented instruction	Appreciation of methodology of genetic research, equality and international understanding by implications
I. Linkage and crossing over	XX and XY conditions, work in *Drosophila* on linkage, crossing over, chromosome mapping, work in *Neurospora*		Lecture/discussion/examination oriented instruction	Same as 'G'
J. Gene expression and interaction	Incomplete dominance; one gene one enzyme hypothesis, sickle cell disease etc.		Lecture/discussion/examination oriented instruction	Same as 'G'
K. Mutation	Explanation, role in evolution and breeding, induction of mutation, molecular explanation, varietal improvements of rice, wheat, etc., through mutation		Lecture/discussion/examination oriented instruction	Same as 'G'
L. Quantitative inheritance	Skin pigmentation, cob length in maize, theory of polygenic inheritance		Lecture/discussion/examination oriented instruction	Same as 'G'
M. Human genetics	Basic approaches to study of human genetics, human chromosomes, autosomal abnormalities—chromosomal, due to multiple sets of genomes; disorders due to incompatibility of genes, Rh factor, ABO group		Lecture/discussion/examination oriented instruction	Same as 'G'
N. Genetics and society	Improvement of plants, improvement of animals, conservation of gene pool, genetic counselling, genetic engineering, protoplast fusion	Isolation of plant protoplasts	Lecture/discussion/examination oriented instruction/ general reading of popular literature	

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
III. Nutrition, health and agricultural applications				
Lower Secondary				
A. Functional anatomy of human reproductive system, pregnancy and child birth, infancy, childhood and adolescence; communicable diseases of man, nutritional disorders of man	Male reproductive system – testes, spermatogenesis – epididymis, – seminal vesicles – prostrate, – urethra Female reproductive system – ovaries – fallopian tubes – uterus – vagina – ovulation – fertilization – pregnancy – development of the foetus – nutrition of the foetus – hazards to the pregnant women and the foetus – birth of the foetus – new born baby – infancy and childhood, hazards – puberty – adolescence Symptoms associated with infections, causal organisms of communicable diseases, mode of infection, examples of diseases such as leprosy, cholera, measles, trachoma, venereal diseases, etc. Protein caloric malnutrition – marasmus – kwashiorkor		Lecture/discussion/examination oriented instruction	Overcoming superstitions in pregnancy, child birth, diseases, etc. through their scientific knowledge; equality and international understanding through the knowledge of human anatomy diseases, etc. (by implications)

Area of concern	Concepts/Principles from text or syllabus	Practical experiences for students	Teaching methodology	Developing values/ Intellectual skills
INDIA (cont'd)				
	Mineral deficiency diseases – calcium – iodine – fluorine – iron and other elements			
	Vitamin deficiency – vitamin A, B group, C, D, E, K			
	Over eating			
	Lathyrism			
B. Agricultural practices and animal husbandry	Crops and factors affecting crop production – soil – water – sunlight	Field trips to agricultural farms, research stations, etc.	Lecture/discussion/ field trip/examination oriented instruction	Appreciation of the role of agriculture and animal husbandry in Indian economy and development
	Crop plants – classification of various types of crops – varietal improvement – seed treatment – care of seedlings – transplanting – fertilizer application – irrigation – weed control – control of diseases and pests – use of plant growth regulators – multiple cropping			
	Improvement of crops – breeding – mutation – introduction – selection			

Area of concern	Concepts / Principles from text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
	Elements of animal husbandry – importance of domestic animals – management of livestock – common diseases of animals			
Higher Secondary				
A. Communicable diseases: Community health	Communicable diseases as a group of acquired diseases, battle against communicable diseases, foundations of parasitology, foundations of epidemiology, foundation of immunology, nature, cause and epidemiology of communicable diseases – infection, factors influencing – infestation – parasitism – pathogen – resistance		Lecture/discussion/examination oriented instruction	Realization of commonness in human suffering and desire to serve the suffering humanity (by implication)
	Classification of communicable diseases – diseases caused by bacteria (cholera, diptheria, tuberculosis, leprosy, tetanus, typhoid, plague) – diseases caused by virus (chickenpox, measles, polimyelitis, rabies) – diseases caused by protozoa (amoebiasis, malaria) – diseases caused by helminths (Filaria, tapeworm, roundworm) – preventive measures against communicable diseases (vaccination, sanitation, sterilization)			
B. Non-communicable diseases; alcoholism and drug addictions	Deficiency diseases – kwashiorkor – vitamin A deficiency		Lecture/discussion/examination oriented instruction	Development of attitude against the use of drugs and alcohol

Area of concern	Concepts / Principles from text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
	Degenerative diseases – causes and symptoms of heart diseases – heart attack – heart surgery – stroke – diabetes – arthritis – cancer – allergies			
	Alcoholism – effects of alcohol on health and family			
	Drug addiction – how it starts – effects of drugs (opium, products of hemp plant, products of cowa plant, LSD, barbiturates)			
C. Industrial microbiology	Antibiotics and their methods of production, food and beverages (cheese, bread making, vinegar, buttermilk, yogurt); organic chemicals and enzymes, dextrans, steroids		Lecture/discussion/examination oriented instruction	
D. Domestication of plants by man; important cultivated crops; diseases and pests of crops; livestock	History of domestication of crops, future of crop production, ocean harvest; cereals: rice, wheat, millets, pulses, oilseeds, fibre crops, vegetables crops, fruit crops, sugarcane	Study of locally available diseases and pests	Lecture/discussion/field trip/study of preserved materials, etc.	
	Diseases – history of plant pathology – classification – control (prophylactic, therapeutic, immunization) – seed borne diseases (symptoms, disease cycle and control of sesame leaf spot,			

Area of concern	Concepts / Principles in text or syllabus	Practical experiences for students	Teaching methodology	Developing values / Intellectual skills
INDIA (cont'd)				
	ergot of bajra, red rot of sugarcane, bacterial blight of rice, black arm of cotton) – soil borne diseases (green ear diseases of bajra, smut disease of bajra, tikka disease of groundnut, root rot of tomato) – air borne diseases (blast of rice, rust of wheat, coffee rust) – others			
	Classification of pests – arthropods – mammals – molluses – birds			
	Some important plant pests – stem borer of rice – pink ballworm of cotton – rice grasshopper – coconut caterpillar – paddy bug – tobacco caterpillar			
	Storage pests of rice and pulses – rice weevil – rice moth – red grain beetle – pulse beetle – lesser grain borer			
	Other cattle resources – breeds of cattle – feeding of cattle – dairy products – sheep and goat – diseases of farm animals – breeding of cattle – breeding of sheep and goat – poultry: feeding, housing, diseases and control, breeding			
	Fisheries			

Teaching contents with regard to environmental aspect

School level	Items prescribed in the course of study	Major items included in the textbook	Practical experiences for students	Teaching strategies, methodologies	Developing values / Intellectual skills
JAPAN					
Lower Secondary School (Grades 7–9)	Science (First area) (5) Relationships among living things a) Production and consumption in the world of life b) Resolvents in the world of life c) Relationships in the world of life	– Photosynthesis and light, photosynthesis and the amount of CO_2 – Consumption and storage of the product of photosynthesis – Consumption by animals – Interactions among living things in the soil – Resolution of carcasses and excrements by micro-organisms, and their utilization by plants – Relationship between autotrophs and heterotrophs – Balance in the natural environment	Experiments – Photosynthesis (iodine-starch reaction, measurement of 0_2 output) – Respiration (manometric method, relationship between photosynthesis and respiration) Collection and observation – Animals in the soil (Tullgren's method) Use of AV materials – relating to the world of life Extra-curricular activities – Survey of the relationship between the distribution of animals in soil and their environmental conditions	Lectures Practices and experiments – demonstration – peer-group learning – individual study Use of AV materials (both ready-made and self-made materials) – slides – video tapes – 8mm and 16 mm motion pictures – concept films – transparencies for OHP Application of experiences gained from extra curricular activities – presentation and discussion Use of modules	To understand that all the animals including human beings live on the product of green plants To make aware the conditions which support human beings To make aware the importance of the balance in the world of life in developing and utilizing the environment To acquire 'scientific method' to be able to design experiments, consider the results and lead to the conclusion To develop attitudes to apply scientific principles to the events of daily life
	(7) Human beings and nature a) Substance and energy which support the life of human beings	– Air, water, soil, sunshine, etc., as living environment of the living things – Substance used by human beings (produced by living things; underground resources)	– Survey of the relationship between living things in the water and water pollution – Survey of the relationship between air pollution and index plants		

School level	Items prescribed in the course of study	Major items included in the textbook	Practical experiences for students	Teaching strategies, methodologies	Developing values / Intellectual skills
JAPAN (cont'd)					
Lower Secondary School (cont'd)	b) Balance in nature and environmental preservation	– Energy used by human beings (energy from the sun, atomic energy, etc.) – Cycle and balance of energy and substance in the world of life – Development and use of natural environment and its preservation	Field trips – To reclaimed land, drainage disposition facilities, nuclear power stations, pollution research centres, etc.		
Upper Secondary School (Grades 10–12)	Biology II (2) Ecology a) Groups of living things and their organization b) Organization and changes of ecosystem c) Flow of energy in ecosystem	Population density; population growth; order; symbiosis; parasitism, competition; vegetation; succession; distribution; ecosystem; food chain; pyramid of numbers; photosynthesis and respiration; compensation point; production rate; productive structure; life form; material cycle; energy flow; equilibrium of ecosystem; conservation of environment	Experiments and practices – Experiment of the multiplication of Drosophylla, etc. – Observation of parasites and symbionts – Survey of vegetation – Measurement of compensation point – Survey of organism communities in the soil Use of AV materials – Relating to vegetation succession, distribution of living things, etc. – Extra-curricular activities (almost same as lower secondary schools)	Almost same as the above	To understand basic concepts and principles; to learn scientific methods; to develop scientific attitudes; and to inculcate proper views on natural environment and life

Teaching contents with regard to environmental aspect
(Prescribed in the new course of study for upper secondary school)

School level	Subject	Items prescribed in the course of study	Special instructions for teachers
JAPAN (cont'd)			
Upper Secondary School (From 1982)	Science I	(4) Balance in the natural environment – Ecosystem and cycle of substance	Should focus on the flow of substance and energy, and teach organic and inorganic nature
		(5) Human beings and nature – Resources	Should deal with fossil fuel as an example and their characteristics and limited deposits
		– Use of solar energy and atomic energy	Should teach their utilization as energy resources and deal with radioactivity
		– Preservation of natural environment	Should teach the influence of natural environment upon human beings and the influence of the activities of human beings upon natural environment
	Science II	(2) Survey of natural environment	Should teach methods of field surveys concerning biology and earth science and problems relating to natural environment
	Biology	(4) Groups of living things a) Formation of groups of living things – groups of animals; – groups of plants	
		b) Changes in groups of living things – changes of groups of animals; – successions; – distribution of living things	As for 'distribution of living things', its focus should be on the ecological distribution, and it should not merely teach geographical distribution of living things in the world

Teaching contents with regard to molecular and genetic aspects

School level	Items prescribed in the course of study	Major items included in the textbook	Practical experiences for students	Teaching strategies, methodologies	Developing values/ Intellectual skills
JAPAN (cont'd)					
Lower Secondary School (Grades 7–9)	(Hardly any relevant item is included)				
Upper Secondary School (Grades 10–12) Until 1982	Biology I (1) Metabolism and energy metabolism a) Cell structure and functions of cells, and components of cells b) Chemical reactions and enzymes in the organism: – special features of chemical reactions, enzymes and their effects in the organism c) Assimilation and dissimilation: – photosynthesis – respiration	Microstructure and functions of cell; bioelements; substances constructing cells; osmosis Metabolism; characteristics of enzymic reaction Photosynthesis (dark reaction, light reaction); chemosynthesis; nitrogen assimilation; respiration (anaeroblic respiration, aerobic respiration, fermentation, glycolysis, Krebs' cycle); ATP and ADP	Experiments – observation of a cell – measurement of osmotic pressure of plant tissue – enzyme (amylase, catalase, dehydrogenase, etc. – photosynthesis and environmental factors – measurement of respiration rate – paperchromatography of photosynthetic pigments	Lectures Experiments and practice – demonstration – peer-group learning – individual study Use of AV materials (mostly ready-made materials) – video tapes – 8mm or 16mm motion pictures – TP for OHP 'Dry-Lab' Modules of teaching materials	Through understanding of basic principles, inculcate proper view of life – unity of life – continuity of life – microscopic view on life To learn appropriate use of instruments and apparatus for experiments To acquire 'scientific methods' to be able to design and carry out experiments; to formulate hypotheses from the results and rules, etc. To inculcate statistic view and thinking To apply the principles of heredity to actual cases of hereditary diseases and characters

School level	Items prescribed in the course of study	Major items included in the textbook	Practical experiences for students	Teaching strategies, methodologies	Developing values/ Intellectual skills
JAPAN (cont'd)					
Upper Secondary School (cont'd)	(3) Continuity of life a) Reproduction b) Development and differentiation c) Heredity and variation	Character and gene; crossing; Mendel's law; linkage; cross-over; sex-linked inheritance; colour-blindness; chromosome map; blood types; mutation; fluctuation; nucleic acid	Experiments – segregation in F_2 of Drosophylla – observation of salivary gland chromosome – histochemistry of nucleic acids		To consider the inevitability and contingency in the development of science through the learning of the achievement of Novel Prize Winners which made biochemistry and genetics into molecular genetics
	Biology II (1) Phenomena of life and and molecules a) Metabolism and energy metabolism – their relationship b) Macromolecules consisting of organisms – structure and specificity of protein and structure of nucleic acids c) Genes and phenotypic expression – transmission of hereditary information; mechanism of the phenotypic expression	– mechanism of enzymic reaction (co-enzyme, apo-enzyme) – mechanism of photosynthesis (Calvin cycle, photochemical formation of ATP) – mechanism of respiration (glycolysis, Krebs cycle, electron transfer system, chemical formation of ATP) – structure and specificity of protein; antigen–antibody reaction – mechanism of muscle contraction (sliding theory) – structure of nucleic acids (DNA, RNA) duplication of DNA	Experiments and practice – co-enzyme and apo-enzyme – hill reaction – quantitative measurement of respiration/ photosynthesis – muscle contraction by ATP – making model of DNA		

School level	Items prescribed in the course of study	Major items included in the textbook	Practical experiences for students	Teaching strategies, methodologies	Developing values / Intellectual skills
JAPAN (cont'd)					
Upper Secondary School (cont'd)		— functions of DNA and RNA in protein biosynthesis, genetic code (triplet theory), operon theory			
	(3) Evolution of living things				
	a) Origin of life				
	b) Mechanism of evolution — theoretical basis of evolution; explanation concerning mechanism of evolution	— random mating; — Hardy-Weinberg's law	Experiments — simulation of random mating		

Teaching contents with regard to molecular and genetic aspects
(Prescribed in the new course of study for upper secondary schools)

School level	Subject	Items prescribed in the course of study	Special instructions for teachers
JAPAN (cont'd)			
Upper Secondary School (Grades 10–12) From 1982	Science I	1. Forces and energy 2. Structure and transformation of substance 3. Evolution: – cell and cell division; reproduction and development; heredity and variation; evolution of living things 4. Balance in the natural world 5. Human beings and nature	As for teaching of cells, it should be limited only to the things which can be observed by optical microscopes. As for development, the process of the early development of animals be emphasized. Heredity should be focused on the Mendel's laws and variation be on mutation. Evolution of living things should also deal with index fossil.
	Science II	1. Observation and experiments of specific phenomena 2. Survey of natural environment 3. Research on historical cases of science	Should give more than one research topics among the three, and carry out in the teaching plan of the year.
	Biology	2. Organisms and energy a) Metabolism and energy metabolism – chemical reactions and enzymes in the organism; assimilation and dissimilation b) Genes and phenotypic expression – structure and duplication of genes; genes and enzymes	As for assimilation, it should be taught, to the extent that students understand the existence of light and dark reactions. When glycolysis, TCA cycle and electron transfer system are taught in connection with respiration in the teaching of assimilation, they should not be treated in depth. As for genes and enzymes, the mechanism of phenotypic expression of genes should be simply taught.

Teaching contents with regard to the application of health, nutrition [illegible] agriculture

	Types of school	Subject / Grade	Items prescribed in [illegible] course of study
APAN (cont'd)		Science	(No item of direct relevance to health)
pplication to health	Lower Secondary School	Physical Education (Health) Grade 7	(1) To understand the mental and physical growth a) Development of the function of breathing and circulation; Occurrence of the second sexual characters (including sex and individual difference) b) Development of athletic motor skills c) Development of the cerebrum in comparison with the development of mental functions; influence of life experience d) Proper care and fulfilment of human desires
		Grade 8	(2) To understand health and environment a) Adaptability of human bodies to the change in natural environment b) Conditions of temperature and illuminance in the room for comfortable and efficient life c) Permissible density of CO_2 and CO in the air within the room d) Formation of Vitamin D by sunlight and sterilizing power of sunlight e) Artificial means to secure clean water for daily life f) Hygienic disposition of living and industrial wastes (the relationship between pollution and health should be taught in accordance with the situation of the community)
		Grade 9	(3) To deepen the understanding of the prevention of accidents, injuries and diseases a) Causes of injuries and their prevention b) Emergency treatment c) Causes of diseases and their prevention d) Early diagnosis and treatment of diseases (4) To understand health and daily life a) Promotion of health through appropriate physical exercises b) Consumption of energy through physical exercises and work c) Well-balanced nourishing food d) Fatigue and its recovery e) Maintenance of health of group members and activities of health centres

	Types of school	Subject / Grade	Items prescribed in the course of study
JAPAN (cont'd)			
Application to health	Upper Secondary School	Science	(No item of direct relevance to health)
	(Until 1982)	Physical Education (Health) Grades 11–12	(1) Health and physical functions a) Significance of health and its requirements b) Physical changes by age c) Physiology of physical adaptation to the environment d) Physiology of physical activities (2) Mental health a) The cerebrum and mental functions b) Desires and their fulfilment c) Mental handicaps and mental health (3) Diseases and their prevention a) Causes of diseases b) Progress of diseases c) Prevention of diseases (4) Accidents and disasters, and their prevention a) Factors in the occurrence of accidents and disasters b) Labour disasters c) Traffic accidents d) Emergency treatment (5) Daily life and health a) Family life and health b) Vocational life and health c) Community life and health (6) National health a) Present situation concerning national health b) Public health activities, and health and medical care systems c) Progress of public health activities, and the maintenance of a healthy society

	Types of school	Subject / Grade	Items prescribed in the course of study
JAPAN (cont'd)			
Application to health	Upper Secondary School (From 1982)	Physical Education (Health) Grades 11–12	(1) Mental and physical functions a) Functions of each physical organ and their co-ordination b) The cerebrum and mental functions c) Desires, and their fulfilment and control d) Mental-physical relationship (2) Health and the environment a) Civilized society and health b) Health problem due to the pollution of the natural environment and their prevention c) Harmony between health and the natural environment (3) Occupations and health a) Occupational diseases and labour disasters b) Maintenance of safety and hygiene in the place of work, and the promotion of health c) Rehabilitation (4) Health of the group a) Healthy family life b) National health standard c) Public health activities, and health and medical care system
Application to health	Lower Secondary School	Home-making (nurture) Grade 9	(1) Mental and physical development of infants a) To know the stages of development of weight, height and physical motor skills b) To know the trend of development in linguistic and emotional skills, and sociability (2) The following points in respect of the clothing and eating of infants a) To examine ways of selection and the wearing of clothes in accordance with the usage b) To be able to make infant clothes for play c) To be able to prepare one day menus for infants d) To be able to prepare snacks for infants e) To examine the necessity to help infants develop living habits in regard to clothes and meal (3) To examine the relationship between the growth of an infant and his environment

	Types of school	Subject / Grade	Items prescribed in the course of study
JAPAN (cont'd)			
Application to nutrition	Lower Secondary School	Home-making (Food) Grade 7	(1) To understand the nutrition of youths and menus of daily meals (2) The following points in respect of the characteristics of food and its selection a) To know the nutritional characteristics of food b) To know the characteristics of rice, fish, meat, vegetables, salt and *Miso* (bean paste) in cooking c) To be able to distinguish the quality of grains, perishables and others
		Grade 9	(1) To understand the nutrition needed by an adult, and to be able to prepare menus of daily meals
		Science	(No item of direct relevance to nutrition)
		Science	(No item of direct relevance to nutrition)
Application to nutrition	Upper Secondary School (Until 1982)	Home-making (Food I)	(1) Functions of nutrients a) Calorie metabolism b) Kinds of carbohydrates and their metabolism c) Kinds of fats and their metabolism d) Kinds of proteins and their metabolism e) Kinds of inorganic substances and their physiological functions f) Kinds of vitamins and their physiological functions (2) Digestion and absorption a) Appetite b) Digestion and digestive enzymes c) Absorption and waste discharge d) Rate of digestion and absorption (3) Computation of amounts of necessary nutrients a) Calories b) Proteins c) Inorganic substances d) Vitamins (4) Special nutrition a) Nutrition for maternity b) Nutrition for infants and pre-school children c) Nutrition for adolescents d) Nutrition for aged people (5) Processed food a) Livestock products b) Agricultural products c) Marine products d) Other processed food

	Types of school	Subject / Grade	Items prescribed in the course of study
JAPAN (cont'd)			
Application to nutrition (cont'd)	Upper Secondary School (Until 1982)	Home-making (Food I)	(6) Food sanitation a) Food poisoning b) Rottenness c) Food additives d) Orally transmitted diseases e) Food sanitation inspection (7) Menus (8) Cooking (9) Food expenses in family life
	Upper Secondary School (From 1982)	Home-making (General family) Grade 10	(1) Designing of home life and a family (2) Clothing and its production (3) Formation of eating habits and cooking 4) House and its management 5) Maternity health and nurture of infants 6) Home-projects and family clubs in school
Application to agriculture	Lower Secondary School	Science	(No item of direct relevance to agriculture)
		Home-making (Cultivation) Grades 8-9	(1) To be able to develop a plan for crop cultivation (2) The following points in respect of the environment suitable for crop cultivation and its adjustment a) To understand the relation between the growth of crops and its environmental conditions b) To understand the relation between the growth of crops and soil and fertilizers (3) The following points in respect of the cultivation of crops with adjustment of the environment a) To be able to implement proper managerial work in accordance with the growing process of crops b) To be able to prevent and eliminate properly diseases and blight of crops c) To be able to grow flowers or vegetables with adjustment of the environment such as maintaining warmth and temperature control (4) To examine the relation between cultivation and life
	Upper Secondary School	Science and all other subjects	(In the general course, there is no item concerned with agriculture. In the agriculture course, agriculture is taught as its specialized subject)

Area of concern	Concepts / Principles in syllabus	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
MALAYSIA				
1. Environmental aspects:				
Soil as a habitat	Structure of soil, organisms living in soil, food relationships within the soil community	Experiments on comparison, acidity, air, water. Extraction of soil organisms from drying soil by use of lamp. Extraction of partially aquatic animals (A Baerman funnel)	Observation, deductions and discussion. Influence of factors such as illumination, energy, air and temperature. Identification of animals and numbers extracted	Able to understand the interrelationships in a community. Soil is made up of organic and mineral components. Presence of soil fauna. Understanding of the relationship and distribution of food. Variety of animals
Interdependence of living organisms with the environment	a) Concept of a habitat. Diversity of habitats and uneven distribution. Survival factor. Colonization competition and succession	Examining the surface of a tree. Qualitative and quantitative estimations. Method of sampling. (Yellowish green, light green and dark green)	Class study, observation, inference and discussion	Be able to measure and account for the hypothesis for unevenness of distribution. Survival in moderately moist conditions where illumination is moderate
	b) Distribution of organisms in a pond	Field trip. Survey of pond. Taking light readings, acidity of water, temperature. Collecting aquatic organisms using a plankton net	Practical procedure. Working in groups at different stations. Random sampling and recording. Inference and discussion	Conservation principles are maintained. Correlation and ideas of food chain and food web. Succession
	ALTERNATIVE			
	c) Uneven distribution of a Belukar	Study of environmental features. Factors affecting distribution	same as above	Discussion on dispersal Colonization and adaptive features in relation
Air pollution	Effects of pollution	Practical procedure. Measurement of oxygen and air. (J-tube method)	Practical, observation and inference. Local case studies and reading. Assignment on other forms of pollution	Awareness of the serious effects of pollutants on humans, other animals and plants
2. Molecular and genetic aspects	Gas exchanges in cells. Respiratory mechanisms. Respiration and production of heat. Chemical energy obtained from the oxidation of sugars. Tracing the path of carbon from carbondioxide	Practical experiments on yeast suspension mixed with 10 per cent glucose solution. Recording and observation. Observation of respiratory surfaces of small animals	Experiment, demonstration and discussion. Discussion on mechanism of breathing. Class study on respiration and the production of heat mechanical energy, ATP (Reading)	Understanding of cells and the respiratory systems. Knowledge of how energy produced is used to do mechanical work. ATP and energy on 14 C. labelled glucose and tracing the path of carbon

Area of concern	Concepts / Principles in syllabus	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
MALAYSIA (cont'd)				
Growth	Investigate methods of measuring growth in animals and plants. Growth of the whole organisms Cell division and growth	Practical work. Growing points in plants. Observation of a stump of a tree	Patterns of growth in trees. (Reading) Patterns of growth in animals (reading)	How to measure growth? Able to interpret growth curves
		Cell division observed in cells of root tip. (Practical) (Using acets-orcein stains) Observing stages of mitosis	Observation and recording and identifying different stages of mitosis	Process of nuclear division. Mitosis is a non-reductional division in which the daughter cells acquire the same complement of chromosomes as the parent cell
Reproduction and development	Role of fertilization in sexual reproduction. Complete metamorphosis and gameto genesis	Introduction to sexual reproduction. (Discussion) Practical observations from the eggs of frog or toad. Life cycle the house fly (Practical procedure) Examination of locust tests. Stages of Meiosis (Class study). Variation. Similarities and differences in finger prints. (Practical). Inheritance of sex	Discussion, practical, observation and answering questions. Material of inheritance (Reading) Explanation and discussion Inheritance of physical traits (Class study)	Understanding of sexual reproduction, ways of breeding (general understanding). Internal and external fertilization
				Awareness of the similarities and differences that occur in living things. How these variations arise and their importance in life. Sex determination, X and Y chromosomes
3. <u>Health, nutrition and agricultural aspects:</u>				
Organs	Working of the lungs artificial respiration	Route taken in by inhaled air (Class study). How the chest volume is increased. (Class study). Action of the diaphragm	Observations and discussions. Use of diagrams and models. Practical experiment measuring exhaled air	Knowledge of respiratory mechanisms of large animals
	The working of the human digestive system.	Experiments on testing the effect of saliva on starch solution. The gut wall as a barrier. (Practical	Studying human digestion. Discussion, charts and models	Understand the digestive systems and action of enzymes

Area of concern	Concepts / Principles in syllabus	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
MALAYSIA (cont'd)				
Organs (cont'd)		using, Visking tubing, sugar and starch solution). Dissection of a small mammal		
	How animals feed Types of teeth.	Dentition. Examination of the cockroach's feeding apparatus (Practical procedure). Fluoride and tooth decay (Class study)	Observation, discussions. Diagrams and models	Structure, classification into deciduous and permanent teeth
Transport system in mammals	Why do animals need a transport system. The use of physical principles to interpret mechanisms in living organisms. Structure is related to function	Watching blood systems in action. (Practical procedure). Freshwater shrimps, *Gammarus*, tadpole. Vessels and their functions. What is blood? (Practical). Examination of mammalism blood. Circulation. The heart (Class study). The lymphatic system	Practical experiments. Determining and identifying the different vessels involved. Diagrams. Discussion.	Understanding of transport systems in man. Knowing the mode of action of the heart. Knowledge of the circulation system
	The eye, ear and the nervous system.	Structure of the eye (Practical procedure using goat's eyes, ears . . . The reflex action. Nervous system	Observation, questions, answers and discussion. Use of models and diagrams	Understand structure and functions.
Smoking and health	Diseases and lungs		Smoking and health (Reading) Discussion	Awareness towards lung cancer
Food and life	Kinds of food. Balance diet, problems of a balanced diet, Eating the right kind of food	Tests for starch, reducing and non-reducing sugars, fats and proteins. Dichlorophenol–indophenol (DCPIP) test for ascorbic acid	Discussion and deduction. Background reading to charts, tables	Importance of food, its sources and values

Area of concern	Concepts / Principles in syllabus	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
MALAYSIA (cont'd)				
Microbes and man	Presence of micro-organisms	Are there bacteria on our bodies and in our food? (Practical procedure). Testing milk for freshness. Growth of mould (Practical procedure). Effect of penicillin on *Bacillus subtilis*. Use of disinfectants (*Practical*)	Practical experiments observations and inference. Discussion. Reading material	Prevention of disease. Stressing problems relating to the maintenance of human health. Prevention and cure of diseases. Understanding of body's reaction to infection
	The spread of disease by mosquitoes		Discussion on charts showing the life-history of Plasmodium	Awareness to ways and means of controlling the spread of the disease.
Plant nutrition	Synthesis of carbohydrates	Plants, animals and carbon-dioxide. (Practical procedure using bicarbonate indicator)	Discussion on carbon dioxide exchange	The essentials for plant nutrition and its importance for normal healthy plant growth
	Minerals in soil needed for healthy plant growth	Growth in different conditions (Practical procedure)	Ions as plant food	
		Investigating the growth of maize in culture solution (Practical procedure)	The plant cell – a storehouse of ions. Discussion	
	Effects of soil erosion, importance of conservation	Soil profiles	Discussion on soil conservation, crop rotation, circulation of nutrients (Nitrogen)	To understand the effects of soil erosion, the importance of soil conservation. Influence of soil organisms. Importance of crop rotation and nitrogen cycle
		Colonization of soil film. (Practical procedure). (Using moist cellophane covered slides)	Soil bacteria. Harmful and useful organisms in the soil	
Water as a transporting medium in plants	Maintaining a balance in terrestrial plants. Two-way flow in plants	Examining root tips (Practical procedure). Investigating the upward flow in a stem (Practical). Examining a view from a stem (Practical procedure)	Experimentation, observation and discussion	Understanding transport in plants. Structure related to function. Understanding of the distinct roles of xylem and phloem
Plant behaviour	Responses of plants to stimuli. Plant hormones. Nastic movement	Do plants respond? (Practical) Responses in roots (Practical procedure). Nastic movement (Practical procedure)	Observation, questions and answers. Discussion on the role of plant hormones	To assemble a few simple experiments which will introduce the idea of tropism. Plant hormones as a means of integration

Area of concern	Concepts/Principles in syllabus	Practical experiences for students	Teaching strategies/ methodologies	Developing values / Intellectual skills
MALAYSIA (cont'd)				
Parasites	Plants parasitic on other plants Parasites which kill hosts Control of cocoa pests. Bagworms on oil palms Biological controls	An animal parasite on a plant. (Practical procedure) (Lady's finger attacked by the larvae *Earias fabia*, a moth). Symbiosis (Practical study)	Observation of specimens, questions and answers. Discussion	Understanding of parasite–host relationship. Understanding of biological control: in suitable conditions, a parasite on predator which kills its host or prey can be used as a biological control

Biology Curriculum of the Ministry of Education and Culture: High School Science II (Reference: HSS II (Text and Teacher's Guide): Living things and their environment

Area of concern	Concepts/Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values/Intellectual skills
PHILIPPINES			
I. Human ecology and aspects of the environment Man and his role in the environment	1. Studying our environment: a) population and community of organisms b) definition of an ecosystem c) relationships of organisms in an ecosystem d) other relationships in an ecosystem e) the flow of energy and materials in the ecosystem f) chemical cycles in the environment g) the flow of energy and materials in the corn-peanut field 2. Some activities of man in the environment: a) improper waste disposal b) chemicals to kill insects c) dirty air d) improper logging e) increase of Filipino population	1. Outdoor activity which includes survey of components of ecosystem, and collection of specimens, i.e. lichens and flagellates 2. Microscopic study of organisms in the laboratory 3. Interpretation of visuals and pictorials on: a) habitat, population, communities b) relationship of organisms in an ecosystem c) the flow of energy and materials in the ecosystem 4. Reports on life history of host-parasite relationship 5. Relate experiences in the use of fertilization/manures in plant cultivation 6. Discussion on proper conservation measures 7. Survey the type and extent of pollution in their communities and measures taken by local officials to check pollution 8. Invite resource persons to talk on local problems 9. Conduct trips to national parks	Use of real-life situations, introduce conservation principles, i.e., avoid over collection Logical interpretation of visuals, relevance of pictures Dissection of flagellates and use of microscope Ability to do survey work on components of ecosystem Decision-making re-proper management of human and natural resources Appreciation of beautiful parks, healthy plants Awareness of local issues Ability to make survey, gather reading materials, gather pesticide/herbicide labels for display in class Ability to follow instructions during simulation games

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
		10. Gather reading materials from the National Pollution Commission	
		11. Secure and bring to class labels of common pesticides and herbicides	
		12. Use of current related articles from journals and magazines	
		13. Mini-census on community population	
		14. Discussion on wise management and efficient utilization of natural and human resources	
		15. Simulation games on "How can a Filipino conserve his environment ? "	
II. Rural community The continuity of life	1. Reproduction in living things a) importance/kinds of reproduction b) Asexual reproduction in plants 2. Transmission of characters application of genetics	1. Dissection of potato into pieces and planted in pots 2. Relate experiences on vegetative propagation of plants they have cultivated 3. Gather information on selective breeding in plants and animals, from magazines, journals and newspapers 4. Interview resource persons like agriculturists and veterinarians 5. Present statistics on rice production done at the IRRI 6. Discussion on application of genetics in selective breeding to food production	Use of real life situations in explaining the concept Ability to ask relevant questions from resource persons Ability to interpret statistical data Decision-making on what plants to propagate for increased food production
III. Community health, hygiene and nutrition The functioning organism	1. Life activities of living organisms a) food is the source of energy b) digestion of food in man c) energy in food	1. Discussion of basic food groups based on chart obtained from Food and Nutrition Research Institute	Awareness of proper food nutrition Evaluation food intake of the individual

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
Man and his role in the environment	2. Some activities of man in the environment 3. Improper disposal of waste and its effect on community hygiene	2. Report on different vitamins and their effect on living organisms 3. Invite resource persons from local health centre to talk about importance of proper nutrition 4. Laboratory activity on "What do foods contain?" 5. Class survey on "Foods I have eaten today." 6. Activity on iodine test for starch, action of bile on fats 7. Discussion on digestive process 8. Computation of total calorie requirement in a day 9. Collect press clippings and other printed matter on water pollution and diseases caused by water contamination 10. Report on readings done by students 11. Discussion on how wastes dumped into rivers affect living organisms 12. Discussion on the different diseases caused by contaminated water such as dysentery, typhoid, cholera and parasitic infection; the role of insects like flies, mosquitoes and cockroaches in the spread of diseases	Following experimental procedure The use of metric system Awareness on proper waste disposal
IV. Skill development Living things: plants and animals	1. How scientists work a) working like a scientist b) characteristics of an experiment	1. Investigation of the growth of mango seeds	Identifying / stating problem

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
		2. Discussion based on the activity	Following procedure in setting up an experiment
		3. Demonstration on how average length of the root is measured and computed	Observation with some degree of accuracy
		4. Discussion on methods and nature of science, qualities of a scientist	Recording observations
		5. Reading assignments on work of F. Redi	Measuring in the metric system
		6. Design experiments based on a few situations, application of what was learned about scientific process	Computing / tabulating observations
			Interpreting observations based on the problem of the experiment
			Application of concepts
V. Use and conservation of natural resources Man and his role in the environment	1. Some activities of man in the environment: a) improper disposal of waste b) chemicals to kill insects c) dirty air d) improper logging e) increase of Filipino population f) how can a Filipino conserve his environment	1. Simulation games	Following instructions
		2. Discussion on concepts and practical application	Appreciation for beauties of nature
		3. Outdoor activity / field trip	Awareness of environmental catastrophes caused by man
		4. Diagram cycles in the environment; examples of food chain / food web	Using arrow diagrams in food chain / food web
		5. Invite resource persons	Relationship with resource persons and community members
		6. Survey on how waste is disposed	Awareness on the limits for use of pesticides
		7. Relate experiences on use of pesticides in farms	Relate effect of over population to available natural resources
		8. Mini-census on population of community	
VI. International understanding	1. History of science	1. Class discussion on scientific work / scientific discoveries	Gathering correct information
	2. Biological researches and biographical sketches of scientists	2. Contest or quiz show	Appreciation for the work of others
	3. Experiments to demonstrate biological principles, i.e., Mendel, Darwin, etc.	3. Reading assignments	

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
VII. Environmental pollution and control Man and his role in the environment	1. Some activities of a) man in the environment b) improper disposal of waste c) chemicals to kill insects d) dirty air e) how can a Filipino conserve his environment	1. Text reading 2. Simulation games and role playing 3. Case studies on activities of man in the community 4. Community programmes to minimize local community problems in the environment	Following instructions Preparing case studies Awareness of community problems Understanding of community problems and doing something to minimize/solve the problems
VIII. Molecular aspects The functioning organism Man and his role in the environment	1. Living organisms need food a) light and photosynthesis b) raw materials needed in photosynthesis c) the products of photosynthesis 2. Life activities of living organisms a) food is the source of energy b) energy in food 3. Studying our environment a) flow of energy and materials b) chemical cycles	1. Laboratory experiments 2. Class discussion 3. Microscopic study of leaves 4. Reading assignments 5. Research on recommended daily requirement 6. Class discussion on use of food, nutrients found in food, function of each nutrient 7. Computation of total calorie requirement in a day 8. Class discussion on total calorie requirement, factors to determine total calorie requirement 9. Class discussion on flow of energy and materials in the ecosystem and chemical cycles	Understand work of scientists Manipulating the microscope Awareness of correct food requirement computation using metric system
IX. Genetic aspects The continuity of life	1. Transmission of characters a) variation in man b) experiments of Mendel c) genotype / phenotype d) dominant/recessive trait e) hybrid, alleles, and other terms in genetics f) carriers of hereditary traits	1. Mini-survey of physical traits of members of class 2. Make family survey of family traits 3. Exercise on fingerprint pattern 4. Diagrams and symbols of phenotype/genotype 5. Diagram of cell/chromosomes/DNA	Appreciation of the science of genetics Awareness of own traits Relate heredity with environment in the development of organism Decision-making on what is important in the development of an organism, heredity or environment

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)	g) meiosis and the transfer of traits h) number of chromosomes i) sex determination j) changes in the gene k) applications of genetics l) heredity and the environment m) patterns of inheritance in man	6. Collect clippings on news items on selective breeding applied to plants and animals, tacked in bulletin boards 7. Collection of handouts or pamphlets as basis for class discussion 8. Debate on: "What is important in development of an organism – heredity or environment?"	

Biology Curriculum of a Special Science High School
(Reference: Course Guide of Quezon City Science High School)

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES			
I. Human ecology and aspects of the environment (Bio – Level 1)	1. The many kinds of living things a) environment causes diversity in living things b) living things tend to adapt to their environment	Lectures of resource persons Film showing Class-discussion	Awareness of presence of living things and their adaptations in the environment
	2. Population, community, ecosystem a) animals and man have structures in their cells that generate energy needed to support their body functions	Laboratory work Class discussion	Ability to relate structure-function relationship
	3. Biology as a solution to man-made problems a) alternative food sources from the environment b) ecological balance and imbalance c) pest control d) scientific farming e) marine ecosystem, coral and mangrove f) algae farming	Nature studies Field trips Laboratory experiments Lectures of resource persons Practicum	Ability to do in-depth studies on specific topics using various resources Relate, understand and evaluate the role of biology in solving man-made problems
II. Rural community (Bio - Level 1)	1. Biology as a solution to man-made problems a) pest control b) asexual reproduction in plants for food production c) alternative food sources from the environment d) scientific farming	Nature studies Specimens collection Field trips Laboratory experiments Invite resource persons Individual research Class discussion Practicum	Relate, understand and evaluate the role of biology as a solution to man-made problems in the community Use of real-life situations in explaining concepts Ability to ask relevant questions from resource persons

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)	e) marine ecosystem, coral and mangrove f) algae farming		Decision making on choice of plants to propagate for increased food production
III. Community health, hygiene and nutrition (Bio – Level 1)	1. Nutritional requirements of animals and man a) food from green plants b) food requirements for growth, maintenance of life	Graphic models Charts and visual aids Laboratory experiments Research analysis Class-discussion Food preservation Field study Energy diagrams	Realize importance of plants Awareness on proper food requirements of animals and man
	2. Organ system a) structures for waste disposal b) the human kidneys c) gas exchange and food intake d) living organisms and man react to environmental changes e) effects of nicotine, alcohol, drugs	Models Charts and visual aids Class discussion Laboratory studies Case studies	Awareness of structures present in living organisms Awareness of proper waste disposal Awareness of effect of nicotine, alcohol and drugs on the organ-system
IV. Skill development (Bio – Level 1)	1. The microscope a) parts and use of the microscope b) cutting and mounting specimens to be examined under the microscope	Laboratory work Class discussion Research work	
	2. The scientific process stating problems, hypothesis, observing and data-gathering, analysis of data, predicting, and generalizing	Laboratory activities	Skill in using the scientific process in finding solutions to problems
	3. Origin of living cell structure and function of cells	Laboratory activities Models, visual aids	Awareness of existence of cells in different organisms.
	4. The many kinds of living things a) hierarchical levels of classification b) Linnaean system of grouping	Laboratory activities Class discussion Reading assignments	Use of hierarchical levels of classification Skills in writing scientific names; how to use the taxonomic key

Areas of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
V. Use and conservation of natural resources (Bio – Level 1)	1. Green plants, food making and its nutritional requirements a) consumers and green plants b) green plants as source of food c) nitrogen, phosphorus, potassium and other minerals are needed by plants d) soil, water and air for plant growth and maintenance	Field study Laboratory exercises Class-discussion Practicum	Awareness on the importance of green plants as food source; the factors affecting growth of plants
	2. Biology as a solution to man-made problems a) alternative food sources from the environment b) ecological balance and imbalance c) pest control d) scientific farming e) marine ecosystem, coral and mangrove f) algae farming	Nature studies Field trips Laboratory experiments Lectures of resource persons Practicum	Relate, evaluate and understand the role of biology in solving man-made problems Awareness of proper conservation measures to resources that have become imbalanced
VI. International understanding (Bio – Level 1)	1. Origin and diversity of life a) Linnaean system of grouping many organisms b) Darwin's theory of natural selection	Reading assignment Individual research Class discussion	Gathering correct information from references Appreciation for the work of others
	2. Heredity and variation a) Griffith experiment b) Mendelian genetics c) heredity in man	Laboratory exercises Research work Class discussion	Accurate repetition of experiments done by scientist Awareness and understanding of defects in man
VII. Environmental pollution and control	1. Waste disposal in living things 2. Pest control	Research work Class discussion Field work	Awareness of proper methods of disposal of waste

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
		Interview resource persons	Awareness and understanding of environmental pollution as a community problem, finding ways to control/minimize/solve pollution problems
	3. Food chain and pyramids a) role of green plants in pollution control	Construct energy charts and pyramids Field study Class discussion	Awareness and understand the reason why we should plant trees
VIII. Molecular aspects (Bio – Level 1)	1. Producers and photosynthesis a) photosynthetic process b) light needed in photosynthesis	Laboratory work Class discussion	Awareness of importance of plants
	2. Cellular metabolism a) protein synthesis b) cellular respiration	Charts / visuals Laboratory work Class discussion	Understand the process of cellular metabolism
	3. Nature of genetic material a) DNA, RNA b) DNA and transduction c) DNA, the genetic substance d) DNA self-copying process	Class experiments Models and visuals	Understand the nature of genetic material
IX. Genetic aspect (Bio – Level 2)	1. Genes and chromosomes a) chromosome structure b) mitosis and meiosis	Microscopic examination of chromosomes	Awareness on stages of chromosome movement in cell division Ability to differentiate mitotic and meiotic states Awareness of biological implications of mitosis and meiosis
	2. Heredity and variation a) hybridization b) breeding experiments c) pedigree analysis	Exercises in hybridization, plant breeding, pedigree analysis Mathematical computations / research work	Awareness of findings in genetics with development of new organisms Skills in analysis of pedigrees

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)	d) improvement of food crops and domestic animals by selective breeding e) dominant and recessive traits	Laboratory exercises on crossing-over, test cross etc.	Awareness of dominant, and recessive traits Awareness of hereditary characteristics in man
	3. Heredity in man a) sex-linked traits b) holandric characters c) sex-influenced traits d) genomes e) polyploidy f) LSD and heredity	Interview resource persons	Awareness of role of heredity and environment in the development of organisms

Biology Curriculum of the Philippine Science High School
(Reference: PSHS syllabus for science and mathematics)

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES			
I. Human ecology and aspects of the environment Biology 1 Diversity among living things	1. Structural characteristics of organisms, including its habitat 2. Economic importance of organisms	Laboratory investigation of different organisms Culturing and identifying organisms	Awareness, appreciation and greater understanding of organisms existing in the environment
Biology 2 A. The Biosphere	1. The web of life – components of a biotic community – interactions in a biotic community 2. Individuals and population – population density – determiners of population – patterns of population growth and population cycles 3. Communities and ecosystems, components of the ecosystem	Laboratory exercises Use of audio-visual aids films, film strips, overhead projectors Class discussion Field activities	Experience the wonderful sense of discovery through the investigatory method Practice in the processes of science Create the desire for scientific research Awareness on the different patterns of life Awareness of the existence of microscopic organisms in the human body
B. Distribution of living things	4. Patterns of life in the microscopic world a) soil ecosystem b) human body as a biotic community i) roles of micro-organisms in the human body ii) diseases: types, virulence, immunity resistance		
II. Rural community Biology 4 Communities	1. The structure of a community 2. The ecosystem 3. Issues / problems in a community	Independent study Laboratory / field activities Class reports / discussion	Awareness of community problems Understand and evaluate the contributions of science and technology to changes in the community

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
		Audio-visual aids Short and periodic tests Models Charts and illustrations Use of references	
III. Community health, hygiene and nutrition Biology 2 Distribution of living things	1. Patterns of life in the microscopic world a) roles of micro-organisms in the human body b) diseases, types, virulence, immunity resistance	Class discussion Laboratory investigations Use of audio-visual materials, i.e. films, film strips	Awareness on the roles of micro-organisms in the human body; various types of common diseases, causative agents of common infectious diseases, their spread, prevention and treatment
Biology 3 Ultra structures	1. Organ-system of organisms, structures and functions	Laboratory activities Film showing Use of references	Stimulate students interest in advanced topics in biology Awareness of structure-function relationship
Biology 4 Bio-energetics and self-regulation	1. Organ-systems of the body 2. Ecology of microbes 3. Community problems	Independent researches Laboratory / field activities Class reports / discussion Audio-visual aids Short and periodic tests Models Charts and illustrations Use of references	Awareness of community problems Understand and evaluate the contribution of science and technology to the changes in the community Awareness of cause and effect as well as knowledge on prevention of diseases affecting the organ-systems
IV. Skill development Biology 1 Nature of science microscope	1. Science as inquiry a) definition of scientific process b) stating scientific problem c) formulating hypothesis	Class discussion Laboratory investigation Actual handling and manipulation of microscope Construction of dichotomous key	Development of inquiry skills using scientific process Choosing desired characteristics in keying out organisms

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)	d) designing simple experiments e) organization and interpretation of data f) framing generalizations	Exercise on identification of organisms	
	2. Manipulation of microscope a) types of microscope b) use of microscope c) manipulation and focus d) magnifying power e) estimating sizes of microscopic objects		
	3. Diversity among living things, construction and use of dichotomous key		
Biology 2 The biosphere	1. Individuals and populations a) population density b) determiners of population c) patterns of population d) growth and population cycles	Construction of growth curves, and diagrams and graphs	Skills in construction and interpretation of curves, diagrams and graphs
Biology 3 - Cellular organization and functions	1. Biological tools and techniques a) staining technique for living and fixed cells b) centrifugation c) micro manipulation d) autoradiography e) chemical analysis f) the microscope	Laboratory activities Actual use of apparatus needed	Skills using biological tools and techniques
Biology 4 Indepth source of selected topics	1. Bio-energetics 2. Self-regulation 3. Self-perpetuation: reproduction 4. Self-perpetuation: adaptation	Independent researches on specific topics, especially related to those affected by science and technology	Applications of scientific process through individual investigation Awareness of techniques used by scientists / technologists

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
V. Use and conservation of natural resources Biology 4 Self perpetuation: adaptation	1. Ecological interrelationships 2. The ecosystem 3. Responsibilities of a scientist	Independent researches Laboratory / field activities Class reports / discussions Audio-visual aids Short and periodic tests Models Charts and illustrations Use of references	Awareness of ecological problems Understand and evaluate the contribution of science and technology to the use and conservation of natural resources
VI. International understanding Biology 1 Nature of science: diversity of living things	1. The world of science 2. Manipulation of microscope – brief history of development 3. Diversity among living things – short history of classification	Class discussion Reading assignment	Gathering correct information Appreciation for the work of others
Biology 2 Evolution of life processes	1. Light as energy for life – historical background of photosynthesis	Class discussion	Awareness and understanding of the works of scientists
Biology 4 Self perpetuation: adaptation	1. The structure of societies 2. Social adaptations 3. The ecosystem 4. Science and society	Independent researches Class report / discussion Audio-visual aids Short and periodic tests Charts and illustrations Use of reference	Understand and evaluate contributions of science and technology to societies and the ecosystem
VII. Environmental pollution and control	1. Extensive use of pesticides and insecticides	Independent researches/case studies	Awareness of ecological problems arising

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
Biology 4 Self perpetuation: adaptation	2. Effect of detergents and biocides on soil organism 3. Relation between population increase and pollution 4. The ecosystem 5. Responsibilities of a scientist	Laboratory activities Class reports / discussions Short and periodical tests Audio-visual aids Charts and illustrations Use of references	from recent advances in science and technology Development of proper attitude towards environmental pollution and control Understand and evaluate the role of science and technology in coursing, preventing, finding solutions to problems on environmental pollution
VIII. Molecular aspects Biology 2 A. The biosphere B. Evolution of life processes C. Evolution of the cell	1. The web of life – flow of energy and cycle of materials – patterns of energy transfer 2. The basis of life 3. The origin of life 4. Chemical energy for life – ATP and energy currency in the cell – reactions of respiration 5. Light as energy for life – mechanisms of photosynthesis 6. Master molecules – the language of life protein synthesis	Laboratory exercises Constructing diagrams on energy flow Audio-visual aids i.e., film strips, overhead visuals. Use of reference materials Class discussions	Experience in discovery through the investigatory approach Create desire for scientific research
Biology 4 Bio-energetics	1. Physical and chemical approaches to life 2. Energy utilization	Independent researches Laboratory activities Class reports / discussions Short / periodical tests Audio-visual aids Charts and illustrations Use of references	Locate indepth source of selected topics Understand and evaluate the contributions of science and technology to the growth in knowledge

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
IX. Genetic aspects Biology 3 Genetic continuity	1. Mitosis and meiosis 2. Work of Mendel 3. Probability of genetics – binomial expansion 4. Patterns of heredity a) dominance and recessiveness b) incomplete dominance c) multiple alleles 5. Patterns of life in land – factors that affect distribution of terrestial organisms – biomes; ecological succession 6. Patterns of life in water – inland water habitats – marine habitats – factors affecting distribution of organisms – adaptations to marine environment	Laboratory activity on blood type genetics Use of audio-visual aids Use of references	Stimulate students interest in advanced topics Awareness of genetic concepts important to the individual
Biology 4 Self perpetuation: adaptation	1. Possible outcomes of any form of disruption of food web through a) elimination of predator population b) elimination of parasite population c) extensive rise of pesticides / insecticides 2. Pros and cons of a) implementing "green revolution" b) monoculture c) stream channellization d) construction of dams	Independent researches Laboratory activities Laboratory reports Participation in class discussion Short and periodical tests Audio-visual aids – invitation to inquiry slides – films – overhead visuals – BSCS single topic-films – techniques films	Use of indepth source of selected topics Awareness of ecological problems arising from recent advances in science and technology Cultivate the abilities and attitudes Understand and evaluate the contribution of science and technology to our society

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Developing values / Intellectual skills
PHILIPPINES (cont'd)			
	3. Effects of detergents and biocides on soil micro-organisms 4. Relation between population increase, pollution, food production, conservation of natural resources, energy crisis 5. The role of man as a powerful agent of change in the ecosystem	Models Charts and illustrations Use of references	
Biology 4 Self perpetuation: reproduction	1. Patterns of heredity 2. Genes and chromosomes 3. Genes and new species 4. Genes and population	Independent researches Class reports / discussions Short / periodical tests Audio-visual aids Charts and illustrations Use of references	Locate indepth sources of selected topics Understand and evaluate the contributions of science and technology to the growth of knowledge

Grade	Objectives	Contents
Republic of KOREA		
(Middle School)		
Grade VII	– To understand that living things vary both in structure and living styles according to their environments.	– The characteristic structures and living styles of organisms on land, and in water and the method of classification. The concept of cell is introduced.
Grade VIII	– To understand that living things form an ecosystem in which they interact with the environment.	– The relationship of organisms with their environments – they create an ecosystem. Treated here are the concepts such as the community of organisms, their environments, circulation of materials and natural equilibrium. – Human population and the environment, factors for environmental pollution and resulting problems.
Grade IX	– To understand that the life of an organism is succeeded, – To understand that an organism requires energy for its survival.	– The continuity of life through reproduction, heredity and evolution. – The process through which an organism secures energy, is highlighted. Photosynthesis and metabolism of organism are introduced.
(High School)		
Grade X – Grade XII	– To understand the basic concepts of life phenomena – To acquire basic skills of inquiry into life phenomena – To understand the diversity of organisms, continuity of life and the position of mankind relative to other organisms – To apply concepts and knowledge to real life and industry in a way that contributes to national development	– Diversity of organisms: concepts used in classifying organisms – animals, plants and micro-organisms – Structures and functions of an organism: a cell and a group of cells, metabolism of an organism and functions of plants and animals – Regulation and homeostasis within an organism: How an organism is regulated and maintain homeostasis. Homeostasis, regulation and behaviours of an organism are dealt with. The principle is that an organ, consisting of cells, carries on its own functions and interacts with others to effect an orchestrated functions of an organism. There are two ways in which an organism reacts to a change from outside. One way is to maintain stability within the organism and this function is called homeostasis. Organisms manifest it in a specific behaviour by controlling hormones and the nerve system. Here comes an act of regulation within an organism.

Grade	Objectives	Contents
Republic of KOREA (cont'd)		– Continuity of life: Patterns of reproduction and development. This topic introduces the concepts of reproduction, nascency, heredity, the origin of life and evolution as a means through which species maintain the continuity of life and undergo the process of evolution. The process of development, by which a single fertilized egg undergoes cell division and becomes an organism, and how it has evolved are important topics. – Organisms and their environments: This topic introduces the concepts and principles of ecosystem. The problems of population growth and environmental pollution are understood in this context. Dealt with under this topic are an individual organism, community, ecosystem, mankind and its environment, production and consumption of food, circulation and decomposition of materials, and natural equilibrium. What is unique about this unit is the intensive treatment of various problems caused by rapid population growth.

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
Republic of KOREA (cont'd)				
Environmental aspects (Lower Secondary– Grade VIII				
Nature and life				
– population problems, human and environment, population increase, population control	– Impact of environmental factors on human species – Effects of population increase on environment – How to control population increase	– Students analyse the population increase and forecast the population of the future – Students observe the effects of space and food on the increase of community – Discuss the causes of population explosion and the effects of population on human environment – Estimate the number of population on the basis of birth rate	– Studies on the growth of human species – Discussion on the population increase in relation to the increase of animals – Use the statistical data about population growth in Korea and the other countries	
– Environment pollution, air pollution, water pollution, soil pollution	– Characteristics of environment pollution – How to determine the environment pollution – Harmful effects of pollutant on human and other organisms – Accumulation process of pollution in the living organism through the food web	– Students report their experiences and information about air pollution, water pollution and soil pollution – Examine the degree of air pollution in their neighbouring environment – Examine the degree of pollution in the sewerage and stream water – Cite an example of soil pollution – Examine the process of transfer and accumulation of pollutants in the food web	– Illustration of examples of soil pollution (e.g., smog, the destruction of nursery in the south coast caused by the industrial sewerage, fish with wrapped backbone in Han river – Discussion on the result of destruction of ecosystem by environmental pollution to human life	– Human beings are an essential component of the ecosystem and environment pollution exerts harmful effects on human beings – The conservation of nature should aim to achieve the equilibrium of ecosystem

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
Republic of KOREA (cont'd)				
– Conservation of nature; utilization and conservation of natural resources and land; measures for the conservation of nature	– Significance of conserving nature in view of economics and environment – How to conserve nature	– Students observe the limited availability of natural resources which are essential for human life	– Studies on the drains of natural resources; fossil fuel – Discussion on the movement for conserving nature, what should we do for the movement	
Molecular biology and genetic aspects (Lower Secondary – Grade IX) Continuity of life				
– Heredity: Mendelian Law, incomplete dominance, individual variation and mutation, heredity in human beings	– How the characteristics of parents are transferred to offsprings – Characteristics of offsprings are determined by environmental and genetic factors	– Investigate the procedure and findings of Mendel's and Correns's experiences – Observe the individual variations of leaf size and discuss the effects of environment on the expression of characteristics – Compare the characteristics of monovular twins and diovular twins – Examine taste blindness and draw the family tree	– Studies on various genetic phenomena: Mendelian Law incomplete dominance sex-linked heredity – Discussion (e.g., about the factors which affect the characteristics of offsprings) – Explanation of the genetic diseases of human – Explanation of the family tree of Darwin	

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND				
1. Ecosystem	Living organisms survive in environments appropriated for their existence	Survey of the school environment. Observe, record and discuss the environmental conditions and the relationships among living organisms	– Use of information and illustrations from various sources – Discussion	– In field trips bring out the aesthetics of the natural environment – When observing habitats have the students restore them to original state
		Conduct an experiment concerning physical factors that influence fresh water snails and water plants		
2. Transfer of energy	The continuous relationship between organisms in terms of eating and being eaten.	Discuss and give examples of food chain	– Discussion	– Application of knowledge and understanding of scientific concepts to real-life situations
	Food chain and food web	Prepare a food web from the food they eat at one meal	– Use of information related to student's real-life situations	
	Some natural advantages in our daily life received from the capability of the decomposers to convert waste materials into fertilizer	Discuss the simple process in making student's own organic fertilizer	– Discussion – Use of local resources	– Application of scientific knowledge to real-life needs
3. Pyramid of numbers	Living organisms being eaten outnumber the consumers	Write a pyramid of numbers of a food web and discuss the significance of the size difference	– Discussion – Use of illustrations from various sources	– Interpretation
4. Population	Amount of food and space control the population size	Discuss John Emlen's study	– Discussion – Use of a historical investigation	– Interpretation of data
	A rapid increase in the number of organisms in the population make the food and space become inadequate	Design an experiment to test whether space can control the population number	– Experimentation – Use of local materials	– Designing an experiment
	The size of any population fluctuates all the time	Interpret graphs showing the change of population size in both laboratory and natural conditions	– Discussion	– Interpretation of data

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
	The fluctuation depends upon the time, place and environmental conditions		– Use of local research data	– Impression on scientific investigation carried by local scientists
5. Cycles of substances	All substances come from the earth in the form of either elements or compounds	Examine a table on essential substances in living organisms	– Discussion	– Interpretation of data
	Two types of circulation; one is the circulation to atmosphere, the other is not atmospheric circulation	Discuss the cycle of water, nitrogen, calcium and the relationships between some of them	– Discussion – Use of information and illustrations from various sources	– Interpretation of data
6. Succession	Succession is a series of replacements by more and more successful communities	Examine samples of successions found in the surrounding environment	– Discussion – Use of local resources	– Recognize those factors which influence changes in environments
	Under certain circumstances, a climax community is altered which can be caused by several factors, both natural and artificial	Give samples of changes in a climax community and discuss the effects on human and natural resources	– Use of illustrations from various resources – Use of local samples – Discussion – Use of slide-sets	
7. Pest control	Many kinds of living organisms damage human, plants and animals. The most crucial of them are those that destroy agricultural products and are consequently of economic importance	Give examples of important pests and describe how they damage human economy	– Use of local resources – Use of information and illustrations from various sources – Use of slide sets – Discussion	– Recognize roles of pests and needs of knowledge and understanding in pest control
	There are several methods of pest control, mechanical control, natural control, biological control and chemical control	Discuss and give examples of methods of pest control found from daily life	– Use of local resources – Discussion – Use of current related articles in newspapers, magazines	– Application of knowledge and understanding in science concepts to real-life situations

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
	Any pesticide is advantageous in one way but disadvantageous in another. It may have effects on human or domestic animals and may also cause other problems such as pollution	Discuss the disadvantages caused by pesticides	– Discussion – Use of local resources – Use of information and illustrations from various sources	– Decision making in using pesticides
8. Pollution: – Water pollution	Major sources of water pollution are waste from houses, industrial and agricultural and agricultural areas, dependent upon environment and vocations of people	Give examples of sources of water pollution	– Discussion – Use of local resources	– Recognize their roles in order to cope with problems of pollution
		Discuss how organic and inorganic waste cause water pollution	– Use of information and illustrations from various sources	
		Measure dirtiness of water	– Experimentation	– Measuring
		Observe and record effects of herbicides and detergents on aquatic plants and animals	– Discussion	– Observing – Recording – Interpretation of data – Making conclusion
	The eradication method consists of processes to get rid of dissolved and undissolved materials	Make a study tour to standardized factories to observe working processes in water purification	– Study tour – Use of local resources – Discussion	– Recognize the crucial needs of water purification of industrial works
– Air pollution	Main sources of air pollution are exhaust air from factories and cars	Interpret graphs showing per cent of gases in samples of polluted air	– Use of information and illustrations from various sources	– Interpretation of data
		Discuss and give examples of disasters caused by air pollution	– Use of local resources – Discussion	– Recognize effects of air pollution
– Soil pollution	Soil may be polluted by many factors, either natural or artificial	Discuss and give examples of soil pollution and its effects	– Use of local resources – Discussion – Use of slide sets	– Recognize human roles in soil pollution
– Other pollution	Other pollution such as noise pollution, visual pollution etc., are also problems in our daily lives	Discuss and give examples of other pollution	– Use of local resources – Discussion	– Application of scientific knowledge and understanding to real-life situations for better living

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
9. Conservation	Soil, water, minerals, forests, pastures and other natural resources are essential to our existence. These resources are now deteriorating by various agents. The conservation of natural resources is a very crucial issue.	Discuss and give examples of natural resources and methods in conservation	– Use of local resources – Use of slide sets – Discussion	– Recognize the crucial needs in the conservation of natural resources

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Genetic aspects

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
1. Heredity	Characteristics of living organisms can be inherited from one generation to the next, they are referred to as genetic characters	Observe different characters of the members of students' own families	– Use of facts obtained from daily life	– Observing – Organizing data
	Certain characters may differ very little from individual to individual	Study the continuous variation in height of a group of their friends	– Use of facts obtained from daily life	– Observing – Measuring – Organizing data – Making conclusions
	Monohybrid and dihybrid cross	Interpret data and information given concerning monohybrid and dihybrid cross	– Use of local data and research findings – Discussion	– Impressions on scientific investigation conducted by local geneticists
		Conduct an experiment on ratios and probabilities	– Experimentation	– Interpretation of data – Observing – Numbering – Making conclusions
	The environment affects characters of living things	Interpret the information given and answer questions concerning effect of the environment on human characteristics	– Use of photographs of the nation's famous athletes – Discussion	– Application of knowledge and understanding of scientific concepts to real-life situation: selection and breeding
2. Genes and chromosomes	Evidences indicate the location of genes on chromosomes	Conclude from evidences given	– Discussion – Use of information and illustrations from various sources	– Interpretation of data – Making conclusions
	Sex determination and sex linkage	Explain results of breedings in drosophila by using Morgan's hypothesis	– Discussion	– Interpretation of data – Inferring
	Sex-linkage in man	Discuss the inheritance of of hemophilia	– Discussion	– Interpretation of data

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
3. Structure and function of DNA	A DNA molecule is described as a long double-strand structure, like a twisted ladder	Examine and interpret information reported by Watson and Crick	– Use of research results found by geneticists	– Interpretation of data – Drawing conclusion
	DNA can replicate in an exact way and can carry information	Examine a diagram showing replication of DNA	– Discussion	– Analysing – Synthesizing
4. Mutation	Errors in DNA replication may occur. The errors may result from either environmental or other causes	Examine and discuss the research findings reported by Muller	– Discussion	– Impression on scientist's work and endeavour
		Discuss the process of selection	– Discussion	– Application of understanding of concepts in selection to real-life situation for better farming

Application to Health and Nutrition

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
1. Nutrition				
– Optimal daily intake of calories	The calorie intake varies, depending on people's physical activities	Interpret graphs indicating the calorie requirements per day for people at different ages and sexes	– Use of data from various sources; locally and globally	– Interpretation of data
– Balanced intake of food	Sufficient and well-proportioned intake of nutrients promotes growth in children and maintains a healthy body in adults	Interpret a table showing the proportions of protein, fat and carbohydrate that one should consume per day	– Use of data and illustration	– Interpretation of data
– Problems in nutrition	A problem occurring in rural areas of developing countries is the lack of sufficient protein and fat; 70 to 80 per cent of people's total intake of food is carbohydrate	Interpret graphs indicating the amount of daily protein consumption of people in various nations	– Discussion – Use of data and information from various sources	– Interpretation of data
	In Thailand a sizeable portion of the population suffer from protein-deficiency-related diseases	Examine and interpret a table concerning number of people suffering from protein deficiency related diseases reported by hospitals in provinces of Thailand	– Use of information from local resources – Discussion	– Interpretation of data – Recognize the importance of application of knowledge and understanding of nutrition for better living
2. Digestion	Swallowing involves the co-operative actions of parts of the mouth cavity	Discuss the possibility of accidents in swallowing	– Discussion	– Application of scientific understanding to real-life situation
	Large intestine plays role in water re-absorbtion	Discuss the causes of diarrhoea and constipation	– Discussion	– Application of scientific understanding to real-life situation
3. Respiration in man	Some lung diseases decrease the surface area for gas exchange	Discuss causes and effects of lung diseases, including treatment and prevention	– Discussion – Use of illustration from various sources	– Application of scientific understanding to real-life situation

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
4. Transport system in animals	Blood pressures of people at different ages, sexes and physical activities are different	Measure their own pulse rates	– Use of student's own body in practical work	– Measuring – Observing – Recording
5. Hormones: – The discovery of insulin	The presence of glucose in urine could be a symptom of the diseases called 'diabetes mellitus'. Insulin treatment and diet control can help a diabetic to live a normal life	Discuss the results of experiment conducted by Banting, Best and Macleod	– Discussion – Historical approach	– Interpretation of data – Awareness of the history of a biological concept
– The thyroid gland	Treatment with iodine cured the goitrous animals	Discuss the discovery made by Bauman and Marine. Making suggestions to add iodine in drinking water and table salt	– Discussion – Historical approach	– Interpretation of data – Awareness of the history of a biological concept – Application of scientific knowledge to real-life situation
6. Human reproduction – Menstrual cycle	The menstrual cyclical changes in ovaries and in endometrium lining of human female	Discuss steps of menstrual cycle	– Discussion – Use of data and information of everyday life	– Application of scientific understanding to real-life situation
7. Behaviour – Temperature regulation in homeotherms	The body structure of homeotherms is related to the environment. The animals can maintain an almost constant body temperature	Discuss the experiments conducted by many scientists e.g. Pasteur, concerning micro-organisms	– Discussion – Use of information and evidences from various sources	– Application of scientific knowledge and understanding to real-life situation
8. Micro-organisms	Micro-organisms cause many diseases, but many of them are of economic, pharmaceutical and sanitary importance	Discuss the experiments conducted by many scientists e.g. pasteur, concerning the study on micro-organisms	– Discussion – Historical approach	– Awareness of the history of a biological concept
		Examine an experiment showing Koeh's postulates	– Discussion	– Interpretation of data

Area of concern	Concepts / Principles in text or syllabus or other instructional materials	Practical experiences for students	Teaching strategies / methodologies	Developing values / Intellectual skills
THAILAND (cont'd)				
9. Control of micro-organisms	It is necessary for man to preserve food or food products so that they will last longer without spoilage	Discuss various types of food preservation	– Discussion – Use of information from various sources	– Application of scientific knowledge to real-life situation
	Diseases caused by micro-organisms can be controlled in many ways	Observe the properties of disinfectants and anti-biotics	– Experimentation – Discussion	– Application of scientific knowledge and understanding to real-life situation
	Our own bodies have mechanisms to prevent and cure diseases	Discuss the process of immunity production Examine and discuss Jenner's work	– Historical approach	– Awareness of the history of a biological concept

Appendix D

AN INVENTORY OF SCIENCE TEACHING COMPETENCIES

(Secondary Level)

I. Equipment and instruments

The secondary school biology teacher should be able to use:

1. alcohol and gas burner
2. balance:
   a) beam
   b) platform
   c) spring
3. barometer
4. burette
5. graduated cylinder
6. distillation unit
7. dissecting instruments
8. incubator
9. manometer
10. compound microscope
11. pipette
12. power supply (AC and DC)
13. thermometer
14. drying oven
15. water bath

II. Laboratory procedures and techniques

The secondary school biology teacher should be able to:

A. prepare

1. temporary slides
   a) squash
   b) smear
   c) wet
2. solutions
   a) molar
   b) percent
   c) serial dilution
3. culture media
   a) sterile liquid
   b) solid
4. simple stains

B. use techniques involving

5. chromatography
   a) paper
   b) thin layer
6. gas collection
7. handling and storage of chemicals

C. isolate, culture, etc.

8. algae
9. bacteria
10. cells
11. Drosophila
12. molds
13. protozoa

D. care for live animals in the laboratory

14. amphibians
15. birds
16. small mammals
17. reptiles

E. set up and maintain

18. an aquarium
19. a terrarium

F. do the following

20. connect and maintain gas cylinders
21. cut, shape and polish glass rods and tubings
22. determine number of bacteria present per unit volume of solution
23. preserve plant and animal specimens
24. weigh and measure accurately
25. construct taxonomic keys

III. Emergency procedures

The secondary school biology teacher should be able to:

A. administer first aid for the following:

1. eye injuries
2. burns
3. cuts and wounds
4. severe bleeding
5. shock and fainting
6. animal bites
7. poisonous chemicals and fumes

B. extinguish fires in the laboratory
   8. by using means according to the type of fire
C. take safety/preventive measures in case of
   9. lightning and electrocutions
   10. earthquakes
   11. fire
   12. typhoon/strong winds
   13. flood
D. administer artificial respiration

IV. Mathematical competencies

The secondary school biology teacher should be able to:

A. perform the following measuring skills:
   1. use the following instruments:
      a) protractor
      b) drawing compass
      c) calculator
   2. use scientific notation and significant digits in recording measurements

B. perform the following computational skills
   3. convert from one unit to another
   4. compute with measures recorded in scientific notation with consideration for significant digits

C. translate from one form to another (words, symbols) statements regarding
   5. percentage
   6. ratio and proportion
   7. direct and inverse proportion
   8. direct square proportion and inverse square proportion
   9. probability

D. construct the following:
   10. drawings of 2 or 3-dimensional geometric figures
   11. scale drawings of geometric figures
   12. graphs of empirical data or of equations

E. perform the following interpretative skills
   13. given a graph (cartesian) of two quantities, establish the relationship between these two quantities
   14. draw inferences from a graph
   15. draw inferences from equations of functional relationships

F. distinguish between
   16. proof and verification
   17. conjectures and logical conclusions
   18. facts and assumptions
   19. inductive and deductive reasoning
   20. necessary and sufficient conditions in a given situation

V. Curriculum projects and professional organizations

The secondary school biology teacher should be:

A. familiar with materials from various curriculum projects of the country and other countries

B. familiar with some journals on Science, Biology and Biology Education of the country and other countries

C. familiar with some of the national/regional science organizations

VI. Educational technology

The secondary school biology teacher should be able to:

A. describe and use the following in teaching:
   1. instructional modules
   2. inquiry techniques
   3. investigative laboratory activities
   4. individualized instruction techniques
   5. lessons which reflect the processes of science

B. operate a/an
   6. camera
   7. projector
      a) 35 mm slide projector
      b) overhead projector
      c) opaque projector
   8. reel sound tape recorder

C. prepare / develop
   9. transparencies

D. utilize library resources
   10. card catalogue
   11. materials in an open-shelf system
   12. vertical files
   13. indices / bibliographies

E. use
   14. techniques of questioning
   15. visual aids appropriate to topics on hand
   16. activity-oriented teaching
   17. instructional games

18. role playing and simulation
19. group dynamics and IPR techniques

F. construct
20. improvised equipment
21. visual aids appropriate to lesson on hand
22. models (e.g., simple crystals)

G. identify community needs and mobilize, use community resources, such as the following in teaching:
23. government agencies and services
24. individuals
25. natural resources
26. local organizations

H. organize and supervise field trips and field studies

I. plan and equip a laboratory for science instruction

J. identify sources of laboratory equipment and supplies

VII. Educational fundamentals

The secondary school biology teacher should be able to:

A. describe
1. the nature of science/mathematics
   a) its relevance to non-scientists
   b) its relation to other fields of endeavour
   c) its impact on society
2. what is meant by scientific/mathematical literacy
3. my personal philosophy concerning
   a) teaching
   b) testing and grading
   c) homework/assignments
   d) discipline
4. my ethical and legal responsibilities as a teacher
5. some of the recent and relevant (to science education) learning theories
6. students
   a) what they are like as adolescents
   b) how they learn
   c) what their goals are
   d) how they benefit by studying science
7. the role of the schools in terms of
   a) responsibilities to students individually, collectively
   b) responsibilities to the community: local, provincial, national, world
   c) relationship to other levels and kinds of school
8. two source books for science teachers
9. two science/mathematics books for the level I teacher

B. apply techniques for
10. classroom management
11. textbook evaluation

C. distinguish between
12. 'content' teaching and 'process' teaching
13. facts, concepts and principles
14. norm-referenced tests and criterion-referenced tests

D. prepare
15. instructional objectives
16. a teaching guide plan which reflects related objectives
17. evaluation instruments/activities which reflect stated objectives
18. an inquiry-oriented instructional activity/lesson
19. teaching activities that reflect the nature and processes of science and mathematics

E. analyse
20. objectives using different levels of skills
21. test items in terms of the following skills
   a) cognitive
   b) affective
   c) psychomotor

F. apply
22. a variety of approaches and strategies in making subject matter interesting to students
23. various forms of motivation to stimulate and sustain student interest in learning
24. various ways of meeting individual differences for more effective learning
25. test results and other competency measures in appraising student performance
26. psychological principles in adapting to/making a quick assessment of a classroom situation

G. prepare own materials using science concepts integrated with topics
27. from other subject areas
28. from everyday experience
29. from the local environment

H. utilize both deductive and inductive reasoning

I. do applied research in line with subjects taught as well as on other issues affecting teachers and school

Annex I

AGENDA

1. Review of current experiences in biology education

2. Identification of key biology concepts and practical experiences related to (a) the environmental aspects; (b) the molecular and genetic aspects; and (c) the application to health, nutrition and agriculture

3. Methodologies, approaches and instructional materials development for emphasizing the three aspects mentioned in Item 2

4. Teaching competencies for biology teachers

5. Suggestions for follow-up activities and concerns which should be reflected in APEID's third cycle programme (1982-1986)

Annex II

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: Mrs. Lucille C. Gregorio (Philippines)
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APEID PUBLICATIONS RELATED TO SCIENCE EDUCATION

Unesco, P.O. Box 1425, Bangkok G.P.O., Bangkok, Thailand

1. *Science in basic functional education: philosophy, approaches, methods and materials; report. 1975*
2. *Science in basic functional education: links with real-life situations; report. 1975**
3. *Integrated science in the junior secondary school in Sri Lanka; study. 1976*
4. *Science in basic functional education; report (of a Module-Writing Workshop). 1977**
5. *The Institute for the Promotion of Teaching Science and Technology of Thailand; study. 1977*
6. *Selection, maintenance and repair of school science equipment; report. 1978*
7. *Physics curriculum development in Asia; report. 1978*
8. *Making and using low-cost educational materials; report. 1979*
9. *Universalizing education: strategies for development and use of instructional materials; report. 1979. (includes six projects on science education, and guidelines for the design, development and use of science instructional materials).*
10. *Designing instructional materials for general education and teacher training: a portfolio of experiences in Asia and Oceania. 1980 (includes a section on science education).*
11. *Self-learning modules for teachers (three of a series already published: (1) Soil salinity and your crops; (2) Good-bye waste; (3) Let's make our school clean and beautiful)*
12. *Linking science education to the rural environment—some experiences; report. 1980*
13. *Linking science education to real-life curriculum design, development and implementation; report. 1980*

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* Out of stock

The Asian Programme of Educational Innovation for Development (APEID) has as its primary goal to contribute to the building of national capabilities for undertaking educational innovations linked to the problems of national development, thereby improving the quality of life of the people in the Member States.

All projects and activities within the framework of APEID are designed, developed and implemented co-operatively by the participating Member States through the national centres which they have associated for this purpose with APEID.

The 21 countries in Asia and Oceania participating in APEID are: Afghanistan, Australia, Bangladesh, China, India, Indonesia, Iran, Japan, Lao People's Democratic Republic, Malaysia, Nepal, New Zealand, Pakistan, Papua New Guinea, Philippines, Republic of Korea, Republic of Maldives, Singapore, Socialist Republic of Viet Nam, Sri Lanka and Thailand. Each country has set up a National Development Group (NDG) to identify and support educational innovations for development within the country and facilitate exchanges between countries.

The Asian Centre of Educational Innovation for Development (ACEID), an integral part of the Unesco Regional Office for Education in Asia and Oceania in Bangkok, co-ordinates the activities under APEID and assists the Associated Centres (AC) in carrying them out.

The aims of APEID are:

- To stimulate efforts in the Member States for the development and implementation of innovations in education, both formal and non-formal;
- To make students, parents, communities, teachers and other educational personnel, aware of the need for relevant changes in education;
- To promote understanding and appreciation of the differences in educational practices and approaches of the Member States.