DOCUMENT RESUME

ED 055 920 SE 012 638

AUTHOR	Lucas, A. M., Ed.
TITLE	Biological Education in Australian Secondary Schools. [Proceedings of a Conference Sponsored by the Australian Academy of Science].
INSTITUTION	Australian Academy of Science, Canberra.
PUB DATE	May 70
NOTE	237p.
EDRS PRICE	MF-$0.65 HC-$9.87
DESCRIPTORS	*Biology; Conference Reports; Course Descriptions; *Curriculum; Discussion (Teaching Technique); *Evaluation; Laboratory Procedures; *Objectives; Secondary School Science
IDENTIFIERS	*Australia

ABSTRACT

The present situation of biology teaching in Australian secondary schools is described in Part 1 of the proceedings of the 1970 conference on "Biological Education in Australian Secondary Schools." The six papers discuss the relationship of biology to other science and non-science subjects, enrollment trends, teacher qualifications, and assessment practices used in each state. Part 2 contains three papers which suggest some aims of biological education for Australian conditions, and a summary of the discussion of these proposed aims. Papers evaluating the Australian adaptation of the BSCS programs, the biology component of the New South Wales "Science" courses, the Queensland "Zoology" course, and the pilot course in "Human Biology" offered in Western Australia, are contained in Part 3. Three background review papers, on discussion as a teaching technique, on the value of laboratory work, and on research on "inquiry" teaching, are included, together with reports of working groups that discussed evaluation techniques, teaching techniques, and the appropriate content of future courses. The report concludes with a list of eight recommendations to the conference sponsors, the Australian Academy of Science. (AL)

BIOLOGICAL EDUCATION

IN

AUSTRALIAN SECONDARY SCHOOLS.

Proceedings of a conference sponsored by

The Australian Academy of Science,

May 5 - 8, 1970.

Edited by

A. M. Lucas.

BIOLOGICAL EDUCATION IN AUSTRALIAN SECONDARY SCHOOLS

ERRATA

p. 5 The address for Mr. Katavatis should read "Hollywood High School, W.A."

"Mrs. Jan Keightley, Marion High School, S.A.," should appear after Mr. Katavatis.

p. 10 line 8, "Dr. Mayer," not Mr.

p. 20 line 6, word 8 is "matriculation"

line 17, insert "students" after "Teachers College"

p. 28 line 3, first word is "historical"

p. 32 heading is ...CERTIFICATE....

p. 47 line 11, word six is "aims"

p. 66 the entry in the 10th row of the column headed ED. DEPT. COUNTRY should be 32†, with the footnote reading "† One teacher had a B. Ag. Sc. and an R.D.A.."

p. 90 line 6, the word is "omissions"

p. 109 line 6 from bottom, word five is "no"

p. 125 line 12 from bottom, word 8 is "of"

p. 127 line 11 from bottom, second word is "economically"

p. 159 line 8, second last word, "exists"

p. 161 line 10 from bottom, third last word, "oestrus"

p. 166 the solid line on the figure represents the "Total Senior Candidates"

p. 169 line 10, 4th word "fairly"

p. 173 7th line, 3rd last word "complaints"

p. 189 3rd last line, 7th word "throughout"

p. 192 reference 13, 1st word of second line "method"

p. 212 3rd line "The Invitation to Enquiry..."

p. 215 13th line, 5th word "taught"

p. 215, line 19 should be followed by the following line which was omitted, "using the BSCS Yellow version text and laboratory manuals and another class taught"

p. 216 10th line, last word "subject"

PREFACE

The papers published here were presented at a conference organised by the South Australian Biology Teachers' Association for the Australian Academy of Science. The residential conference, attended by teachers and biologists from all Australian states and one from the United States was held at Raywood, the South Australian Education Department's Inservice Conference Centre at Bridgewater in the Adelaide Hills. Since much important discussion, debate and exchange of information took place outside the conference rooms, a full transcript of the discussion of papers and of working sessions would only be a partial report of the discussion. For this reason, a summary of the conclusions reached is printed after each group of papers that were formally discussed. These summaries were presented to the conference at a final session and agreed to as a fair and accurate summary of proceedings. The recommendations for action that these summaries contain are reprinted separately as the final section of the report.

Many people played an important role in planning and conducting this conference. The other members of an ad-hoc committee of the S.A. Biology Teachers Association, (Mr. L. Bamford, Mr. I. Mosel, and Mr. P. Thomson) all assisted greatly in the planning of the scope and programme of the Conference. Mr. Bamford was responsible for liason with the Australian Academy of Science through Professor R. N. Robertson FAA. It was largely through their efforts that it was financially possible for participants from all States to attend. The assistance of Academy of Science Field Officers in suggesting the names of participants was extremely useful.

The courtesy and efficiency of Mr. R. O'Hare, Mr. Cameron and their staff at Raywood was greatly appreciated by all conference members. Acknowledgements are also due to all State Departments of Education and other employing authorities for facilitating the attendance of members of their staffs.

The Conference is greatly indebted to the efficient and rapid work of Miss K. Johnson who, although faced with seemingly impossible deadlines, was able to produce copies of papers for all conference members before the conference commenced.

A. M. Lucas.

July 1 ,1970.

CONTENTS

LIST OF PARTICIPANTS

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OPENING ADDRESS

D. J. ANDERS

Mr. Chairman, Ladies and Gentlemen,

I am extremely pleased to be with you today and to welcome this distinguished gathering to Raywood. In these beautiful surroundings, which have been the venue for a succession of important conferences, I know that your discussions will be profitable and that your informal meetings with each other will lead to friendship and a deepened understanding of the problems that are under consideration. I hope that you will leave this place with happy memories, refreshed and stimulated for the tasks upon which you are engaged.

I have a deep conviction which I share, I am sure, with you that the important questions that the world faces at present are fundamentally biological ones and that biology as a school subject has a great deal to offer - perhaps more than any other science - both in educational development and in social understanding.

I am a biologist manque. When I first entered a Teachers' College in 1933 I asked the Principal if I might undertake what I thought was a splendid course offered by the late Professor Brailsford Robertson. It was a course in the Mental and Moral Sciences, containing a large serve of biology with some philosophy, psychology and logic as side dishes. It seemed to be to be the ideal course for a teacher, but I was informed, kindly but firmly, that biology was a subject for girls taught by women. So I took another course and tacked some biology on when I had finished the more serious studies.

This, of course, was the position in the schools at that time. People seemed to have forgotten the sex of visitors like Darwin or Banks or Solander and chose to overlook the existence of the famous biologists who were teaching in the universities in the excitement of discoveries about the atom that were in the centre of the stage at that time.

It was as though someone had paraphrased Dr. Johnstone - claret for boys, port for men and brandy for heroes. Mathematics and Physics were the intoxicating things then. Fortunately, the Australian taste for dry reds has improved over the years.

Those of us who were concerned about the teaching of Biology in South Australia made our first attempts to introduce it more widely into the schools through the General Science courses of the forties. Although this move did not have great success at the time, it had an incidental effect of considerable importance in South Australia.

In order to increase the academic range of teachers in Biology, Professor J. G. Wood, Professor of Botany, made arrangements for selected teachers to pursue studies towards a higher degree through evening, weekend and vacation periods. One of the successful graduates was Dr. S. J. Edmonds, who played a significant part in later developments.

The question of finding teachers with sufficient qualifications to teach Biology had always been a difficulty. Committee members on subject committees were forced to concede that, notwithstanding their success as teachers, most of the elementary work was in the hands of teachers trained as teachers of physical education or of home science.

This position was not remedied to any great extent until the late fifties and early sixties when all South Australian teachers undertaking science degrees were required to offer Biology among their first year subjects. Later, about 10% of all such students were permitted to undertake further studies in biology. This number has increased over the years and now there is a substantial number of highly qualified teachers of biology in the schools.

About ten years ago there was increasing dissatisfaction among teachers and university staff with the nature of the existing courses in Biology. Dr. P. Martin, now Professor of Botany, had led the discussions and had been responsible for the introduction of new texts and more realistic syllabuses. He seized upon the B.S.C.S. materials when they were produced and with the encouragement of Dr. Edmonds, who was Chairman of the Committee, arranged for their introduction on a pilot basis in selected schools. The three versions, Yellow, Blue and Green, produced in America were used. The teachers had little information about the methods or purposes of the courses, so the boot-strap organization, the Biology Teachers Association was formed as a means of mutual help and consolation. Mr. Brian James was the leading spirit in this group and inspired by his enthusiasm, teachers met regularly to exchange experiences and materials, to offer suggestions and to find some common ground.

I still treasure the first publication of this group - a Biology Teachers Handbook - full of useful practical hints for the struggling young teacher of biology.

It was at about this time that we became aware that similar moves were taking place in Victoria. Miss Effie Best, now studying in Columbus, Ohio, introduced us to Mr. David Morgan and Mr. John Nicholas. I remember sitting with Lester Russell in a Biology storeroom at Adelaide Boys' High School listening to tape recordings prepared by David Morgan of a strange new technique called 'inquiry'. We were considerably puzzled by this, but decided if this was what had to be done, well, we would try it.

Prompted by the enthusiasm of the teachers and at the insistence of Dr. Peter Martin, Dr. Edmonds arranged for Mr. Mayer, from the B.S.C.S. Project in Boulder, Colorado, to include South Australia in his itinerary. He addressed the now solid band of B.S.C.S. teachers and arrangements were made for the continued use of the B.S.C.S. materials until a local version was produced. I did not realize the magnitude of this concession until I met Dr. Grobmann in person.

The task of producing an Australian version had to be faced. With the small nucleus of interested people determined to work hard, an approach was made to the Academy of Sciences for support. The South Australians on the Academy committee were fully aware of the situation and the Biological Education Committee of the Academy undertook the general oversight of the production.

The general editor, David Morgan, and his assistant editors had a formidable task with inexorable deadlines all along the way. Material was produced, duplicated and sent around Australia for comment by interested people. The content and the practicability of the text was checked at many levels and the roll of honour of those who helped - for it was an honour to be associated with this project - is found on the front and rear pages of the "Web of Life".

It was a magnificent production when it appeared and it has won praise everywhere. I have seen a letter from Dr. Schwab where his admiration runs to the hope that others will see fit to plagiarize it.

It has been a wonderful boon in the schools and students are proud to carry it with them and show to envious classmates.

We have now come to the stage where good materials have to be made even better.

This Conference has been arranged and organized by the South Australian Biology Teachers Association with the support of the Australian Academy of Science which has generously made a grant towards the accommodation and travelling expenses of visitors.

I am sure that the discussions of this informed and interested group will lead to the production of even better materials for use in schools.

Biology, from being regarded as a 'soft option' by some, is taking its place as a major means of educating students in schools.

I have much pleasure in declaring this Conference open.

SECTION I.

THE PRESENT SITUATION

The six papers in this section describe the present situation regarding biology teaching in secondary schools in each state of the Commonwealth. They indicate how the biology component of science courses is interrelated to the other sciences and the other subjects of the curriculum. In all states all secondary students have at least some exposure to some biological ideas during their school courses, but many do not have any biology teaching after grade 9 or 10 level.

QUEENSLAND.

M. Specht.

In Queensland, the last five years of a student's school life are spent at secondary school. The student enters the school at Grade 8 level, and proceeds through to Grade 10 before he faces a Public Examination - and possibly, after another two years, the Senior Public Examination.

In Grade 8 all students in school cover the same syllabus in Science.

The Aims of the course are:

(1) To make students aware of scientific concepts and principles that function in their experience and to help explain them.

(2) To help students acquire an understanding of scientific facts that are part of their environment.

(3) To promote the development of such scientific attitudes as spirit of enquiry, open-mindedness, suspended judgement, intellectual honesty and sustained effort.

(4) To provide a sound foundation, theoretical and practical, for the further study of the sciences.

(5) To develop an interest in science and a realization of its potentialities.

Materials for the course have been selected according to three criteria:

(1) The relevance of the material for this day and age.

(2) Its importance as a basis for further study.

(3) Its relationship to the interests and abilities of the students.

The Biology in the course introduces the student to the living world, giving him a broad review of it. The syllabus suggests that 45 periods from a total allotment of 150 for the subject be allotted to biology.

Students learn something of:

Differences between animals and plants.

The cell as the structural unit of organisms.

The cell as the functional unit of organisms.

Animal diversity

Plant diversity

Evolution

As practical work, students look at animal and plant cells, collect representatives of the animal phyla, and it is suggested that collecting excursions be undertaken. Practical projects for the section on Plant Diversity are listed, e.g. collect and name representatives of plant phyla, of various types of roots, stems, leaves, flowers; germinate spores from fern, mushroom, germinate monocot and dicot seeds; show that a green plant contains water and carbon; show production of starch in a leaf; show that chlorophyll is necessary for production of starch in leaves; show oxygen produced during photosynthesis, oxygen used during respiration, carbon dioxide produced during respiration, living animals and plants produce heat in their bodies.

When students have completed Grade 8, a choice of subjects lies before them. They may proceed with Science A, or enter the General Science Course, or indeed, they may elect to do no Science subject at all.

Science A proceeds through Grades 9 and 10.

Science A, Grade 9. During this year students study ecology, and 65 periods out of 150 are devoted to it. Interactions in ecosystems, life in the sea, life on land, life in freshwater are dealt with. Feeding relationships, energy relationships, and biogeochemical cycles are discussed as interactions. Two excursions are undertaken, to two of the major types of ecosystem. Students are expected to be able to answer questions in the Junior examination (essay or objective type) on their excursions knowledge.

Science A, Grade 10. During this year students have 56 of their 150 periods devoted to Physiology - with a major emphasis on Man, though the treatment should be comparative. Emphasis is also on macroscopic structure and function. Students start with a broad body plan of man, proceed to tissues, skeleton, and the various systems: circulatory, respiratory, nervous, endocrine, and reproductive.

General Science: This course is offered for those students who do not wish to proceed with Science subjects after Grade 10.

The Aims of this course are:

(1) To stimulate and develop the student's interest and curiosity in physical and biological phenomena.

(2) To develop an understanding of those principles of science which are applicable to situations the adolescent is likely to encounter in the home, at work, during leisure hours and in the immediate environment;

(3) To provide a variety of learning experiences designed to foster the skills and attitudes involved in using the methods of science to solve simple problems;

(4) To develop an understanding of the underlying nature of science and an appreciation of its romance, power, limitations and impact on our way of life.

The syllabus states that the student should be placed in the role of explorer or discoverer, rather than be given a guided tour of knowledge. The syllabus repeats the emphasis on experiments, observation, and on the student's development of scientific attitudes.

Six topics in the biological field are covered; four of them in Grade 9, two in Grade 10. They are:

1. How does a green plant work?
2. Under what conditions do seeds germinate?
3. How can man grow better crops?
4. How do our bodies work?
5. Animal and plant ecology.
6. Life in a community.

Students approach this course as a laboratory orientated subject. Agricultural subjects are also offered at this level. They are mostly taught in country High Schools, though two schools in the metropolitan area do offer them. The subjects have some degree of overlap between them.

They are:

Agricultural Mechanics: to be treated in the context of the farming and pastoral scene, not merely as phases of mechanics or agricultural engineering. The course consists of:

(1) Historical survey

(2) Fundamental mechanical principles

(3) Farm plant and machinery

(4) Elementary field engineering

(5) Engines and tractors

Animal Husbandry: The syllabus is divided into three sections:

(1) Types and breeds of livestock and their distribution

(2) Elementary animal biology and animal health

(3) The livestock industries.

It is suggested that 60% of the total teaching time be devoted to Sections (1) and (2) amd 40% to Section (3).

Agriculture: Teaching method should aim at the development of an experimental objective, and critical attitude towards agricultural practices and problems. The syllabus is divided into five main sections and is based on 170 teaching periods:

(1) The development of agriculture in Australia (10 periods)

(2) Agricultural ecology (80 periods)

(3) Crop processing and storage (15 periods)

(4) Elementary field engineering

(5) Elements of farm management (20 periods)

There is considerable emphasis on field and practical work of different kinds.

Students taking these subjects are frequently from farming families, and expect to go on the land themselves. Some students aim to attend Agricultural College, or do an Agriculture degree.

At the end of Grade 10, all students in school sit for the Junior Public Exam.; at the conclusion of it they either enter the job market, go to one of the Institutes of Technology, or proceed at school for two more years. In Grade 11 the subjects with biological content are Biology (Web of Life) and Zoology.

Biology: The Australian version of the B.S.C.S. materials was introduced into pilot schools in Queensland in 1968, at the same time the teaching of Senior Botany and Physiology was wound up. As there is no Leaving examination, students proceed through a two-year period to the Senior examination, taking internal examinations on the way.

Only the pilot course has completed its two years; teachers dealt with all chapters marked as essential in the Teachers Guide, and set the remaining chapters as reading assignments.

TESTING: Grades 8 - 10. Internal until Junior Public Exam.

All students sit for the Junior Public Exam - there is no arrangement at present, as there has been in Victoria and South Australia, for internal exams.

Science A: One paper of $2\frac{1}{2}$ hours duration.

Mainly objective questions, (single word answers, single sentence answers, multiple choice, matching, drawing of diagrams, labelling of given diagrams), together with some essay, or expression type questions.

The number of marks allotted to the various sciences represented in the paper will be approximately proportional to the time allocations for those sciences as set out in the syllabus.

General Science: One 2-hour paper will be set on the syllabus in General Science for Grades 9 and 10. The questions will be mainly objective-type together with some short conventional-type questions.

Agricultural Mechanics: Examination papers will be divided into two sections; Section A contains questions of the objective type, all of which must be attempted.

Section B contains questions of the essay type and alternatives will be given.

It is suggested that one hour be allocated to Section A and two hours to Section B. Sections A and B carry marks of approximately equal value.

Animal Husbandry: as above, adequate choice of questions allowed in exam paper gives teacher freedom of teaching.

Agriculture: as above.

In all agricultural subjects examiners take into consideration

(a) English, particularly clearness and conciseness

(b) legibility

(c) general neatness.

Grades 11 - 12. Exams. are internal until the Senior Public Exam at the end of Grade 12.

The Senior Public exam is used for matirulcation to University; testing for Biology consists of one three-hour paper made up of objective, short answer and one essay question.

Teachers have formed an exam panel which has tried to make up a bank of questions for use bv other teachers and for the examiners' use or information. Questions have been obtained from school exam papers.

QUALIFICATIONS OF TEACHERS.

The numbers quoted in the accompanying table have been compiled from teachers who have attended the Preparation Courses held for teachers entering Senior Biology. Three of these have been held 1967 - 69. Among these teachers were Teachers College, a few of whom are currently teaching science subjects. The numbers cannot be considered accurate, or necessarily representative.

STATUS

This has been a report of Biology teaching as it now exists. By the nature of the report, it will be only of temporary value. The students who sat for the Matriculation exam in 1969 were the first to go through under the syllabus as outlined here; but soon the Junior Public exam will be eliminated. Students at present in primary school are learning Science there, so that they will enter Secondary school with some knowledge of Science. Students now spend one more year at Teachers College than did their companions who have just passed out as teachers.

The scene rapidly changes.

STUDENT NUMBERS

	Biology	General Science	Agriculture	Zoology	Biology
Grade 8	33,268				
Grade 9	18,643				
Grade 10	17,103	1,346	353		
Grade 11					2,000
Grade 12				1,911 (1969)	567

Senior subjects over the last five years

	Botany	Physiology	Zoology	Biology	Total enrollment
1966	76	348	2084	-	8364
1967	104	383	1367	-	10295
1968	120	542	2033	-	10233
1969	8	353	1911	567	11141

TEACHER QUALIFICATIONS

(Sample: Teachers who attended the three Preparation Courses for Senior Biology held in 1967, 1968 and 1969, including Teacher's College students, a few of whom are currently teaching science subjects.)

University degrees	
Without Biology content	10
First degree with Biology content	26
Post graduate qualifications a) Dip. Ed.	20
b) Masters, Ph.D.	10
Tertiary Diploma	
(A. Ed.; Dip. Physio.; Q.I.T. Lab. Tech., etc; Q.D.A.; Q.D.H.; Dip. Phys. Ed.; Dip. App. Chem.;)	23
Non-graduates, some University Biology subjects	106
No Tertiary Biology content (other than Teachers College subjects.)	45

NEW SOUTH WALES

C.L. MACDONALD

The new system of secondary education in New South Wales, introduced in 1962, adopted a six year plan involving two Public Examinations. The four years of junior high school terminate with the School Certificate Examination and are followed by two years of senior high school terminating with the Higher School Certificate Examination. So far there have been five School Certificate Examinations and three Higher School Certificate Examinations.

Biology, as a subject, is not taught in N.S.W., there being only three science subjects available in the secondary curriculum. These are termed:

1. Science
2. Agriculture
3. Sheep Husbandry and Wool Science,

2 and 3 are specialised elective courses, taken by relatively few students.

The Junior Course in Science

The Wyndham Report on Secondary Education stated that "there are certain fields of thought and experience of which no adolescent should be ignorant". Science is one of these fields and thus in 1962 Science, for the first time, was made a compulsory subject for all secondary school students as far as the School Certificate.

The junior syllabus is written and examined at three levels of difficulty:

1. Advanced
2. Ordinary - Pass and Credit
3. Modified.

This syllabus has been tried, revised and is popularly accepted as a worthwhile junior course. In content it contains 2/7 Biology, together with 2/7 Physics, 2/7 Chemistry and 1/7 Geology. It is intended to be taught as an integrated course in SCIENCE rather than fragments of the four separate disciplines.

While the subject matter of the syllabus is stated under the four separate disciplines, it is intended that the integrating agent will be the teacher who will determine an approach suited to his teaching methods and to the needs of his pupils. The three main unifying ideas for this syllabus are Energy, the Particle Model of Matter and the Scientific Method.

The biology of this course involves three main emphases:

1. energy relations
2. adaptation
3. evolution

It includes the following topics:

1. how an animal works
2. how a green plant works
3. cells
4. interdependence of plants and animals
5. diversity of living organisms
6. genetics
7. evolution

Of the 700 teaching periods available over the four years, 200 of these will be devoted to biology. In this time it is expected that the pupil will be introduced to the rudimentary concepts of biological science in which principles, rather than morphological detail and natural history diversity, will be stressed. The emphasis is on the study of the organism with the student being introduced to the concepts of the cellular basis of life and interdependence at the c ommunity level.

Stress is placed on teaching by means of observation and experimentation in the junior school with some extensions into interpretation and explanation especially at the Advanced Level. The content of the biology section of the syllabus is structured in such a way that the major part of the course can be taught by means of:

1. examining specimens
2. dissections
3. experiments
4. field work of a simple nature

In a well integrated programme of teaching there would be some biology in each of the four years. An example of such a programme is given in Appendix A. The biology would be interwoven with the other three disciplines to produce an integrated course. Although the student has not accumulated a vast array of technical terminology, anatomical detail and life history studies at the end of this course, he has been introduced to the basic concepts of the Science of Life.

The School Certificate Course is a terminal course for a significant section of the school population and thus all these children have received some formal training in biology.

The Senior Course in Science

The situation here is by no means finally settled and there has been much controversy and publicity in the Press concerning Senior Science in N.S.W.

At present science is being offered as a single unit at three different levels embodying four courses:

1. Third level - 6 periods per week - 1 subject status.
2. Second level (short course) - 6 periods per week - 1 subject status
3. Second level (full course) - 9 periods per week - 1½ subject status
4. First level - 11 periods per week - 1½ subject status at a higher level.

The third level course is an integrated science course and takes the form of a story designed to give a deeper understanding of man's place in nature and the impact of science on man and his culture. The biology content considers the adaptive diversification of living things throughout the surface layers of the planet. It also gives some explanation of evolution through the understanding of genetics and considers man's cultural evolution.

The biology topics in this syllabus are:

1. evolution of living things
2. recent communities of animals and plants

3. the evolution of man

4. genetics and the mechanism of evolution

5. man's exploitation of biological resources.

Although the content of this course gives greater emphasis to community study and describes the evolution of man on the planet in its broadest sense, the spirit of teaching involved in it is essentially the same as the junior course.

The aim of the biology in the <u>Second Level Course</u> is to present the principles common to all living organisms at three levels: cells, organisms and populations. The emphasis changes from organismal biology in the junior course to cells and populations in this senior course. Only in the Full Course are there specific topics on organisms (Integration and Behaviour). Such a course is geared to show students something of the great revolution that Biology is undergoing.

Cellular biology is studied right down to the level of the complex molecules characteristic of living cells.

The syllabus brings together genetics, evolution and ecology under the one heading of <u>populations biology</u>. Genetics is taught as the science of inheritance and origin of variation, ecology as the study of the distribution and abundance of species and evolution as the origin of the diversity of life on Earth. The ultimate understanding of many of the problems of populations biology will depend upon an understanding of events at the cellular level.

Students studying the Second Level <u>Full</u> course may extend their studies in <u>ONE</u> discipline to <u>First Level Study</u>. In biology the topics studied (considered as one per term) are:

1. cell metabolism - chloroplasts, D.N.A. & R.N.A.
2. behaviour - particularly unlearned, and learning in man
3. historical development of Genetics
4. quantitive study of the distribution and abundance of species
5. quantitive study of succession.

The Second Level and First Level courses should be thought of not as integrated but as interlocking sciences where points of similarity rather than differences between the disciplines, can be emphasised.

The aim in formulating the biology of these courses has been to develop a course in modern biology rather than classical biology with the addition of some new topics. Some major problems still face those concerned with implementing these courses, the most important of which are:

1. the development of suitable, appropriate practical work
2. the devising of satisfactory teaching programmes
3. the obtaining of effective teaching aids
4. the learning of efficient teaching techniques appropriate to each topic.

Although some argue that a reversion to separate disciplines at the senior level would be desirable there are strong arguments in favour of a course in SCIENCE at the secondary level of education. As far as biology is concerned, it is studied by nearly all students throughout their school life <u>in association with physics and chemistry</u>. This situation is highly desirable for those wishing to continue with Biology as part of their post secondary education.

APPENDIX A

CIENCE - THE SCHOOL CERTIFICATE COURSE - 4 YEAR PLAN

E I - MAN - living in a scientific age

Heat
Air
Water
Earth
Light
Living things
The Solar System
Electricity
The particles of matter
The particles of living matter

E II - MAN - the living machine

The foods of man
The animal body
Obtaining and using food
Liquid transport systems
Transport system in animals
The energy of chemicals
Release of energy in animals
The separation of materials
Excretion in animals
Ideas of motion
Movement in animals
Stimuli received by man
The senses of man
The nervous system of animals

THEME III - MAN - at home on planet Earth

A. The use of heat on Earth
B. The substances from which Earth is made
C. Heat in the Earth - rocks
D. Common substances of Earth
E. The changing surface of the Earth
F. Some useful products from the Earth
G. Movements occurring in the Earth
H. The vegetation of the Earth
I. The communities of Earth
J. The Earth's surface
K. Building materials used by man
L. Movements on the Earth

THEME IV- MAN - at the frontiers of knowledge

A. The behaviour of chemicals
B. How chemists calculate
C. Knowledge and the use of energy
D. An electric age
E. Man in space
F. Earth history
G. The history of life
H. The history of living things

	First Form Course	Second Form Course		Third Form Course		Fourth Form Cours	
le	1	1	2	2	3	3	4
cs	A - H	I - J	A - L	M - N	A - H	I - L	A - H

APPENDIX B

Numbers of Candidates sitting for Public Examinations in N.S.W.

YEAR	SCHOOL CERTIFICATE	HIGHER SCHOOL CERTIFICATE
1965	35,512	-
1966	40,423	-
1967	45,526	18,336
1968	53,581	23,562
1969	57,763	26,462
1970*	61,500	31,100
1971*	64,250	33,300
1972*	67,700	35,300
1973*	72,100	37,700
1974*	74,330	39,000

* Estimates

APPENDIX C

1969 SCHOOL CERTIFICATE EXAMINATION

LEVEL	No. ENTERED	% ENTRY	% PASS	
A	21,890	37.89	28.7	
O	33,059	57.24	Credit	23.3
			Pass	35.5
M	2,814	4.87	4.8	
TOTAL	57,753	100.00	92.3	

Percentage candidature at Advanced Level

1965	27.21
1966	28.94
1967	35.52
1968	34.82
1969	37.89

APPENDIX D

1969 HIGHER SCHOOL CERTIFICAT EXAMINATION

LEVEL	No. ENTERED	% ENTRY SCIENCE	% ENTRY TOTAL
I	2,514	12.06	9.52
II F	4,639	22.24	17.54
II S	8,799	42.24	33.12
III	4,884	23.46	18.44
TOTAL	20,836	100.00	78.62

PERCENTAGE AWARDS - 1969 H.S.C.

ENTRY / AWARD	I	II F	II S	III
I	5.0	-	-	-
II F	6.0	15.4	-	-
II S	0.4	3.4	28.4	-
III	0.4	1.5	5.3	20.0
FAIL	0.3	2.0	8.5	3.4
TOTAL	12.1	22.3	42.3	23.4

APPENDIX E

QUALIFICATIONS OF TEACHERS

Only figures available are fr m a 1967 survey.

LEVEL		QUALIFIED TEACHERS
II F	Biology	83%
II S	Biology	78%

"Qualified teachers" are those who are trained teachers with a successfully completed University course in Biology.

APPENDIX F

TESTING PROCEDURES

A. SCHOOL CERTIFICATE

Award given on a composite mark gained from the examination result and the school assessment in the following ratio:

$$\frac{\text{Scaled school assessment}}{\text{Scaled examination score}} = \frac{1}{1}$$

SCIENCE EXAMINATION PAPERS

LEVEL	TIME	TOTAL MARK	STRUCTURE
M	1 hr.	80	35 multiple choice 15 single statement
0	$1\frac{1}{2}$ hr.	125	Part I - pass 50 multiple choice 1 written answer Part 2 - credit extension 1 written answer 15 single statement
A	2 hr.	150	70 multiple choice 15 single statement 2 written answer

Appendix F continued on next page.

APPENDIX F cont.

B. HIGHER SCHOOL CERTIFICATE

Award gained on scaled examination score.

SCIENCE EXAMINATION PAPERS

LEVEL	TIME	TOTAL MARK	STRUCTURE
III	2 hr.	100	32 multiple choice 32 single statement 6 paragraph answer 4 essay type
II S	3 hr.	130	5/6 sections, each containing 6 multiple choice 6 single statement 2 paragraph answer 1 essay type (26 marks each)
II F	3 hr.	195	5/6 sections, each containing 8 multiple choice 8 single statement 2 paragraph answer 1 essay type (39 marks each)
I	II F + 2 hr.	270	Paper 1 - II F paper Paper 2 Three essays out of five ALL in ONE discipline.

Note:-

The Total Mark shown is an indication of the weighting given to each level in the determination of order of merit lists at the School Certificate and High School Certificate Examination.

VICTORIA

L. R. Morgan

In Victoria, at the secondary level there are three separate regions of biology education, the technical schools, the junior secondary in the high schools and the senior secondary in the high schools. Unfortunately, up to this stage there has not been a great deal of liaison between these three groups.

I will describe briefly what is going on in each of these groups. Secondary education is devided into 6 stages, forms one to six.

I. TECHNICAL SCHOOLS

In the technical schools Science is compulsory until the end of form 4. This means that all students study some biology during their first three years at the technical school. After that if they choose Form IV Science Part 1 they also study some biology and if they study General Science or Biology in form V. However, at form IV most of the better students do Science Part 2 which is just physics and chemistry. This means that usually only girls and some of the weaker boy students do some biology at a higher level.

There is some difficulty with the teaching of biology in the technical schools as most of the science teachers are trained in either Engineering and/or Chemistry, and so their background in biology is limited.

Science - Forms 1 - 3

Aims

(a) To develop an understanding of a series of basic scientific concepts (as distinct from isolated facts).

(b) To develop the ability to plan, conduct and evaluate experiments or researches.

Emphasis

During this stage the students carry out many experiments to try to find out answers to questions by their own investigation. The use of the library is encouraged.

Content

Form 1 - There are a total of 24 topics and 3 of these deal with biology -

(a) Organisms feed, breathe, grow and reproduce.

(b) Organisms are made up of cells.

(c) Cells differ in type.

Form 2 - There are 22 topics and 4 deal with biology -

(a) All life depends ultimately on photosynthesis for food.

(b) Many living things require oxygen to release energy from food.

(c) Living things exist in a state of balance with their total environment.

(d) Living things have survived because of adaptation to their environment.

Form 3 - There are 24 topics and 4 deal with biology -

(a) Foods contain chemical compounds, e.g. carbohydrates, etc.

(b) A balanced diet is necessary to develop and maintain a healthy body.

(c) Careful preparation conserves food nutrients.

(d) There are many techniques of food processing and preservation.

At this stage there is an emphasis on understanding rather than just rote learning. The tests set by individual teachers are aimed mainly at comprehension and application. The test items are mostly objective with a few longer responses.

Science Part 1 - Form 4

Aims

(a) To present science as an inherent part of man's culture and not just as a servant to trade and engineering courses.

(b) To present students with a wide range of scientific knowledge that will contribute towards making them effective citizens.

(c) To show how the disciplines of a pure science can be applied to everyday problems.

Emphasis

The students at this stage sit for an external examination which contains mostly knowledge items and, as the syllabus is long, little time is spent doing practical work and most time is taken up with formal lessons. This course is under review at the present time.

Content

Science IV Part 1 consists of two sections

(a) Pure Science and

(b) Applied Science.

The Pure Science section is compulsory and includes Ecology. The aspects studied in Ecology include

ecosystems

biogeochemical cycles

energy

limiting factors

populations

interspecies interactions

natural selection

adaptation and

ecological communities.

In the Applied Science the students have to study Conservation. The section dealing with conservation includes

man, the most powerful ecological factor

population

need for conservation and methods of conservation.

They may study Food Science which is the Form 3 biology section expanded.

General Science - Form V

Aims

(a) To present significant material from the various branches of science to enable a student to gain some understanding of himself and a knowledge of scientific concepts related to himself and his environment.

Emphasis

This is similar to the emphasis given in form IV Science Part I, and for similar reasons.

Content

The biological content includes the following -

physical basis of life

classification

animal kingdom

physiology of man

plant kingdom

plant physiology

other kingdoms

reproduction

heredity

evolution

Biology - Form V

Aims

(a) To develop an understanding of the fundamental facts, laws and principles of biology.

(b) To develop problem-solving skills based on these facts, etc., so that they can be applied to new situations.

(c) To develop an understanding and appreciation of the contribution of biology to culture.

(d) To develop basic practical skills of experimentation and of observation and recording of biological phenomena.

Emphasis

Some schools do their own biology course which may be a modified "Web of Life", i.e., sections which seem to be appropriate to the particular students. In this case the individual teachers set their own examination, which has to be approved by the Technical Schools Science Standing Committee.

Other schools use the set syllabus and do the external examination which has the emphasis on knowledge. The practical work is of the traditional type - observe and draw with very little experimental work.

Content

This is based on the following sections -

physical basis of life

classification

animal kingdom

morphology, anatomy, histology of the mammal

physiology of man

plant kingdom

morphology, anatomy, histology of flowering plant

plant physiology

microorganisms

reproduction

heredity

evolution

field biology.

This course is under review.

II. SECONDARY SCHOOLS - JUNIOR SECONDARY

Forms 1 - 4

There may be some biology at each level. This ranges from practically none to a whole term's biology. Often the amount of biology included is determined by the background of the teacher.

There is no external examination and no prescribed syllabus, so teachers are free to do what they feel is suitable for their class, or as their background allows.

The Victorian Universities and Schools Examinations Board (VUSEB) Science Standing Committee, however, recommends the use of the Junior Secondary Science Project (JSSP) materials in forms 1 and 2.

The Green series is recommended for form 1. This has 9 units, 3 of which deal with biological topics -

Unit 6	Energy for Life
Unit 8	Food for Living Things
Unit 9	Things and Places

The Rei series is recommended for form 2. Once again there are 9 units and 2 of these deal with biology -

Unit 2	Looking for Patterns
Unit 7	How Mammals Function

In these courses there is an emphasis on the individual activity of each student and the tests for the students are supplied with the materials.

Forms 3 - 4

A course of study is recommended for these two levels.

Aims

Among the aims of the course are that the students should acquire -

(a) An understanding of the universe as conceived of by scientists.

(b) Some understanding of the scope and nature of science.

(c) Certain skills important to science.

(d) Certain attitudes relevant to science.

Emphasis

The Standing Committee believes that a major emphasis should be placed on student activity in presenting science courses at these levels.

Content

In form 3 the year is divided into 11 units of approximately similar duration and 3 of these deal with biology -

1. Energy transformations in living things.
2. Life in the soil
3. From simple to complex organisms.

In form 4 the year is divided into 11 units, the same as for form 3, and once again 3 units deal with biology -

1. Growth and development
2. Inheritance and variation
3. The evolution and future of life on earth.

A number of teachers actually do quite different courses, some of which are based on courses used in other States or other countries, e.g. Nuffield materials. Some have a practical emphasis, while others depend largely on formal teaching.

III. SECONDARY SCHOOLS - SENIOR SECONDARY

1. Agricultural Science

Fifth Form

Aims

The subject is intended primarily to provide a terminal course which is suitable as part of a general education. Its aims are as follows -

(a) To stimulate interest in agriculture.

(b) To provide an understanding of science as applied to agriculture.

(c) To develop an appreciation of the contribution of agriculture to the community.

(d) To give experience in scientific method.

Emphasis

Wherever appropriate teaching should based on direct observation and experimentation. The course does involve learning a lot of facts, but the students should have some appreciation of the wider implication of the facts.

Content

The course is composed of three sections -

(a) Environment (climate and soil)

(b) Agricultural biology.

(c) Principles and practice of plant and animal management.

Sixth Form

Aims

The syllabus has been designed to help the pupil to see -

(a) Farm plants and animals in relation to the world of living organisms.

(b) Farm practices in relation to biological and economic principles and scientific method.

Emphasis

The importance of careful recording and scientific reasoning is to be stressed, particularly in practical work.

Content

The course is composed of four sections -

(a) Environment (climate and soil)

(b) Agricultural biology

(c) Agricultural ecology

(d) Economic principles of farm management.

Numbers taking Agricultural Science

1968 - 5th Form

			Total presented for Agricultural Science	Number of entries for Leaving	% Studying Agricultural Science
Class A	Boys	Girls			
	56	26			
			82	13789	0.6%
Class B	256	46			
			302	19338	1.6%
Total for State			384	33127	1.2%

1968 - 6th Form

Number Attempting Whole Matriculation Examination	Number Attempting Agricultural Science	% Attempting Agricultural Science
14617	61	0.4%

2. Biology

Fifth Form

Students at this level study the "Web of Life" course, using the textbook "Web of Life" and the part 1 Student's Manual.

Aims

The aims prescribed are the same as those set out on p. 6 of the Teacher's Guide, supplied with the "Web of Life" materials.

Emphasis

In order to meet these sims, it is essential that a student's activities be organized so that -

(a) A major part of the work involves direct, personal observation and experimentation by the individual student.

(b) He learns to find things out for himself, and to think critically.

(c) Concepts arise from a student's own experience whenever possible. (Biological knowledge should not be presented as a rhetoric of conclusions.)

(d) Students gain practice in applying concepts developed in the course.

Content

The course content is basically chapters 1 - 16 of the "Web of Life" together with the exercises set out in the Students Manual part 1.

Assessing Students

If the school is classified as "Class A" then the biology teacher is free to set his own examinations, or use any appropriate testing system (see comments, Table 3) to determine which students should obtain a pass in the subject. Up to a point he can choose which aspects of the course he concentrates on and which he leaves out. If he wishes he can submit a quite different course to the VUSEB for approval.

On the other hand, if the school is "Class B" then the students sit for a $2\frac{1}{2}$ hour examination at the end of the year which is set by a panel appointed by the VUSEB. This means that the students are expected to have covered certain basic ideas and basic exercises or their equivalent. This is roughly the material marked basic in the Teacher's Guide for all chapters except 9 and 14 which are not to be examined. The examination tests a variety of skills, not just knowledge.

From Table 1 it can be seen that in 1969, 32.7% of the number of entries for Leaving studied Biology, while in 1968 there were 29.8% and in 1967 27.0%. This suggests that there has been an increase in the interest shown in the subject in the last few years.

Sixth Form

These students study the second half of the "Web of Life" and carry out exercises from the part 2 Student's Manual.

Aims and Emphasis

The aims and emphasis of the course are similar to those for 5th form.

All the students sit for a written 3 hour examination at the end of the year which is set by a panel of examiners appointed by the VUSEB. The material to be examined is set out in the VUSEB Handbook and is roughly the material marked basic in the Teacher's Guide. Certain chapters are not to be examined, i.e., chapters 30, 31, most of 32, part of 34, part of 38, 40, part of 41. However, quite a number of teachers include certain of the optional chapters and also quite a number of the optional exercises.

This course was introduced into 6th form in 1968, and a study of the percentage attempting Biology suggests an increase in interest.

1967, before this course was introduced	24.2%
1968, the first year of the new course	25.1%
1969	29.1%

Teacher Qualifications

The qualifications of teachers taking 5th form and 6th form are set out in Table 2.

The sample of 102 teachers taking 6th form biology all had some teacher training. There are not figures available at the moment to indicate what percentage of teachers taking 5th form biology have no teacher training.

Table 1. Number and proportion of students studying Biology in Victoria, 1969.

<table>
<tr><th>Form</th><th>Technical Schools</th><th colspan="5">Secondary Schools</th></tr>
<tr><td>1
2
3
4</td><td>All students study Science which includes some biology

Weaker students study Science 1, includes Ecology, Conservation</td><td colspan="5">A rough estimate suggests about 80% of students study Science which usually includes some biology.</td></tr>
<tr><td rowspan="4">5</td><td rowspan="4">Leaving General Science - includes some biology.
Studied by weaker students.

Biology - studied mainly by girls and boys who study art and related subjects.</td><td></td><td colspan="2">Total presented for Biology
Boys / Girls</td><td>No. of entries for Leaving (i.e. 5th form)</td><td>% Studying Biology</td></tr>
<tr><td>Class A : examination set by teacher in each school.</td><td>2469</td><td>4445
6914</td><td>17801</td><td>38.84</td></tr>
<tr><td>Class B : examination set by VUSEB</td><td>957</td><td>3612
4569</td><td>17282</td><td>26.45</td></tr>
<tr><td>Total for Victoria</td><td colspan="2">11483</td><td>35083</td><td>32.73</td></tr>
<tr><td rowspan="4">6</td><td rowspan="4"></td><td colspan="2">Number attempting whole Matriculation examination</td><td colspan="2">Number attempting Biology</td><td>% Attempting Biology</td></tr>
<tr><td>Boys</td><td>9288</td><td colspan="2">1504</td><td>16.2</td></tr>
<tr><td>Girls</td><td>7644</td><td colspan="2">3423</td><td>44.8</td></tr>
<tr><td>Total</td><td>16932</td><td colspan="2">4927</td><td>29.1</td></tr>
</table>

Table 2, The qualifications and training of the teachers taking biology at each level, Victoria.

Form	Technical Schools	Secondary Schools
51. 1 2 3 4	Many technical teachers taking Science are trained in Engineering and/or Chemistry so have a good background in Maths, Physics and Chemistry.	No data available. Science taught by the Biology, Chemistry, Physics, Maths or some other teacher.
5		Sample 263 teachers from High Schools, Catholic and Independent Schools, Qualifications Science graduates with major in biological science 43.6% Science graduates with some biological science 12.9% Some University biological science 27.0% Diplomates with biological science 4.9% Some tertiary biological science 9.9% No tertiary biological science 1.5% Teacher Training Dip. Ed. 31.1% · B. Ed. 4.6% · T.S.T.C. 21.9% · T.P.T.C. 12.4% · Other 19.1% · Nil 11.2%
6		Qualifications - Sample 239 teachers from High Schools, Catholic and Independent Schools. Science graduates with major in biological science 52.3% At least one Part II biological science (University) or the equivalent 26.4% Part I University biological science or the equivalent 16.4% No tertiary biological science 4.6% Teacher Training - Sample 102 teachers from High Schools, Catholic and Independent Schools. Dip. Ed. · B. Ed. · T.S.T.C. · T.P.T.C. · A.C.T.T.

Table 3. The nature and extent of the testing procedures used in Victoria, 1969.

Form	Technical Schools	Secondary Schools		
1 2 3 4	Examinations set by teachers in each school. Objective type exam. with a few longer responses. Science Part 1 - Examination external objective and some longer responses mostly knowledge.	No external examinations Type of testing varies from school to school		
5	Most sit for an external examination - mostly knowledge.	Class A : examinations set by teacher in each school. Methods of testing used:- formal examinations ($2\frac{1}{2}$ hours), short tests, practical tests, projects, assessment of student participation in class.		
		Total presented for biology	% Pass	Total % pass
		Boys 2469 Girls 4445	78.01 81.64	80.34
		Class B : examination set by VUSEB. One $2\frac{1}{2}$ hour written examination at the end of the year. Testing throughout year at class teachers discretion.		
		Total presented for biology	% Pass	Total % Pass
		Boys 957 Girls 3612	55.80 60.85	59.79
6		One written 3 hour examination set by VUSEB at the end of the year for all students.		
		Total presented for biology	% Pass	Total % Pass
		Boys 1504 Girls 3423	66.82 65.99	66.24

TASMANIA.

L. M. Mulcahy.

The Schools Board of Tasmania was constituted in 1946 and took out of the hands of the University the responsibility for examining students at the Intermediate level or 4th year of Secondary Education. This examination was approximately equivalent to the present Victorian Leaving Examination.

The Board remained as it was originally constituted until 1966 when it was reconstituted with a larger number of members selected from a wider field of academic interests. At this time, too, changes were introduced which led to the abolition of the Schools Board Certificate and to the adoption of the School Certificate which replaced it. Eventually in 1969, the University moved out of the school examining field and the Schools Board replaced the Matriculation Examination with the Higher School Certificate.

225 or 8% of all candidates entered for Biology in 1961 when it was first examined as a separate subject at School Certificate level. This figure increased to a maximum of 961 or 21% of the candidates in 1966, and since then there has been a gradual decrease to 850 or 11.7% of the candidates in 1969. One factor contributing to the decrease in Biology student numbers was the preference for Science IIC, a mixed Science subject with the emphasis on human physiology.

At the Matriculation level, now Higher School Certificate, Biology has been examined for many years with a gradual increase of candidates a maximum of 1584 or 50.1% of the total number of candidates in

1969. The large proportion of candidates offering Biology as a subject at Higher School Certificate level can be partly explained by the University Rules for Matriculation which demand a Science or Maths subject from candidates wishing to matriculate. However this picture may radically alter in the future due to two occurrences.

First, in 1967 the then Minister for Education convened a committee to examine the role of the school in society. The committee received evidence from all interested bodies and a report was compiled and published in 1968.

Among other things this report recommended: "Primary education and the first four years of secondary education should be general in nature, with the same fields of study for all students."

Education Department Schools are following this principle and in consequence Biology will probably disappear as a separate subject for School Certificate in most of its schools, being replaced by a general sdience. However this is not necessarily the case with Independent Schools or Catholic Schools. At least two Independent Schools have adopted the Nuffield Course of separate subjects and others are examining these courses at this time.

The second factor that may bring about radical change is the alteration of the Rules for Matriculation by the University so that candidates are no longer required to offer a science subject.

Tasmania has 104 schools offering education at the secondary level, 76 Education Department Schools, 20 Catholic Schools and 8 Independent Schools. The Department schools consist of 3 Matriculation Colleges which cater for the 5th and 6th year of secondary education only, 2 High schools providing 5 or 6 years of secondary education, 25 High schools and 3 District High schools providing 4 years of secondary education, 35 Area schools which provide mainly an agricultural education but also 4 years of academic instruction, and 8 District schools which are combined primary and secondary schools. 13 Catholic schools and the 8 Independent schools provide education to the 5th and 6 th years or High School Certificate level.

In some schools pupils start the Biology course in their third year, after 2 years of General Science. In others Biology is not offered as a separate subject at all, and the schools offer a variety of other science courses.

Biology may be offered at two levels, Level II and Level III, for the Higher School Certificate.

School Certificate Biology involves an elementary study of the structure and physiology of a mammal and of a flowering plant, together with ecology, heredity, evolution, microorganisms and classification. The 'Web of Life' course for Higher School Certificate was first introduced into Tasmania in 1967 and the old syllabus was gradually phased out. 1969 was the final year in which candidates could choose alternate syllabuses. Level II is based on the first 17 chapters of 'The Web of Life' while Level III comprises the second half of the book only.

School Certificate Biology is examined internally by schools, and candidates are accredited under a moderation system. To quote [fro]m the Schools Board's Regional Moderation Handbook 1969:

"The Schools Board of Tasmania has adopted the principle that teachers should be responsible for the assessment of their pupils, and to this end proposes to use moderation procedures for the award of the School Certificate in 1969. These procedures will enable the Board to accept responsibility for standards through its Chief and Regional Moderators.

To provide for decentralization, the Board has divided the state into eight regions. In defining the regions, the Board attempted to make each region as representative as possible of all types of secondary schools."

To summarise the procedure, regional moderation is designed to achieve reasonable comparability of standards between schools and this is done by subject moderators scrutinising each other's examination papers, marking and results.

The determination of final awards for individual candidates is the responsibility of the School Moderator who is usually the Principal of the school.

Naturally there is a wide diversity in the examining methods in schools. Some schools give unit tests after each section of the syllabus has been taught; others give terminal examinations with a final examination in the third term of the 4th year examining the whole syllabus; others give monthly testing on work covered during the current and previous months, and so on.

Higher School Certificate Biology is examined externally, the examination paper being set by the Chief Examination, usually the Professor of the subject at the University, with the help of other examiners, usually members of the Faculty or related Faculties.

Teachers of Biology in Tasmania very considerably in both academic qualifications and teaching experience. As in other States science teachers are a scarce commodity. Teachers of H.S.C. Biology in Independent Schools are all experienced teachers and with one exception all possess science degrees. In Catholic schools the H.S.C. Biology teachers are graduates and experienced, while Matriculation colleges have graduate teachers although some are relatively inexperienced.

School Certificate Biology teachers do not necessarily have a degree. Generally the situation is that the Senior Master in charge of Science in the school does have a degree, but teachers working in his department may not.

Biology in Tasmania gained tremendously with the arrival of Professor Bruce Johnson who occupies the chair of Zoology at the University. In consultation with other faculty members he was instrumental in changing the first year course from Zoology and Botany as separate subjects to a combined course of Biology. Even more important, the Faculty provided a Biology course which was a terminal course especially suited for Art students who were interested in Science.

In consequence many students who study Biology as their only science at Higher School Certificate level are now able to continue their studies in the subject at University level for at least one year, and this may later be increased to two or three years.

Biology in Tasmania is at this time at the crossroads. The adoption of general science in preference to single sciences in many schools will naturally deplete the numbers of School Certificate

Biology candidates. Whether or not the relaxation of Matriculation rules by the University will have any marked effect on the number of students taking the subject remains to be seen. But whatever the case, the success of Biology as a subject will continue to depend upon the interest aroused by the courses offered, and the ability of the teacher to handle the subject.

SOUTH AUSTRALIA

R. E. Page.

This paper presents a brief background to the system of organization of South Australian secondary schools, and then summarises in tabular and graphical form pertinent information about the status of biological education in this State in 1970.

GENERAL ORGANIZATION

Secondary schools cater for grades 8 - 12 with twelth grade being the matriculation year. The students age range is from 12+ to 18+. Education Department secondary schools comprise High, Technical High and Area schools, and there are also Roman Catholic and other Independent schools at secondary leve

In Departmental schools, and, to a lesser extent, in Independent schools, a "track" system operates: all typ of schools are becoming more comprehensive.

Track 0 keeps open the way to matriculation; the content of a Track 1 course may fall short of a suitable preparation for a Matriculation subject, although it keeps open the way to most forms of tertiary study other than University; Track 2 subjects "pursue understanding and acqusition of skills ... [and] is mainly concerned with application of these matters to early entry into direct employment ... and to possible vocational studies ... Track 3 syllabuses are used with Remove classes and Track 4 syllabuses with special classes" (1). There may be transfer between Tracks ; the end of each school year.

Figure 1 outlines the track system. In each rectangle the symbols show, from top to bottom:

a) the Track, e.g. "3-2" means "third year, Track 2."

b) the percentage of students in each track each year, and

c) the time devoted to science, if the student takes a science. In the senior school Track 0 the time allotment shown is the time per subject, i.e., a 5 - 0 student taking both chemistry and biology would commit 2 x 240 minutes to science subjects.

SCIENCE ORGANIZATION

Recently the Department schools have attempted to rationalise the science syllabuses for all schools and all tracks. The newly formed Science Curriculum Committee with representatives expert in different types of schools and the different tracks within the schools should facilitate this rationalization.

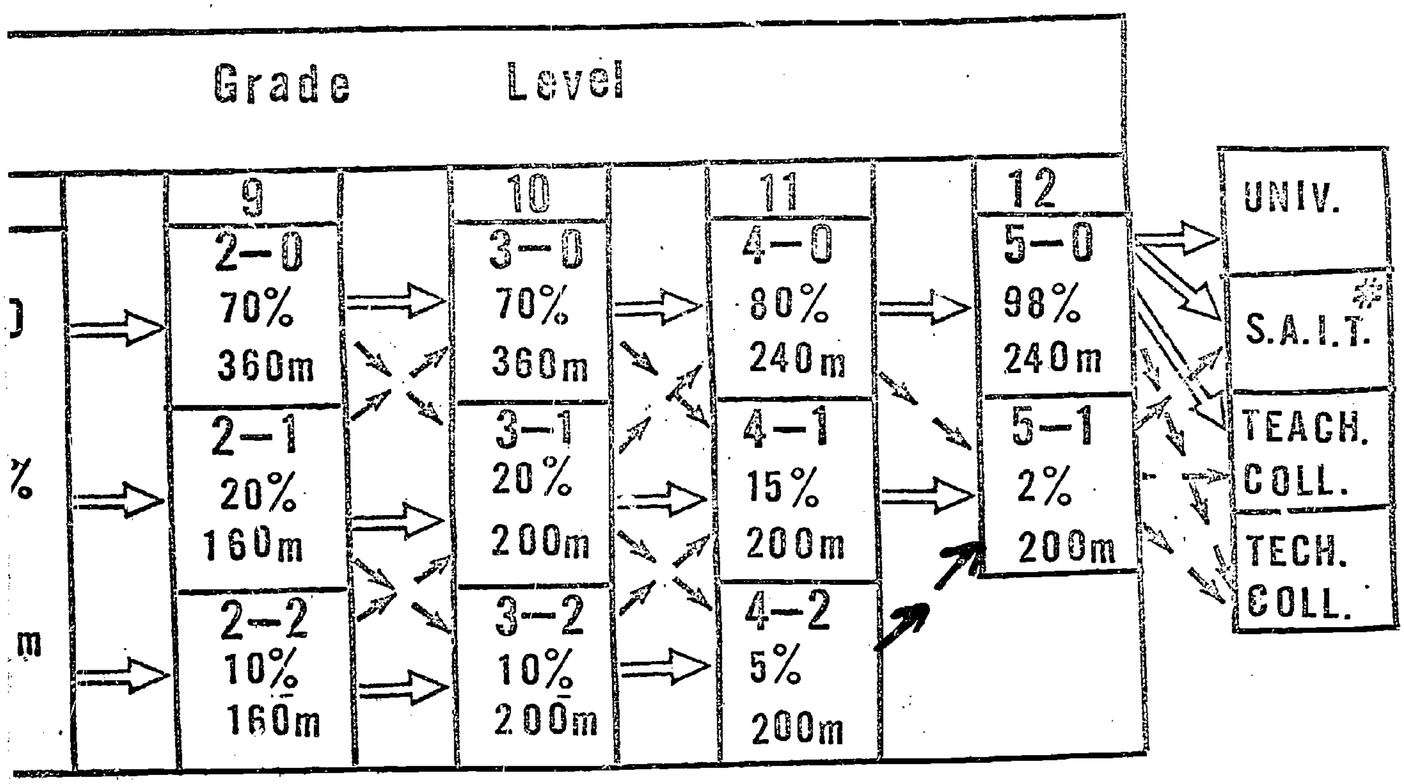
Subjects available

In the junior secondary government schools the only science subject available for all tracks is General Science. In grade 11 4 - 1 General Science, 4 - 1 Physical Science and 4 - 1 Agricultural Science; and 4 - 2 General Science are offered. In grade 12, 5 - 1 Biology, 5 - 1 Physical Science and 5 - 1 Agricultural Science are taught. In grades 11 and 12 Track 0 students may take Physics, Chemistry, Biology and Geology courses examined by the Public Examination Board.

Objectives

Two general sets of science objectives are now conceded in [illegible]th Australian schools:

TRACK SYSTEM
HIGH SCHOOLS



ression

⟹ Normal

- → Possible

See text for explanation

*S.A. Institute of Technology

Content objectives - a study of the environment

Behavioural objectives - how to find out about the environment.

An inquiry approach is recommended, leading to a knowledge of:

1. What kinds of things are in the environment?
2. What are the materials of the environment?
3. What are they made of?
4. How do they interact?

At the same time, it is an objective of the courses to teach:

1. Scientific skills (observations, classifying, testing hypotheses, etc.).
2. Skills in understanding (reorganizing and understanding concepts, etc.).
3. Laboratory skills.
4. Communication skills.

Testing procedures

Although there is considerable variation, continuous assessment is carried out in most schools over the full five year period. This results in about eight assessment periods per year. No certificates are issued for academic achievement before grade 11.

Grade 11 and 12 subjects in Track 0 and some Track 1 subjects are externally examined by the Public Examinations Board and certificates showing the grades achieved are issued to all candidates. In Tracks 4 - 2 and 5 - 1 the Education Department issues certificates based on the results of continuing assessment plus a final examination which, although set and marked internally, is moderated by Department officers.

BIOLOGY EDUCATION

Students

With the introduction of general science in the junior secondary school, in which all students deal with the placental mammal and the flowering plant, there has been a dramatic increase in the number of students taking Biology in grades 11 and 12 but, although the present matriculation requirements allow science - oriented students to include Biology in their subjects, it is still prudent for them to exclude it. Thus the majority of senior Biology students are "arts-type" students. If this position were to change it would be reasonable to suppose that the Biology explosion would present a great problem to Biology teaching resources.

Figure 2 shows the great increase in relative numbers taking Public Examination Board examinations in Biology.

Teachers and class size

The following tables are based upon replies to questionnaires sent in 1969 to all S.A. Biology teachers preparing students for the Public Examination Board Biology examinations.

P. E.B. SCIENCE CANDIDATES 1964—1970

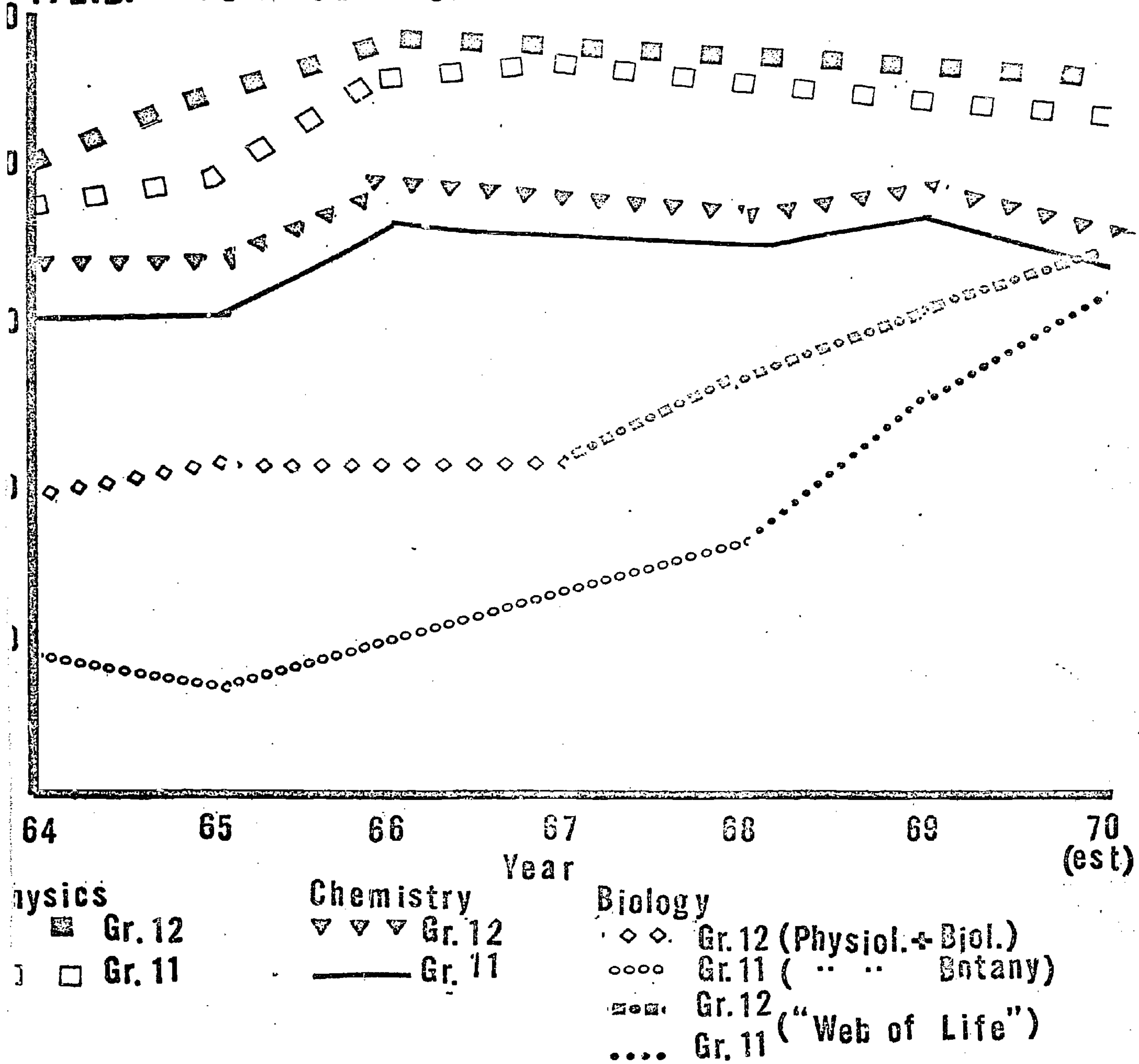


Table 1.

TYPE OF SCHOOL

	ED. DEPT. METROPOLITAN	ED. DEPT. COUNTRY	ROMAN CATHOLIC	OTHER INDEPENDENT	TOTAL
SENT	70	52	18	20	160
RETURNED	24	31	11	12	78
% RETURNED	34	60	61	60	49

Proportion of questionnaires returned from each type of school in 1969.

(Data in tables 2 and 3 are based upon this sample of 78 biology teachers.)

From this table it is obvious that the data may not give a true indication of the capabilities of those responsible for Biology teaching in the various schools. The sample may be far from random and heavily biased towards those teachers who are genuinely interested in Biology and/or Biology teaching. However, more complete data are not yet available.

Table 2.

		TYPE OF SCHOOL				
TEACHING EXPERIENCE		ED. DEPT. METROPOLITAN	ROMAN CATHOLIC	ED. DEPT. COUNTRY	OTHER INDEPENDENT	TOTAL
	YEARS					
	0 - 5	12	5	17	3	37
	5 - 9	9	3	10	4	26
	10 + 14	2	2	3	3	10
	15 - 19		1	1	1	3
	20 +	1			1	2
		24	11	31	12	78
QUALIFICATIONS						
	M. Sc. B. Sc. (Hons)			2	2	4
	B. Ag. Sc. B. Sc.	16	5	16	7	44
	Part degree	7	4	10	2	23
	Other RDA BA	1		4	2	7
			9	32	13	78
	Dip. Ed.	9	1	3	3	16
	Dip. T.	13	4	18	1	36
	Part Dip. Ed.	2		3		5
		24	5	24	4	57
	1 Bio/Sc. subject *	24	11	31	12	78
	Pt. II Bio/ Sc. subject**	17	8	21	7	53
INSERVICE	0	5	2	8	5	20
	1	8	2	13	1	24
	2+	11	7	10	6	24
		24	11	31	12	78

Experience, qualifications and attendance at inservice conferences of South Australian Biology teachers.

* Only 1 Biological Science subject at a University.

** At least one part II level university Biological Science subject at a University.

Table 3.

	TYPE OF SCHOOL									
	Education Department				Roman Catholic		Other Independent		Total	
	Metropolitan		Country							
Grade level	11	12	11	12	11	12	11	12	11	12
Class size										
30 +	7	7	1	1	2	0	2	2	12	10
25 - 29	9	6	7	0	2	0	3	0	19	6
20 - 24	8	1	8	3	4	2	5	9	23	15
15 - 19	6	4	8	2	1	2	3	0	16	8
10 - 14	1	2	0	4	1	0	1	2	3	8
1 - 10	0	0	1	4	0	1	0	0	1	5
	31	20	25	14	10	5	14	13	76	52

Distribution of Track 0 Biology class size in different types of South Australian schools, 1969.

Examinations

Since 1967 the Public Examinations Board has worked closely with teachers to ensure that candidates were evaluated on the basis of the broad objectives of the course. The examination paper allows for some objectivity in grading, with about one third being multiple -

choice, one third short response and one third essay - type questions.

This pattern is followed in 5 - 1 Biology examinations, but continuous assessment plays a more important part in the final grade than does the final examination.

REFERENCE

1. Anders, D. J., 1969 S.A.S.T.A. Journal, August, 7 - 11.

WESTERN AUSTRALIA.

K.J. Betjeman

Introduction

Although the topic of this paper is essentially "Biological Education in Secondary Schools in Western Australia", it is necessary to view biology as part of the total science education pattern in order to fully appreciate its current status. For this reason I propose to consider "Science Education in Secondary Schools in Western Australia" with specific reference to biology.

Overview of Secondary Education

In Western Australia secondary education is offered over five years following seven years of primary education. The years of secondary education are named in numerical succession (First Year, Second Year, etc. to Fifth Year), however as this conference is concerned with interstate comparisons, discussion will be easier if I use grade references. Table 1 provides background data for grades 8 to 12.

Grade	Western Australian Nomenclature.		Predicted % Retention of Grade 8,1970	Pop. Feb. 1970	Certification	Age
12	Fifth Year	Upper School	27	4,784	Leaving Certificate (Battery of examinations - some at higher level for matriculation).	17.3
11	Fourth Year		35	6,513		16.3
10*	Third Year	Lower School	93	17,519	Achievement Certificate (Cumulative evaluation over three years).	15.3
9	Second Year		99	19,432		14.4
8	First Year		100	20,109		13.3

* End of compulsory education.

TABLE 1 : Background Data.

A detailed discussion of secondary education in Western Australia is available in the Dettman Report (1969).

Overview of Secondary Science Grades 8 to 10

The distribution of students and science subjects for 1970 grade 8 is shown in Figure I. Science education in grades 8 to 10 in Western Australia is currently undergoing a change in both classroom method and course organisation. It is probably fair to extrapolate and say that this distribution is indicative of the possible future general distribution up to the end of grade 10.

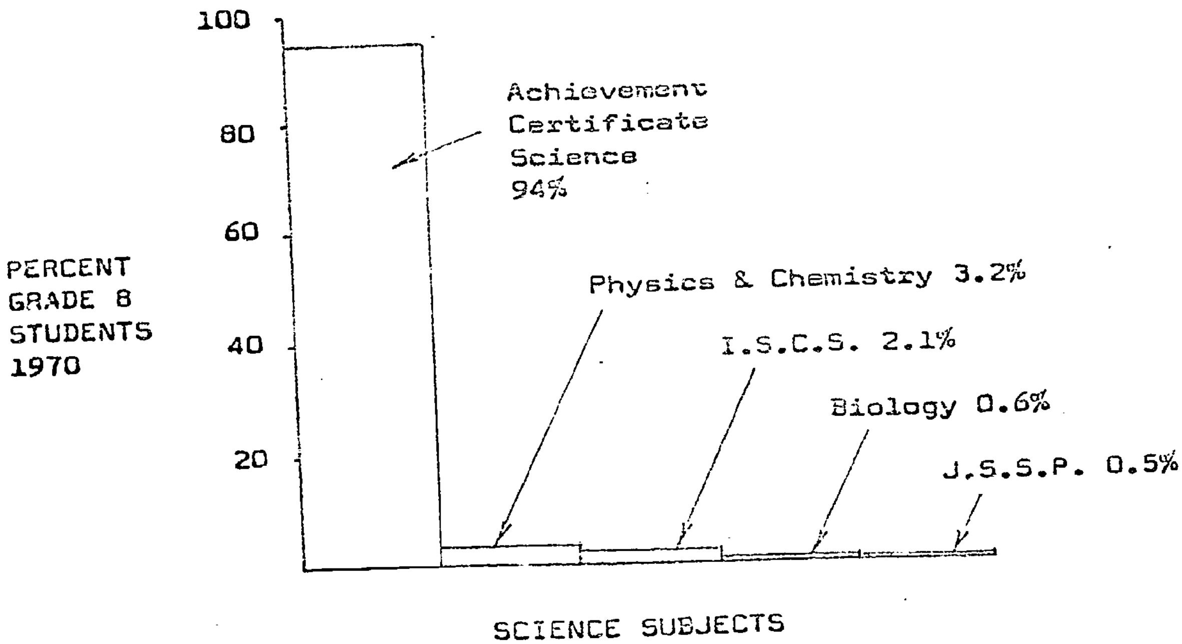


Figure 1 : Distribution of Grade 8 Students in Science

All students in Government schools and most Catholic Independent schools study Achievement Certificate science, mathematics, english, and social studies as compulsory "core subjects" at one of three levels - advanced (upper quartile of the state population), intermediate, and basic (lower quartile of the state population). Each subject is allocated six forty minute periods per week. Most students in non-Catholic Independent Schools study a combination of physics and chemistry. Small numbers of other students study some geology, biology, or physiology and hygiene (Dettman Report, 1969, pp. 35-36). The latter three subjects are tending to be absorbed in general science curricula and may disappear in the near future.

More than 90% of secondary school students in grades 8 to 10 study, or will be studying, Achievement Certificate Science. This course has a compartmentalised topic structure of which 9 topics in 27 are biological, and in which 8 of the 9 biology topics can be studied at one of three levels appropriate for grouped differences in student abilities.

Table 2 summarises the aims, content, methods, and time allocation of the biological components of science courses for grades 8 to 10. In summary, biological education for the majority of students in grades 8 to 10 does not exist as a separate discipline - rather it is one component of general science education.

Overview of Secondary Science Grades 11 to 12:

Figure 2 shows the dist[illegible] of Government School students and science subjects for grade 11, 1970. In addition to the four sciences shown on the graph, there is a small number (less than 1% of the state grade 11 population) of students in Independent schools studying Geology or Agricultural Science. Even though the grade 12 distribution shows slightly higher percentages for physics and chemistry, they still do not exceed the percentage of biology students.

Science Course

	Achievement Certificate Science	Physiology and Hygiene	Biology
Aims	To develop attitudes, interests, knowledge, understanding and skills which will enable the students to develop an appreciation of themselves and their changing environment. (Specific aims are listed in Education Department publication AIB-T-I-O and in the Teachers Guide for each topic).	To develop an understanding of the structure, function, and care of the body, and control of the environment as it relates to sound health practices.	To acquire a knowledge of the world of living organisms.
Biology Content	Characteristics* of Living Things; Diversity of Plants; Diversity of Animals; Insects; Vertebrate Physiology; Flowering Plant Physiology; Genetics; Ecological Relationships; One or more open ended research topics with a biological bias. *Only this topic not treated at three levels.	The whole body organisation; Respiration Food and Nutrition; Body Defenses; Excretion; Response; Locomotion; Community Health; Communicable Disease; First Aid.	Characteristics of Living Organisms; Plant Anatomy and Physiology; Anatomy of an aquatic, amphibious, & terrestrial vertebrate; Habitat, importance, features, life cycle of a range of invertebrates.
Method	Maximum student participation through laboratory centred activities structured to achieve specific topic aims.	Teacher and text book centred.	Teacher and text book centred.
Time Allocation.	6 periods each 40 minutes per week. Each topic approx. 4 weeks.	Minimum of 4 periods each 40 minutes per week.	5 periods each 40 minutes per week.

TABLE 2 : Grades 8 to 10 Biological Sciences.

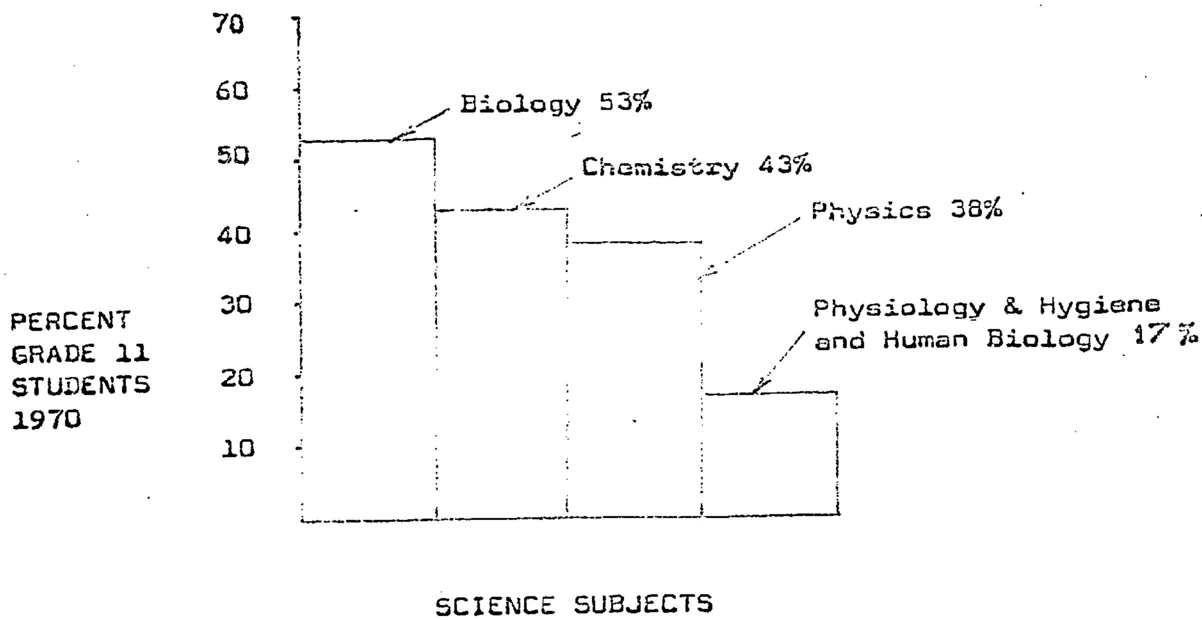


Figure 2 : Distribution of Grade 11 Students in Science

Table 3 summarises the aims, content, methods, and time allocation of grades 11 and 12 biological sciences. Web of Life Biology is taught in all Government schools and is replacing traditional descriptive biology in most Independent schools. Curriculum developers do not want Human Biology to be regarded as a "soft option" science - rather they would like the subject to illuminate its own special viewpoint and effectively forge a link between the sciences and the humanities.

The traditional prestige of physics and chemistry, and the influence of tertiary institutions on subject selection in secondary schools plays a major role in determining the science subject selection by grade 11 and 12 students, i.e. because passes at Leaving level in physics and chemistry are pre-requisites to university studies in these subjects and because many university departments (including Biological science departments) prefer physics and chemistry over biology, the university is in effect encouraging potential university students to opt out of secondary school biology. It is common practice for students who intend to proceed to a science or mathematics tertiary education to study both physics and chemistry. A small percentage (5-6%) of the more able students select both biology and chemistry. Students proceeding to a non science tertiary education select Biology alone or Biology with Physiology and Hygiene (or Human Biology).

These trends are illustrated by Figure 3 showing the distribution of student abilities (estimated from the A.C.E.R. Advanced

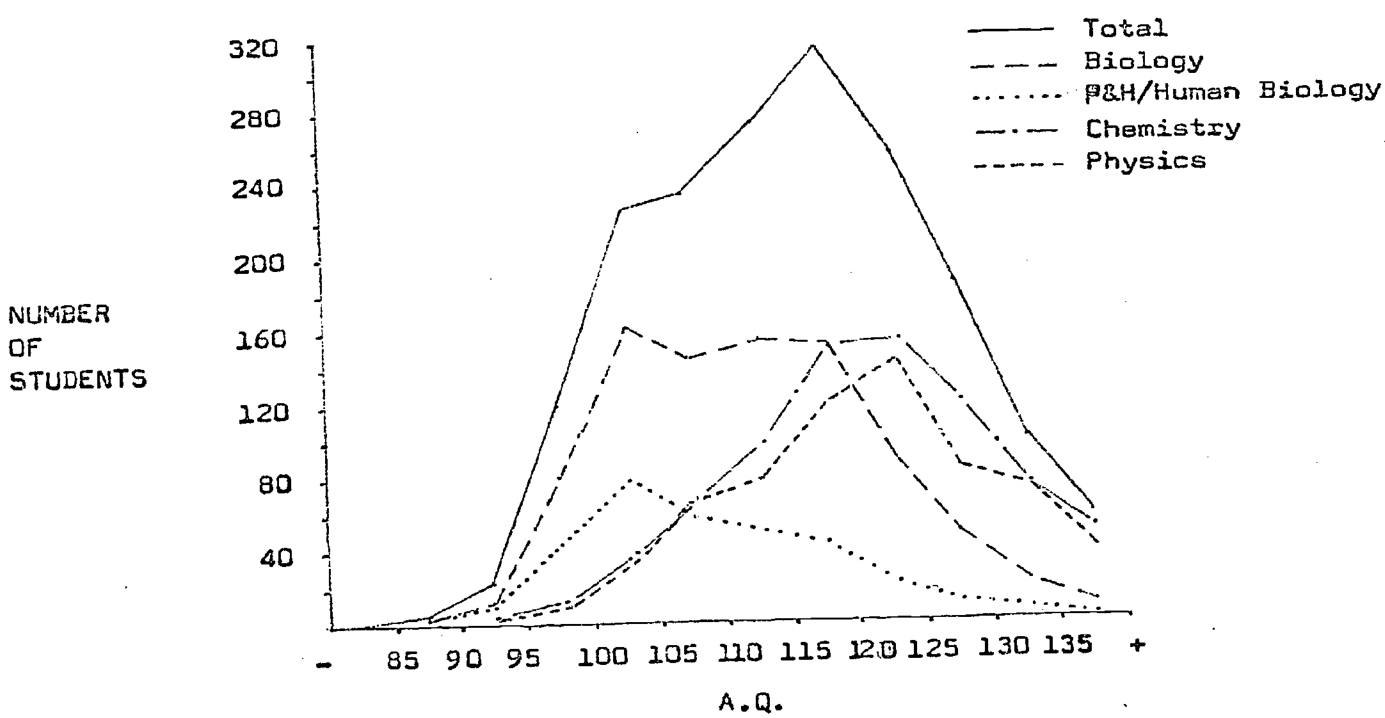


Figure 3 : Distribution of 1969 Grade 11 Student Abilities in the Sciences

Biology Course

	Web of Life Biology	Physiology & Hygiene*	Human Biology* (*alternatives)	Agricultural Science
Aims	To learn some facts and big ideas of biology, to view biology as inquiry, to become familiar with the Scientific Method, to use course concepts and methods in everyday situations, to think critically, to realise the tentative nature of hypotheses, to base value judgements on sound thinking, to develop communication and practical skills, to appreciate that man is part of the living world.	To develop an understanding of structure, function, and care of the body.	To encourage the study of man using biological principles and to relate these to man's mental, nutritional, educational, health, and social problems.	To give an introduction to the scientific principles underlying agricultural practice.
Content	Grade 11 - All of Part I. Grade 12 - Part II modified to reduce the time demand of basic work by 15%.	More detailed cover of grades 8 to 10 physiology and hygiene.	Human anatomy and physiology; Microbiology; life cycle and origins of man; variations between men; races of man; mental, bodily & community health.	Climate, plant anatomy and physiology, plant diseases and pests, soil management, plant nutrients, farm rotation, crops & pastures, genetics, animal husbandry, agricultural machinery, farm management.

(Contd./........)

	Web of Life Biology	Physiology & Hygiene*	Human Biology* (*alternatives)	Agricultural Science
Method	Student centred laboratory work and discussion with emphasis on inquiry and the big ideas of biology	Teacher and textbook centred.	An experimental rather than an authoritarian approach whenever possible.	Combination of teacher and textbook methods with farming experience.
Time Allocation	Grade 11-minimum 5 periods each 40 minutes per week. Trend is to 6 periods. Grade 12 - 6 periods each 40 minutes per week.	5 periods each 40 minutes per week.	5 or 6 periods each 40 minutes per week.	Minimum 5 periods each 40 minutes per week.

TABLE 3 - Grades 11 and 12 Biological Sciences.

Test of Quantitative Ability) in the sciences from total 1969 grade 11 populations in 16 of 33 Government Senior High Schools. Although each subject includes the full range of student abilities, the distribution of the physical science populations have positive skew while the biological sciences have negative skew. This is more apparent if the percentage of students for each AQ interval is graphed (Figure 4).

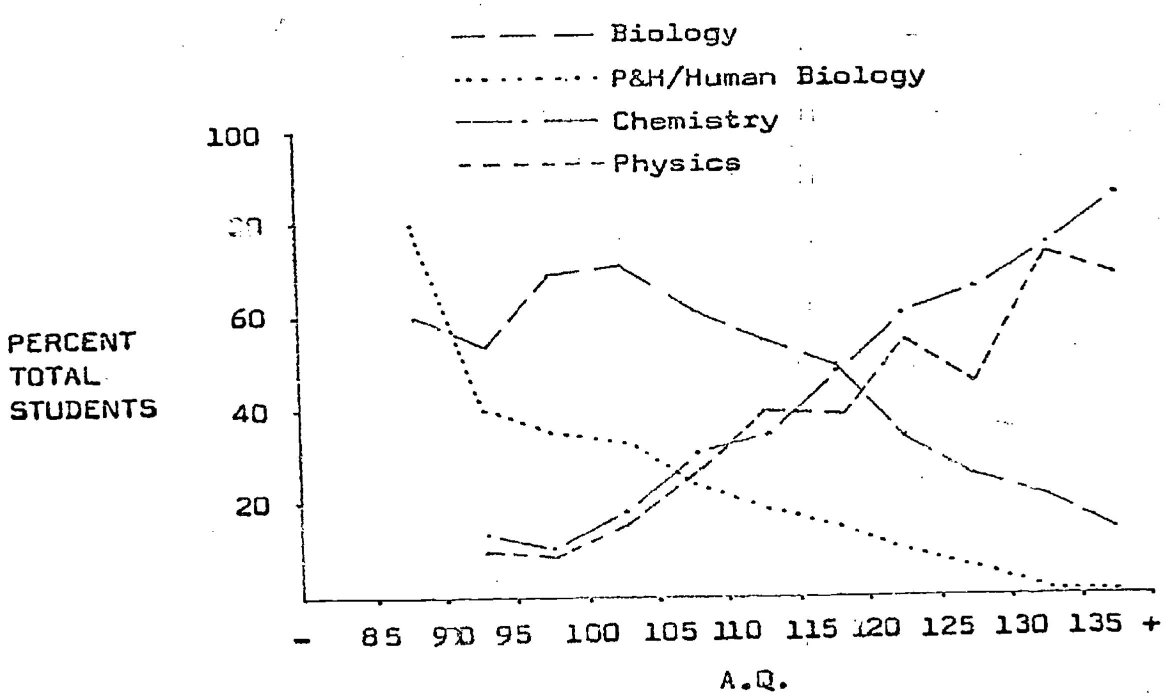


Figure 4 : Percent of Each Ability Interval of 1969 Grade 11 Students for Each of the Sciences

The retention rate of biology students from grades 11 to 12 has varied within the range 70 - 80% during the past five years. Although there was a 22% decrease in the biology population from 1969 grade 11 to 1970 grade 12 and the drop-outs (due to dislike of biology or employment) came from all AQ intervals, generally they included slightly greater numbers of the less able students (Figure 5). This pattern is repeated for the subject Physiology and Hygiene.

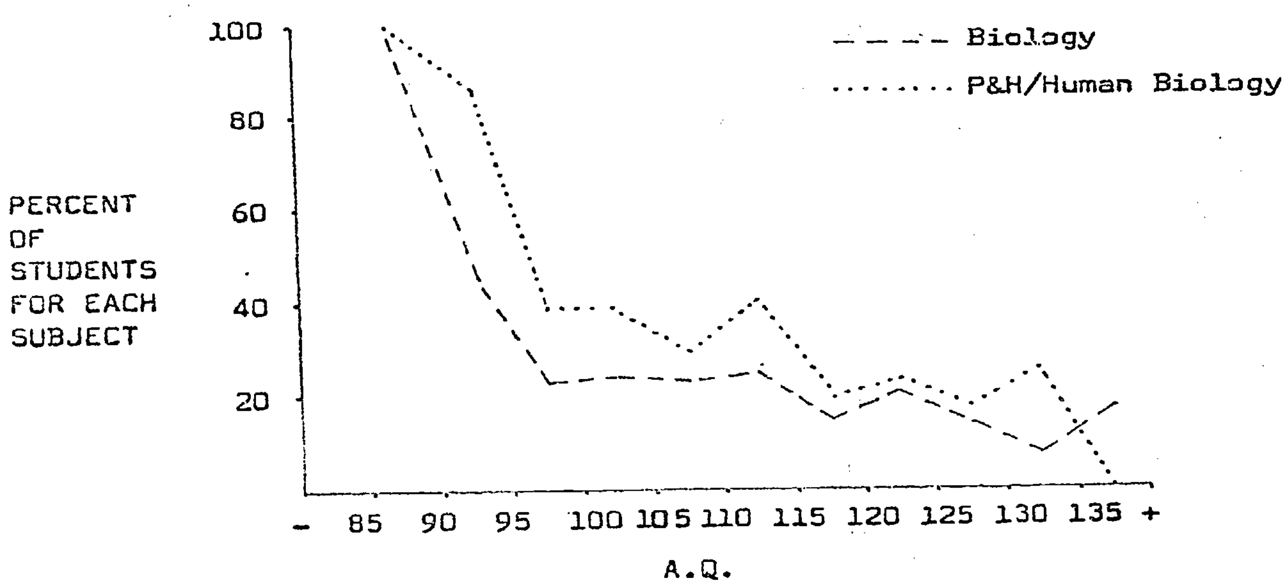


Figure 5 : Grade 11 to 12 Dropout in Biology, Physiology & Hygiene, and Human Biology

Methods of Evaluation and Certification Grades 8 to 10

As from 1970 students commencing secondary education will no longer be subject to external examinations. Instead, student achievement will be assessed by internal school methods externally moderated by a Board of Secondary Education. This system gives maximum flexibility to science teachers in determining what and how to assess and allows them to complete an on-going assessment of the student over three years. At the end of grade 10 the Board issues each student with an Achievement Certificate showing the levels and grades of the subjects studied.

Assessment in the biological (and other) science topics is left to the discretion of the science teacher in charge. Usually it will involve a wide range of methods suitable to the aims of the topic. In-service work, interschool and intraschool science meetings, liason with subject moderators from the Board, and liason with Education Department representatives ensures reasonable comparability of standards.

Methods of Evaluation and Certification Grades 11 and 12

Public examinations are conducted at the end of grade 12 by the Public Examinations Board of the University of Western Australia. Biology is examined at two levels - a Leaving level paper of three hours duration and by student choice, an additional Matriculation level paper also three hours duration. Physiology and Hygiene and Human Biology are not approved as matriculation subjects and are examined at Leaving level only. Students who pass subjects at Leaving level are awarded certificates wh[illegible] show the subjects passed or passed with distinction.

In order to matriculate, a student need not enter fo any science subject. However, for those proceeding [illegible] science tertiary education, matriculation physics and chemistry is the most common choice.

Demand and Supply of Biology Teachers

Although most science teachers teach some grade 8 to 10 science, it is common practice to specialise as physical science or biological science teachers in grades 11 and 12. Consequently, all Biology, Physiology and Hygiene, and Human Biology is taught by one to four teachers in each Senior High School. Figure 6 seems to indicate that there is an adequate supply of teachers qualified in one or more first year university biology subjects. However, the percent of staff qualified at this level includes many who have taken biology as an appendage to an arts major or as a fill-in subject in a physical science degree. Very few biology teachers are biology majors. The availability of qualified biology teachers is appreciably less than for the physical sciences.

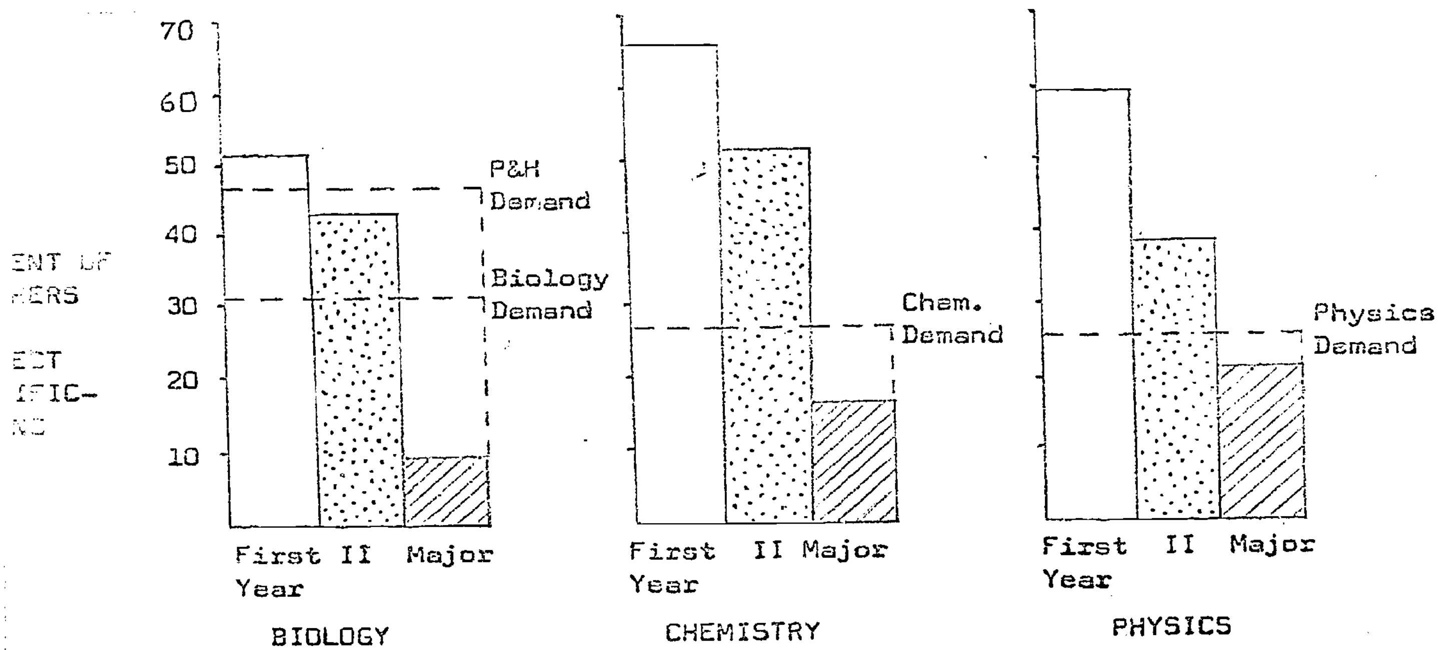


Figure 6 : Demand and Supply of Science Teachers in Senior High Schools 1969

CONCLUSION.

In concluding, I would like to make the following three observations:

(1) Biology does not exist as a separate science discipline in grades 8 to 10. Instead, it is one component of a general science education.

(2) Enrolments in biology are increasing by approximately 1-2% of the total grade 11 population each year probably due to increasing grade 10 to 11 retention rates. This raises the question of the suitability of the rationale,

and the degree of difficulty of Web of Life Biology as the only science for terminal students. There is a growing need for a more appropriate science course which caters for terminal secondary students, especially the less able group from the lower quartile of the Grade 11 population. Possibly such a science course should emphasize man and the environmental problems created by and related to man.

(3) There is developing realisation among Western Australian students that biology can be both challenging and interesting, and that they must question the traditional prestige of the physical sciences. A small but increasing proportion of academically more able students are electing to study biology. It is the general feeling of Western Australian biology teachers that Web of Life biology can provide suitable stimulation for these students.

References:

Western Australia, Education Department, "Secondary Education in Western Australia" Report of the Committee on Sec. Ed., 1969, Perth.

Western Australia, University, "Manual of Public Examinations for the Year 1970", Perth.

Western Australia, Education Department, Achievement Certificate Course, "Science Introduction for Teachers", 1970, Perth.

SECTION II

THE AIMS OF BIOLOGICAL EDUCATION

Three speakers presented their own statement of what the aims of biological education in Australia should be at present. Professor Allbrook and Dr. Boyden both think that biology courses should bear a close relation to Man; since "in the next decade there will be a need for more and better basic biological education in the citizenry as a whole". Allbrook, however carefully spells out that there needs to be an understanding of the ecosystem, adaptation, cell theory, the chemical structural basis of protoplasm and of heredity. Boyden's paper, on the other hand, emphasises the necessity to concentrate on teaching "biological topics of special significance to modern society", giving the impression that he would see the role of the biology teacher as one of inculcating particular attitudes toward some aspects of modern society, which results from the "interplay which is taking place continuously between the processes of nature on one hand the process of culture on the other".

Mr. Morgan is particularly concerned with looking at the place of biology education in the general education system and is opposed to biology courses being used to inculcate a particular set of attitudes toward any given social problem. This theme is spelt out carefully as are his reasons for advocating "broad understanding of biological processes": "to start, proceed, and finish with man in a course precludes the development of insights which come from a wider study."

A brief summary of the discussion that followed these papers is given, setting out the areas where agreement is reached. Further relevant comment on the areas covered by these papers will be found in the report of the discussion group in "Content" (p. 124.).

The Aims of Biology Teaching in Australian Secondary Schools

D. G. Morgan

My purpose in giving this address is to consider factors that determine which content and methods a course designer should include in a classroom programme, and which he should leave out. The time youngsters spend in schools is limited, and there is a great deal which might be included. What goes into, and what comes out of school courses needs very careful thought, so that the time students spend in school is used to best advantage.

Education in biology cannot be considered separately from the rest of the educational process; what is done in biology must depend on the overall goals of secondary education.

Various people over the years have attempted to state the aims of education; perhaps no one person's ideas are generally accepted. In a recent address, D. H. Munro (1) grouped theories of education under three headings:

1. "Assimilation" theories, in which the main aims are social adjustment, emotional security, and integration into the community way of life. As he puts it, the individual is "a barbarian to be tamed, a character to be moulded, a foreign body to be assimilated, a personality to be adjusted".

2. "Practicalist", or "Preparation-for-Life" theories, in which the main aims are to give the pupil skills he is almost certain to need and want rather than to try and pour him into a mould of someone else's choosing. For example, the individual might be taught how to write letters, use a library, make a speech, answer the telephone, buy a house, drive a car, budget pocket money, and so on.
3. What Munro calls "Intellectualist" theories, in which the aim is not to adjust the child to society but to give him the background knowledge, the skills, and the attitudes that will enable him to criticize society and see society, as far as is possible, objectively.

I suggest that Australian educators would, overall, agree with aspects of all three types of theory. I shall attempt a synthesis of views relevant to our discussions here, views with which our society might be prepared to agree. If you do not agree, I hope that you will say so in the discussion which follows this address.

Educators should be conscious that they have been entrusted by parents, and by society, with the nurture of students. As educators, we are expected to bring about changes in students broadly in accordance with the wishes (often only vaguely-defined) of parents and society, using specialist skills which the parent usually does not possess. Our laws even require that a child be taken from his parents, forcibly if necessary, and put before a teacher. The educator has a clear responsibility to live up to the expectations of the community; he should always be mindful of his responsibilities.

In our society, the education process is seen as developing the individual, rather than the group or the population. Compare this with stated policy in a society working under another social system, as quoted by Munro:

> "In the Kindergarten and Junior School, where basic habits and attitudes to life are formed, the foundations of [the particular ideology] are systematically laid, particularly by the imaginative telling of stories of heroic deeds so that almost without realizing it the children will understand the great and historic role of our multi-national country in the liberation of all nations from exploitation, from lawlessness and from national and religious oppression. They are given a sense of belonging to something great, a cause to strive for, and in the achievement of this purpose they are willing to accept the disciplines placed upon them. ... [They are] prepared to live happily and efficiently in the society in which they will live during their adult lives."

While our society does seem to want certain characteristics in all of its citizens, much of our educational thinking is directed towards production of people who are <u>expected</u> to be individually different, though within certain accepted limits. (The difference between our outlook and the one quoted above is therefore one of degree, rather than an absolute one.)

I will now try to spell out what I believe are agreed goals of

Australian educational systems.

The individual student, in the course of his formal education, should be subjected to a variety of learning experiences, such that:

(i) He becomes informed as to our cultural heritage, in all its aspects. This includes coming to know something of mankind and its arts, and of the surroundings of man as seen by man.

(ii) He gains particular knowledge, psychomotor skills, intellectual skills, and attitudes, chosen so that he can make a living and live in harmony with other people.

(iii) He is able to make some contribution to human society as a whole, however small that contribution may be. Our society is a changing society, one dedicated to change; the educated person must therefore be more than a conformist, he should be an independently-thinking person capable, in some measure, of acting independently of others. But to be able to make a contribution to society is not enough.

(iv) He must be willing to make some contribution to the life of society. This is a question of attitude development. Somehow the student must become a socially-concerned adult, if only because by being concerned for others he may, in the long run, be helping himself.

(v) He becomes better able to lead a personally-satisfying life. He should be able to develop interests which give him aesthestic pleasure, which are rewarding in themselves. Sometimes we stop short of this goal in our educational processes, and perhaps some people are the worse for our admissions.

It is not my own belief, nor do I believe it is a predominating view in our community, that secondary education should be directed primarily towards tertiary education. The secondary school is becoming part of the common eduoational experience of all - the "common school" - and I believe that <u>the educated citizen</u>, with the characteristics set out above, is its primary goal. Such a person should be admirably suited to further eduoation.

Of course, broad educational goals are likely to be achieved satisfactorily and consistently only if the educational system, and the learning situations provided through that system, are geared towards achieving these goals. It is naive to assume that such goals will be reached because in our better moments we have the right intentions.

In attempting to achieve these broad goals, a number of guidlines seem important, particularly in the context of the overall themes of this conference. I wish to suggest several.

(i) There is certain particular knowledge, and particular psychometer and cognitive skills, that must be acquired by each student. Such knowledge and skills should be selected, I believe, according to its immediate or potential relevance to the student, both as an individual and as a member of society.

(ii) Knowledge should be derived, wherever possible, from direct, personal experience or the next-best substitute. This procedure improves the quality of a student's "information-input", and increases his awareness of his total surroundings. It is only too easy for the educator to resort to verbalism, to the using of words which mean little to the hearers, or which convey a meaning to the hearer different from the one intended. Educators have a responsibility to provide a carefully-chosen range of experiences for students.

(iii) Much attention should be given to developing intellectual skills associated with using information, including problem-solving skills. Possession of higher cognitive skills is an important attribute of an independently-thinking adult member of society. We should try to take education to a point at which a person is capable of and willing to learn for himself; such people should then not stop learning while they possess the physical faculties to do so.

(iv) Students need to gain practice in applying their understandings to situations that form part of everyday life. Classroom programmes should be relevant, and should be seen to be relevant, to aspects of everyday living. Apart from occasional aesthetic satisfaction, there may be little gain to the student from classroom programmes which are completely unrelated to his immediate or future world.

(v) The learning situations used for a particular student should be determined in part by his capacities, background, and interests. Classroom procedures should therefore be different for different students, and should change for a particular student as he proceeds through the educational system. While it is hard to have a variety of educational procedures simultaneously operating in a given classroom, we should strive towards this situation when we design learning situations. (Admittedly, though with a given single educational procedure and 35 different phenotypes in a class, 35 different products are likely to result, without catering for individual differences some of the products will develop in ways neither intended nor desirable.)

(vi) It should be recognized that not all students will be capable of reaching the same levels of attainment. The educational system should be such that every individual, however "dumb" or "clever" he may be, makes gains towards the overall objectives of the educational programme. The amount of gain should perhaps be rewarded, as well as - or instead of - the attainment or non-attainment of some pre-determined "pass" level.

What about the development of attitudes in students? Our attitudes determine, of course, how we behave. Many people believe that there are certain attitudes that should be developed in all students.

Such expressed goals as "love of hard work", "concern for our fellow man" have found their way into statements of educational policy in the past. But what about attitudes towards vexed social questions of the moment?

(vii) I suggest that to deliberately develop a particular attitude towards such a problem is not a proper role of our educational system. Educators should concentrate on developing <u>informed</u>, <u>intellectually-capable</u>, <u>socially-concerned</u> individuals capable of making rational, objective judgements for themselves. For one thing, there will be many social questions of the future which we cannot yet foresee, but which students will have to face.

For a teacher to indoctrinate students with his own attitudes (and prejudices) towards particular social questions, no matter how right they seem to him, is a breach of responsibility on his part. Because of the ways in which attitudes usually develop - through personal experiences, and through perceived social pressures, especially in areas in which people feel insecure - it is only too easy for a respected teacher to do this, albeit unconsciously. Though it is easier to indoctrinate people than to educate them to make their own assessments, I suggest that such a goal is worth the effort. Educators need to ensure that students learn to handle contentious social questions, but in as objective an environment as possible, one in which the teacher deliberately plays his own views down.

So far I have been considering broad goals and guidelines which might apply to all educators. However it is traditional to classify the educational process into subject areas. At this conference we are reviewing only part of the educational process: that which takes place within the periods of time identified on timetables as "biology". Our goals, as biology teachers, will be little different from those of the history, or English, or music teacher. But our emphases will be different. The biology teacher will be influenced by considerations which seem to apply especially to his particular field.

(i) The nature of the scientific process is a key part of our present culture, and so warrants a place in the education of all students. The senior biology class is the only place in which more mature students can have a real opportunity to appreciate the nature of the scientific activity: what a scientist does, how he thinks, how to regard the "findings" of science.

(ii) Not all of the findings of science are of immediate or potential relevance to the student. Biology teachers must cull out material which, while interesting, is competing with more worthwhile content for the very limited time available.

(iii) The findings of science should be conveyed in such a way that observation and inference are clearly distinguished, that the student appreciates the continually changing nature of scientific knowledge, and the degrees to which the various generalizations of the science are supported by evidence.

(iv) Conceptualizing of broad understandings of biological processes is probably more important in the long term than masses of specific, unrelated information. However, the student must be able to obtain information for himself, and deal with such data in a scientific way.

(v) In selecting which broad understandings of the living world should be developed within the limited time allotted to a biology course, it would seem important to attempt to develop some overall picture of the living world, as understood by mankind through the biological sciences. Man, and man's relationships with his surroundings, can then be seen in the context of our overall understanding of the world. To start, proceed, and finish with man in a course precludes the development of insights which come from a wider study.

I believe that the overall goals, guidelines, and particular considerations I have set out should influence course designers in selecting content and designing learning situations. In my view, only if a procedure substantially meets these requirements should it be included in a classroom programme. How much time is devoted to different aspects is a matter for consensus.

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FULFILMENT AND RESPONSIBILITY IN BIOLOGICAL EDUCATION

David B. Allbrook

In a forward looking Conference such as this, where we are riding the crest of the scientific wave, it is good to get historical perspective. I wish to take you back to the first known scientific biologist. Aristotle's time was 347 B.C. - 335 B.C., when he travelled the island of Lesbos and the straits of Pyrrha.

Why should we study Biology? In his words:

> Of natural substances, some are ungenerated and indestructible throughout eternity, others share in generation and destruction. The former (that is, the heavenly bodies) are precious and divine, but we have less opportunity to investigate them since the evidence available to the senses, by means of which one might study them and the things that we long to know about, is very scanty. But concerning the things that perish, that is plants and animals, we have much better means of obtaining information, since we live among them. For anyone who is willing to take sufficient trouble can learn a great deal concerning each one of their kinds. But each of these two groups has its own attraction. For even though our comprehension of the heavenly bodies issmall yet because they are so precious it brings us more pleasure than knowing everything in our region, just as a partial glimpse we chance to get of

those we love brings us more pleasure than an accurate vision of other things, however many or great they are. On the other hand our knowledge of the things that perish has the advantage in that we can obtain more and better information about them; and again since they are nearer to us and more closely related to our own nature, this restores the balance to some extent as against the study of the things that are divine.

Since we have already discussed the things that are divine and set out our opinion about them, it remains to speak of animals without, as far as possible, omitting any one of them, but dealing with noble and ignoble alike. For even in those that are not attractive to the senses, yet to the intellect the craftmanship of nature provides extraordinary pleasures for those who can recognise the causes in things and who are naturally inclined to philosophy. For if we derive enjoyment from looking at imitations of these things because we are then contemplating the art of the craftsman - whether painter or sculptor - who made them, it would be strange and absurd not to delight far more in studying the natural objects themselves, provided at least that we can perceive their causes. And so we must not feel a childish disgust at the investigation of the meaner animals. For there is something of the marvellous in all natural things. The story goes that when some strangers who came to visit

He[illegible]litus entered and saw him warming himself at the kitchen [illegible] they hesitated : but Heraclitus said, 'Do not be a[illegible]. Come in. For there are gods even here.' Similarly we [illegible]uld approach the investigation of every kind of animal w[illegible] being ashamed, since in each one of them there is s[illegible]ing natural and something beautiful.

Th[illegible] [illegible]senee of chance and the serving of ends are found in the works of nature especially. And the end for the sake of which a thing has been constructed or has come to be bel[illegible]s to what is beautiful.

Aristotle then points out that if anyone is squeamish about examining animals, he ought to be so about man also.

But if anyone considers that the investigation of the other anima[illegible]s is beneath his dignity, then he ought to hold a similar view about the study of himself. For it is not po[illegible]ble to look at the constituent parts of human beings, suc[illegible] as blood, flesh, bones, blood-vessels and the like, without considerable distaste. But when we discuss any one of the parts or structures, we must not suppose that when we are talking about - and the object for which our inquiry is undertaken - is their material, but rather the wh[illegible] form, just as in discussing a house, it is the whole form, [illegible]ot the bricks and mortar and timber in themselves, that is our concern. So too the student of nature investiga[illegible] [illegible] composition and the substance as a whole, and not the materials which are found apart from the substance of which they are the materials. (1)

Most of us took to biology because we were fascinated by the study of living things. Perhaps it was their movement, or their growth, or their diversity, or the fascination of their reproduction that began it. Our childhood awareness was directed and encouraged by a mentor to whom we could turn for words of wisdom and encouragement, and who had within himself the capacity to fan curiosity.

Such a school teacher was Dr. R.H. Whitehouse. (Sometime Professor of Zoology at Gat College, Lahore and Vice Principal of Lahore University, Punjab, and then Biology Master, Mercers' School, London, 1936-46). In India and London he helped many travel towards distant horizons of achievement. In one indolent and sloppy youth he stimulated industry and accuracy in field work and laboratory. He was my first teacher contact who succeeded in actually making me think for myself. He was an expert at transforming the energetic questionings of adolescence into creative activity. He rarely gave pat answers, but parried questions with more penetrating questions, and suggestions for reading and simple investigation. Group discussion in the VIth form Biology Course was a regular feature. He was able to do this because of his own width of knowledge and love for and personal familiarity with his subject, and also with the men who made biology, such as Sir Victor Horsley and Graham Kerr. He seemed a formidable man, intolerant of nincompoops, yet ready with praise for the trier no matter how modest his gifts. He was a great schoolmaster whose erstwhile pupils are, today, middle-aged research biologists, Professors, medical men and medical teachers in India, Pakistan, the Middle East, England, Australia and New Zealand.

If we analyse this personal anecdote we learn that the primary aims of biological education may include the following: a sharpening of a pupil's awareness of his environment, especially his biological environment, a stimulation of his latent curiosity, a training of his critical faculties, and an opening of the storehouses of other men's knowledge and experience.

One other seed was sown in me by R.H. Whitehouse. He let me have a very minor part in the work which went into one of his biology textbooks for schools - "Dissection of the Earthworm" I think it was. I learnt what fun discovery and creative work could be. So perhaps we should add that to our list of aims. Because if all biology teachers can do likewise for their pupils they will have increased the happiness of the world by quite a quantum.

These aims are of primary importance, for they achieve personal satisfaction and fulfilment in people. All are relevant to the pupil's development as an educated person. They are mandatory for growth in a technological civilization.

But educationists have responsibilities to society as a whole, as well as to individuals. Biologically trained educators have a weighty share of this responsibility. It is becoming increasingly heavy. This is because of the massive increase in the canon of systematised biological knowledge in the last two decades. The increase is a direct result of the application of new physical and chemical techniques to basic biological research. There has been an important marriage of field work, population studies and ecology with laboratory investigation. This is exemplified best in the applied biological sciences such as medicine,

fisheries, veterinary medicine, forestry and food sciences. Each of these has undergone an explosion of knowledge in the last 20 years. A byproduct of the new biological knowledge has been the growth of entirely new industries such as the pharmaceutical and pesticide industries. In turn, these have poured money, men and resources into yet more research - and so it continues.

All this has a profound significance in relation to Australian secondary education. In the next decade there will be a need for more and better basic biological education in the citizenry as a whole. How is this to be met? In Western Australia it is estimated that not less than 21 biological science university graduates are needed per annum now to staff government and private secondary schools. Yet the lamentable fact is that in Western Australia the current annual production of all suitable (Pass and Honours) graduates and Associates is less than half of that number. That number has to satisfy all demands including that of secondary education. It seems clear that the kind of standard needed in secondary biological education is not yet being met, though a magnificent beginning has been made. Much of the school teaching is being done by poorly trained staff.

Thus an increase in the numbers coming forward for training in biology is an urgent requirement. The need is to make the working conditions of a secondary teacher of biology good enough to attract many more able, well-trained people into the profession. You are able to spell out what these may be.

For some years past I have been increasingly fascinated by the field which has come to be called Human Biology. This stems from a period of ten years when I lived in Uganda and had the privilege to be on the staff of a developing new University Medical School. One had the opportunity to observe and share in a period of fascinating social, economic, political and biological change in the African population of that State. One could see how the African environment affected man. But one could also see the effects of man on his surroundings - it happens very quickly, especially in a period of rapid educational, economic and political development. In Uganda the catastrophic effect of sleeping sickness epidemics in the early decades of this century on the population of tropical Africa can teach us how disease will be affected by the changing mobility of people brought about by trade. The sleeping sickness also shows how <u>Glossina palpebris</u> and the relation of this vector to trypanosomiasis, both human and bovine, can retard development by reducing population and preventing the use of beasts of burden, and eliminating the point of wheeled transport. (Wheels were never used in Central Africa).

Another example which we lived with was the profound social and educational effect of childhood protein malnutrition. In our part of Africa this was not produced by poverty, but by social pressures to eat prestige foods (a plaintain which contains no protein) during the early childhood growing period. The psychological and physical effects of this on the growth and development of Ugandan children was profound. To a large extent the pattern altered in that ten years.

In Australia we have rather similar aspects of Human Biology which in the years ahead will dominate our thinking. Educators, health authorities and private and government policy makers need to see the issues whilst it is early. I refer to the aboriginal population of Australia. The northern half of Western Australia now has one of the highest birth rates in the world. Until the 1950's it was very low and the aboriginal population was small and declining. Now it is probably over 4% per annum. It will certainly continue this way. The social and educational future opportunities this gives to the Aborigines and to white Australians of the next generation is of prime importance, especially to our children. Surely all young Australians should know about this and be taught the cause and effect of such a significant trend and their own individual and corporate responsibilities.

My conviction is that <u>all</u> secondary courses in Biology should have a good sized component of human studies. The problem is to know just how much. This should include psychology, group interactions, culture, language, man's organic and cultural evolution, the biology of race and ageing in man.

At school level surely the teaching of basic plant and animal structure and function should be continually orientated to the current real life problems we, as men, have to face. We <u>must</u> see ourselves as part of nature, but capable of changing it for good or ill. Then the great themes of adaptation, ecosystems, balance of nature and so on have a <u>tremendous relevance</u>. I am suggesting that for <u>Australia</u> the area I have mentioned will be the most important domestic issue for the coming generations.

Within a biology context this teaching hardly makes sense without a working knowledge of the cell theory and the chemical structural basis of protoplasm, and heredity. But given good teaching methods, these basic concepts are simple enough and should be part of common knowledge of all modern educated people. Our future Biology courses in schools must be "Biology for Everyman", not for the potential scientist.

In our Western Australian course of Human Biology we have tried to show the biology of man: first as part of the whole system of biological interaction between organisms, and secondly as a unique thing because of man's culture.

It is a tall order, and we are experimenting, for we have much to learn.

My final comment is that, in all our teaching of biology, it is essential that we should strive to present our material as an example of the general objectives of science education. These are that students should complete school courses knowing about definitions, conventional classification, prediction and the use of hypothesis, the use of models, observation, measurement and quantification, the concept of controls in experiment, samples, tentativeness and uncertainty, reliability and data retrieval. This all sounds advanced but when you think about it, these things are the basis of intelligent life.

We should try to show biological science as a human activity, and biologists as flesh and blood human beings, with successes and failures and foibles.

Perhaps we should allow some of our students to develop laboratory skills such as microscopic observation, dissecting, field observation, recording of observations in graphs, illustrations and tables. Not all students would want to do these things but I would not like to see these techniques excluded by edict. At the same time we should flee in horror from the "rigged" experiment as an hypocritical waste of time.

We should try to inculcate attitudes of open-mindedness, scepticism and an understanding both of the uses and limitations of scientific method.

However, my last shot is this: no matter what material does or does not go into a syllabus, in the final analysis EVERYTHING depends on the enthusiasm, training and personal qualities of the biology teacher. The main burden of this talk is to emphasize <u>that</u> simple fact. Of course we must discuss balance and content of courses. As a result of our continuing discussions we shall be constantly modifying our courses in the light of basic biological research in our universities but, in the end, what is actually taught to and learned by the student depends on the teacher's personal assessment of what is important, and how he, himself, sees his own personal role.

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BIOLOGY TEACHING IN SCHOOLS IN TERMS OF THE NEEDS OF MODERN SOCIETY

Stephen Boyden.

We are here for a frank exchange of views on education in biological science in Australian schools and it seems to me that we should be trying to answer three main questions.

They are:-

(1) What should be the aims of education in biological science in schools in Australia?

(2) Are these aims at present being achieved? (That is, if we can agree on what the aims are).

(3) If they are not being achieved, what steps should be taken to improve the situation?

I will address myself to the first two of these questions and I will try to summarise some of my own thinking on the whole problem of school biology. But before doing so, I would like to make a comment on the aims of education in general.

One of the main aims of education should surely be to provide the individual with a balanced and coherent picture of the human situation in historical and biological perspective, and with an awareness and understanding of the nature of the most important problems that face his society (and today this means world society). It should also aim to stimulate his thinking so that he is able to play his full part in the collective efforts of his community to cope with these problems. In view of the magnitude of the problems facing man on earth and the unprecedented rate of social and environmental change, these aims of education have never been more important than they are at the present time. In the case of each academic discipline, therefore, the objective should be to convey information and to stimulate thinking on the important ideas and principles that have come to light in that discipline, especially as they relate to the problems of human society and to the ideas and principles of other disciplines.

Bearing in mind that one of the main objectives of education should be to provide the student with some understanding of the present human situation in biological and historical perspective, let us go back in time and consider briefly some of the events of outstanding significance which prepared the ground for the important global developments which now loom so large on the horizon as threats to civilisation and mankind. It was between two and three thousand million years ago that a new set of processes - the processes of life - first began to appear and superimpose themselves, so to speak, on the inorganic world. While these new processes were utterly dependent on the more ancient physico-chemical processes on which they were based, they eventually gave rise to a highly complex and diverse system of living organisms which has transformed the character of the earth's surface to a considerable extent. And then, only some two million years ago, the first glimmers appeared of yet another new set of processes - the processes of human culture - a development which was destined to prove perhaps as significant as the origin of life itself. Just as the processes of life are both dependent upon and yet different from the physical and chemical processes which preceded them, so it is with the processes of human culture: they arose from, depend upon, and yet are in many ways different from the processes of life. The existence in the biosphere of these three distinct sets of processes is reflected in the structure both of educational programmes and of academic institutions themselves.

Clearly, for an understanding of the total situation we need to pay some attention not only to each set of processes in its own right, but also to the extraordinarily important interaction between them, for the functioning and maintenance of the total system (i.e. the biosphere and civilisation) depends on this interaction. While considerable time is devoted in science education today to the interplay between the processes of life and the underlying and more ancient inorganic processes on which they depend, extraordinarily little attention is being paid to the interaction at the other interphase - that is, between the processes of human culture on the one hand and processes of nature on the other. I suggest that the universities are primarily to blame for this serious deficiency in our educational programmes, since they have not only allowed, but have also apparently encouraged the development of the misleading and damaging dichotomy between the natural sciences on the one hand and the social sciences and the humanities on the other.

This continual interplay between cultural and natural processes is of crucial significance in relation to our attempts to understand the problems of society. The history of civilisation itself is in the last analysis mainly a story of this interaction;

and a balanced and comprehensive view of the world situation is impossible without proper appreciation of this fact. Moreover, it is the tremendous intensification of this interaction that is responsible for the widespread changes in the total environment now causing so much concern among ecologists.

Before proceeding to the question of the aims of education in biology, I would like to list a few of the things that I feel that science education in schools should <u>not</u> do. In presenting this list, I imagine that I may be challenging the opinions of many educationists, including some biologists, and while I will not elaborate on these points now, I look forward to some debate on them during the discussion later on.

I suggest that:-

(1) Science education should not aim to attract students to a career in science (although it should provide a fair and balanced picture of what careers in science are like, and of what they have to offer to the individual scientists and to the community).

(2) It should not set out to glamourise science or to paint a false picture of scientists as selfless benefactors of mankind that can do not wrong (certain science textbooks in use in this country give the impression that this is one of the main intentions of the authors).

(3) It should not suggest that any problems that mankind may still be left with will be solved simply by further intensification of scientific research and technological advance.

(4) It should not aim to instruct in the methods and techniques of practising scientists, except to the extent of indicating the sort of things that scientists spend their time doing. This can be better achieved by arranging visits to laboratories where scientific work is in progress than by long hours of practicals at the bench, which are a waste of time for the vast majority of students who never take up a scientific career. (Much of the time now spent at the bench could be better used for "environmental encounters", as suggested by Professor W. Stapp, and for active discussion on social implications of scientific knowledge and technological developments).

(5) The aim of science education in schools should not be to prepare the students for the first year at University, but rather for responsible citizenship. It is the universities which should adjust their courses to the school curricula, and not vice versa.

(6) Science education should not aim to transmit facts for their own sake, but only insofar as they assist in the understanding of important scientific principles, especially as they relate to human problems and responsibilities.

(7) It should not set out to teach "hard" science for the sake of its "hardness". The material presented and discussed should be selected on the basis of its importance in relation to our attempts to comprehend the processes of nature and the problems of human society.

Turning now to biology, this is a subject that can make a very special contribution towards providing youth with a comprehensive and integrated view of the human situation. I think that most of us would agree that the most important single species on earth as far as we are concerned and also, in the present situation, as far as the biosphere as a whole is concerned, is Homo sapiens; and it stands to reason, therefore, that this species should figure very prominently in biology courses. It is impossible, or at least unrealistic, to attempt to study the biology of man in modern society without paying attention to the social processes that affect the biological conditions of his life and to the social repercussions of his biologically-determined reactions to environmental influences. In other words, whether the emphasis be on the human organism and its responses to the environment, or on the environmental effects and ecological implications of human activities, the proper study of human biology necessarily involves a bridging of the gap between the natural and social sciences.

Having emphasised the need to promote understanding of important scientific principles as they relate to the problems of human society, I feel that perhaps at this point I should enlarge somewhat on this question and give one or two illustrations of what I have in mind. I should like to say first that it is my impression that some (but not all) of the important principles that have come to light in biological science are, per se, treated very satisfactorily in recently introduced school textbooks. I am thinking particularly here of the "Web of Life" which gives due prominence, for instance, to the theory of natural selection and the principles of inheritance and ecology, and they are presented in a clear and interesting way.

On the other hand, it seems to me that some aspects of biology of vital importance to society are either omitted or at least are not given the prominence they deserve. Arising out of the Darwinian theory of natural selection, there is one fundamental principle or biological "law" of profound social significance that receives very little attention in biology courses. It is the law of "organismic sensitivity to environmental change". It is based on the fact that, through the processes of natural selection, species develop genetically determined characteristics which render them extremely well suited to the conditions under which they are evolving. Thus, when the conditions deviate to any extent from those prevailing in the evolutionary environment, signs of biological maladjustment are likely to occur. This principle applies to all species, including Homo sapiens. In the long run, under natural conditions, the situation resolves itself because, if the environmental changes persist, the population in question will either become extinct or it will, through natural selection, undergo genetic adaptation so that the individuals are once again "suited" to the prevailing conditions. Apart from its significance for individual animals, this principle has important ecological implications since, ultimately, it is through this effect on individual organisms that disturbances are felt in whole populations and ecosystems.

Let us consider for a moment the relevance of the law of organismic sensitivity to environmental change in relation to modern society. The processes of civilisation have, over the centuries, introduced countless deviations in the biological conditions of life of the human organism, and as would be anticipated from this law, signs of biological maladjustment have inevitably followed these changes. An obvious example was the

appearance in human populations, in endemic and epidemic proportions, of various contagious diseases, such as plague, cholera, typhoid, dysentery and tuberculosis, resulting from the increase in density of human populations and other environmental changes associated with the processes of civilisation.

These changes in host-parasite relationships represent one of the few cases in which the new selection pressures associated with civilisation were strong enough to produce a substantial degree of genetic or evolutionary adaptation in man. Nevertheless, the fact that these contagious diseases have to a large extent been eliminated from modern society is due largely to the processes, not of genetic adaptation, but of cultural adaptation (the most important of which has been the introduction of new standards of hygiene appropriate to the new environmental conditions).

There are countless other examples in history of the operation of the law of organismic sensitivity to environmental change and of consequent signs of biological maladjustment in the human organism. In fact, it is true to say that the most outstanding single feature of the recent biology of man is the extraordinary number of changes that has taken place in his conditions of life. These include, for example:- (i) changes in quality of food and water and feeding habits, (ii) changes in quality of air inhaled, (iii) changes in number of social contacts, (iv) changes in the accessibility of biologically and psychologically potent chemicals, (v) changes in levels of environmental noise, (vi) changes in levels of physical activity, (vii) changes in sexual environment, (viii) changes in infant feeding and lactation patterns and (ix) changes in the number of viruses in the environment capable of causing disturbances in the respiratory and alimentary tract. All these examples of changes in man's biological conditions of life are the consequence of social developments, and all involve some kind of biological response on the part of human organisms, and in each case this response has further social repercussions.

The fact that the human species has not only survived these environmental changes and consequent biological maladjustment, but has in fact increased about one thousand times in numbers since the neolithic development is, of course, due in very large part to the processes of <u>cultural adaptation</u> (and also in part to "pseudo-adaptation").* It is safe to assume also that the future well-being and indeed survival of mankind will depend largely on whether the processes of cultural adaptation will be successful in overcoming (or better forestalling) new manifestations of biological maladjustment resulting from the rapidly changing total environment

* The term "pseudo-adaptation" has been used to describe the effects resulting from the widening of the difference between Darwinian fitness and fitness in the colloquial sense of the word. In other words, the protection that civilisation affords to the individual who is in a state of ill-health (and also to his offspring) results in a situation in which survival and reproduction can take place in a population in which the majority of individuals are in a state of biological maladjustment which would not have allowed reproductive success under more rigorous conditions of pre-civilisation society.

of man. In view of the obvious social significance of cultural adaptation, it is unfortunate that this topic receives so little attention in education. The view might be taken that, while genetic or evolutionary adaptation is a matter for biology teachers, cultural adaptation is not, and that it should in fact be left to those who are concerned with education in social studies. The point is, of course, that we are here concerned with an extremely important aspect of the interaction between cultural and natural processes, and it does not make sense to split this subject down the middle so that the biological aspects are taught in biology classes and the social aspects in social studies classes. In this way, the essential feature of the situation, namely the constant interplay between these two sets of processes, would be lost to the student. And furthermore, at the present time, the processes of cultural adaptation to biological maladjustment (and pseudo-adaptation) are not adequately dealt with in either biology or social studies, and I suggest that, in the absence of moves to remedy this deficiency from other quarters, educators in biology have a special responsibility to do something about it.

I am suggesting, then, that the biological principle of organismic sensitivity to environmental change is one of supreme significance in relation to the physical and mental health of communities and of individuals, and it relates to the whole question of the quality of life in a rapidly changing environment. It is probably, at least in terms of the immediate problems of mankind on earth, the most socially significant concept to arise out of

Darwin's theory of natural selection and Mendelian genetics. I suggest therefore, that it should be one of the main themes in biological education and that it should be presented together with a thorough discussion of cultural adaptation in its various forms.

Turning now from organisms to ecosystems, I have already made the point that the general principles of ecology relating to the "balance of nature" are on the whole well handled in some of the newer biology courses in schools. However, even in this instance, I would suggest that these courses still fall far short of our expectation in terms of the aims of education mentioned above. An extremely significant aspect of the scientific scene at present is the increasing number of ecologists who are expressing very deep concern about the rapid and widespread changes that are occurring in our total environment as a result of rapidly accelerating cultural processes. Some of them suggest that the disturbances in the biosphere resulting from these changes will be so great that civilisation will be unable to survive for more than a few more decades. Needless to say, there are also others (although there are fewer biologists among them) who regard these rather gloomy predictions as unwarranted and exaggerated. We must accept that, at the present time, there is not sufficient knowledge available for us to be able to state definitely and in quantitative terms how great the danger is; or rather, we <u>do</u> know how <u>great</u> the danger is (i.e. we know that if social processes continue unhindered in the direction they are going now, ultimate destruction of the biosphere and of civilisation is inevitable) - but we do not know precisely how <u>close</u> we are to the limits of tolerance of the biosphere.

It is clear that there are limits to both the maximum and the optimum number of people the earth can support, and to the amount of chemical garbage we can throw out into the biosphere before it is choked beyond recovery. And at present, there can be no doubt that the escalatory processes (e.g. the techno-demographic spiral and the economic and military competition between nations) which are driving us towards these limits are continuing to accelerate and gain momentum, and no one seems to know how to stop them. Thus, while we must all accept that the earth and its natural resources are finite, the only difference between the more pessimistic and the more optimistic views lies in the question of how near the runaway processes of civilisation have already brought us to eco-catastrophe.

It is clear that these are matters which our society must treat with the utmost seriousness, and this fact should be reflected in our educational programmes. Students must be told fairly and squarely that many scientists believe that man is about to face, or is facing the greatest threat to his well-being and survival that has ever occurred, and that catastrophe on an unprecedented scale is not far away. They must also be informed of the arguments on which these gloomy predictions are based, and also of the views of others who take the opposite stand, telling us there is no cause for alarm. The must also be told of the academic, political, commercial and religious allegiances of the proponents of the different points of view, and they should be encouraged to discuss and debate these problems themselves.

Take, for example, the population situation. The students must be informed not only of the straight facts relating to population increase, but also of what ecologists are saying about the significance of recent population trends and of the associated explosive growth of technology and industry. They must be told of the views of those scientists who regard the situation as extremely grave and urgent, and they must be made aware of the viewpoints and arguments of other individuals and groups (e.g. the Catholics and the Communists) who do not advocate controlling the population growth. This controversy is perhaps the most critical one, in relation to the future of mankind, that has ever arisen in the history of civilisation, and it is indeed discouraging to discover the manner in which these vital issues are treated in science textbooks. In one senior science biology textbook, for instance, I can find only one page referring to population changes in the human species - changes which, quite apart from their significance in terms of the future well-being of mankind, represent one of the most spectacular biological developments in the biosphere since the beginning of life on earth. At the end of this page the following statement is made:- "We are now facing a new crisis and the need for a second agricultural revolution. Man, with his knowledge of modern biology, is now seeking new ways of increasing the productivity of the earth and the seas. The problem is not yet solved. It is one of the greatest challenges modern biology presents to the youth of today".

In spite of the clarion call in the last sentence, I find such a statement of the situation deplorably inadequate. Is this really all that biologists have to say to the senior science biology students of today about the population situation? This treatment of the subject not only belittles the problem itself, but it also implies, as is so often the case in today's science textbooks, that all the answers to any problems that may be left to mankind lie in further intensification of scientific research and technological development.

What possible educational justification can there be for shielding the youth of today from these crucial issues, and thus providing them with a completely false and rosy picture of the world situation?

Before leaving the topic of ecology, I would like to refer to one important single fact of relevance in our attempts to present the student with some understanding of the present world situation in biological and historical perspective. It is simply the fact that human society has come to use quite recently in its daily interaction with the environment about as much energy as all other land animals and plants put together. That is to say, human society now utilises in one day about the same amount of energy as is fixed through photosynthesis by the earth's terrestrial vegetation in the same period of time. If ever there was an ecologically significant fact, this is it; and yet I can find no mention of it in any of the school biology textbooks that I have examined.

I could continue for some time to list biological topics of special significance in relation to modern society, but which receive extraordinarily scant treatment in both school and university biology courses; they include, for example, the chemicalisation of the environment, the biological implications of the nuclear threat and problems of aggression and other aspects of behaviour in man. However, I will not tax your patience further, and I feel the time has come for me to summarise what I feel should be the main aims and objectives of biology education in secondary schools. They are as follows:-

(1) To assist in providing the student with a comprehensive and balanced picture of the human situation in biological and historical perspective.

(2) To provide the student with an understanding of the basic principles that have come to light in biological science especially as they relate to the well-being of mankind now and in the future.

(3) To convey an appreciation of the impact of human society on the biosphere and to introduce the student to the concept of the constant and highly significant interplay between cultural and biological processes.

(4) To introduce the student to an area of study which might come to represent for him a source of continuing and intense interest, and of personal satisfaction and enlightenment.

(5) To deal fully with important schools of thought relating to the future of the biosphere and the future well-being of mankind - giving full treatment, for example, to the biological implications of the continuing population growth and the associated technological revolution.

(6) To stress not only the important principles that have come

to light, but also the important areas of ignorance that still exist.

Up to this point I have been dealing almost entirely with the first of the three questions that I assumed we are trying to answer, namely - what should be the aims of education in biology in schools? As for the second question - are these aims at present ng achieved? - my answer to this question (in terms of the aims as I see them) is short. In my opinion, they are not being achieved.

As for the third question, what should be done to improve the situation? - I think it is better to leave this for the discussion, since in any case you may well not agree with the points that I have been making, and any attempt of mine to answer the third question would represent a further waste of your time.

In conclusion, I would like to restate my firm opinion that we have in the past neglected, very much to the detriment of our understanding of the human situation and probably of the well-being of mankind, the study of the interplay which is taking place continually between the processes of nature on the one hand and the processes of culture on the other. I feel that both in schools and in universities, big efforts should be made as soon as possible to correct this very serious deficiency in their education programmes.

I believe that biology, by the very nature of the subject, offers a very special opportunity for moves in this direction, and that steps should be taken now to modify, or in some cases, to revolutionise biology teaching with this concept in mind. It would be in many ways a very difficult task. To begin with, we have to somehow overcome the inevitable resistance from die-hard specialists, some of whom are unable to appreciate the value and importance of interdisciplinary, cross-disciplinary and integrative work; and, of course, it is also much easier to prepare specialised courses and curricula dealing with subjects which have been nicely described in the literature.

The point that I wish to stress is that strict compartmentalisation of subjects in education in schools very effectively inhibits the development of understanding of the human situation as a whole. And yet, at the present time, there is nothing more desperately needed by society than people capable of taking a long-range and comprehensive view of human society and its problems.

I have referred in these comments only to science textbooks and curricula, and very little to individual teachers. The reasons for this are obvious in that curricula and textbooks are easy to examine, and they must surely reflect to a considerable extent the "official" view on these matters. On the other hand, I am fully aware that, in spite of all the regulations, much depends on the views and social consciences of the individual teachers, many of whom I know are already very concerned about some of the major issues that I have discussed today. I know that many teachers do, in fact, introduce in one way or another some teaching along these lines, although it seems that the degree to which they are permitted to do so varies from state to state.

I also appreciate that tremendous advances have in fact been made in recent years as a result of immense efforts on the part of individual enthusiasts, who have already overcome some very formidable obstacl No one who is aware of the importance of biological knowledge in relation to human well-being can fail to respect the efforts of those who eventually succeeded in having the study of the phenomena of life introduced into the schools in New South Wales, and we have nothing but admiration for those whose dedicated efforts resulted in the creation of the excellent Australian version of the B.S.C.S. book - "Web of Life". Certainly these moves must be regarded as very significant steps forward. My point is simply that, bearing in mind the urgent need for a more comprehensive and holistic understanding in the community of the problems of society, many of which have strong biological components, I personally feel that we have still a very long way to go.

The great challenge that faces the members of the rising generation today is to sort out the mess that has been created by their forefathers, to unravel the complex interrelationships between the forces threatening the total environment, and to work out and implement, before it is too late, plans for protecting the biosphere, civilisation and future generations of mankind. The great challenge facing the present adult generation is to provide young people with an education that will prepare them emotionally and intellectually for this gargantuan task.

SUMMARY OF DISCUSSIONS OF "AIMS" PAPERS.

The discussion did not produce a set of aims or behavioural objectives for all biology teaching in Australian Secondary s hools.

Most conference members felt that there were few aims for biology teaching that could, or should, be externally imposed upon teachers. Teachers, however, should decide their own aims, or chose a course consistent with their own aims. The presence of independently developed courses for either junior or senior secondary schools in all states except New South Wales makes it difficult to decide on appropriate aims for either level. This problem is intensified in States, such as Victoria, where each school is free to decide its own aims and emphases, at least up to the Grade 10 level.

However, the conference recommends that the following broad objectives should form a framework within which courses and materials for biology teaching should be developed:

1. Biology courses at all secondary levels should be planned and taught so that man's place in, and interaction with, the biosphere permeates the whole course. This does not mean that the course should be centred on man as an example, but that the relevan all topics to this theme should be made clear.

2. Any biology course should show something of the processes and logic of science, not as a separate topic, but within the framework of the course content.

SECTION III

CRITICAL EVALUATION OF CURRENT COURSES

In this session speakers familiar with each of the major courses offered at senior level in Australian secondary schools discussed the advantages and disadvantages of these courses.

Each speaker commented on the problems of both time and content in their course. There was not enough time available to cover the material prescribed in the syllabus.

It was felt that teacher preparation and in-service courses must play an increasingly important part in the development of Biology teaching. A general feeling that emerged in discussion was that the success or otherwise of any course depended on the individual teacher's competence.

The meeting also considered the relevance of the various courses in the light of Dr. Boyden's address of the previous day in which he criticised the failure to teach the social implications of biological principles. It was agreed that perhaps only the West Australian Human Biology Course gave adequate treatment to this facet of biology education.

In speaking of the advantages of "The Web of Life" Mr. Hutton referred to the attractive format of the Text, the usefulness of the "Teacher's Guide" and the comprehensive nature of the "Laboratory Manuals". He felt however, there was need for a thorough revision of all three and particularly stressed the lack of continuity or theme in the text materials.

Miss Stock made a number of points concerning the advantages of teaching biology as part of an integrated science course. She was concerned however, by the fact that much of the N.S.W. material was highly theoretical and too divorced from practical work.

The address by Mr. Stephenson revealed Queensland Zoology to be something of a backwater in terms of syllabus development. The course was too much orientated towards tertiary work.

Mr. Katavatis explained that the W.A. Human Biology Course was still in the developmental stages. At the moment it was suffering from a lack of teaching aids but both teacher and student enthusiasm was high.

AN EVALUATION OF "WEB OF LIFE" MATERIALS AND COURSES

Deane Hutton

Have you ever driven your car up a busy mountain road on the wrong side, in the face of on-coming semi-trailers? Of course not! If a special law were passed today making it legal for you to do so, would you take the opportunity? I think you would consider the proposal with the kind of levity with which biology teachers view some of the opportunities presented to them by syllabus writers and Examination Boards. Such boards have said to us, "Here is a Biology syllabus - a list of topics. You could use the 'Web of Life', but you're quite welcome to use any other materials." When driving uphill, nobody wants to run into a prime-mover coupled to a fully-loaded trailer. And the 'Web of Life' is a pretty formidable prime-mover - particularly when firmly coupled by a syllabus to a fully loaded examination. No wonder few people have tried using other materials in States where the biology syllabus is so plainly this book.

In many courses of study, it is true that the syllabus and the textbook are almost the same thing. However, where the 'Web of Life' materials are concerned, this relationship seems to be even stronger than usual. In fact, the authors of the book knew that they were writing material from which the syllabus would evolve. Consequently, where the 'Web of Life' materials and the accompanying derived syllabus have been introduced, there has been little or no experimentation with other textbooks.

ORIGIN OF 'WEB OF LIFE'

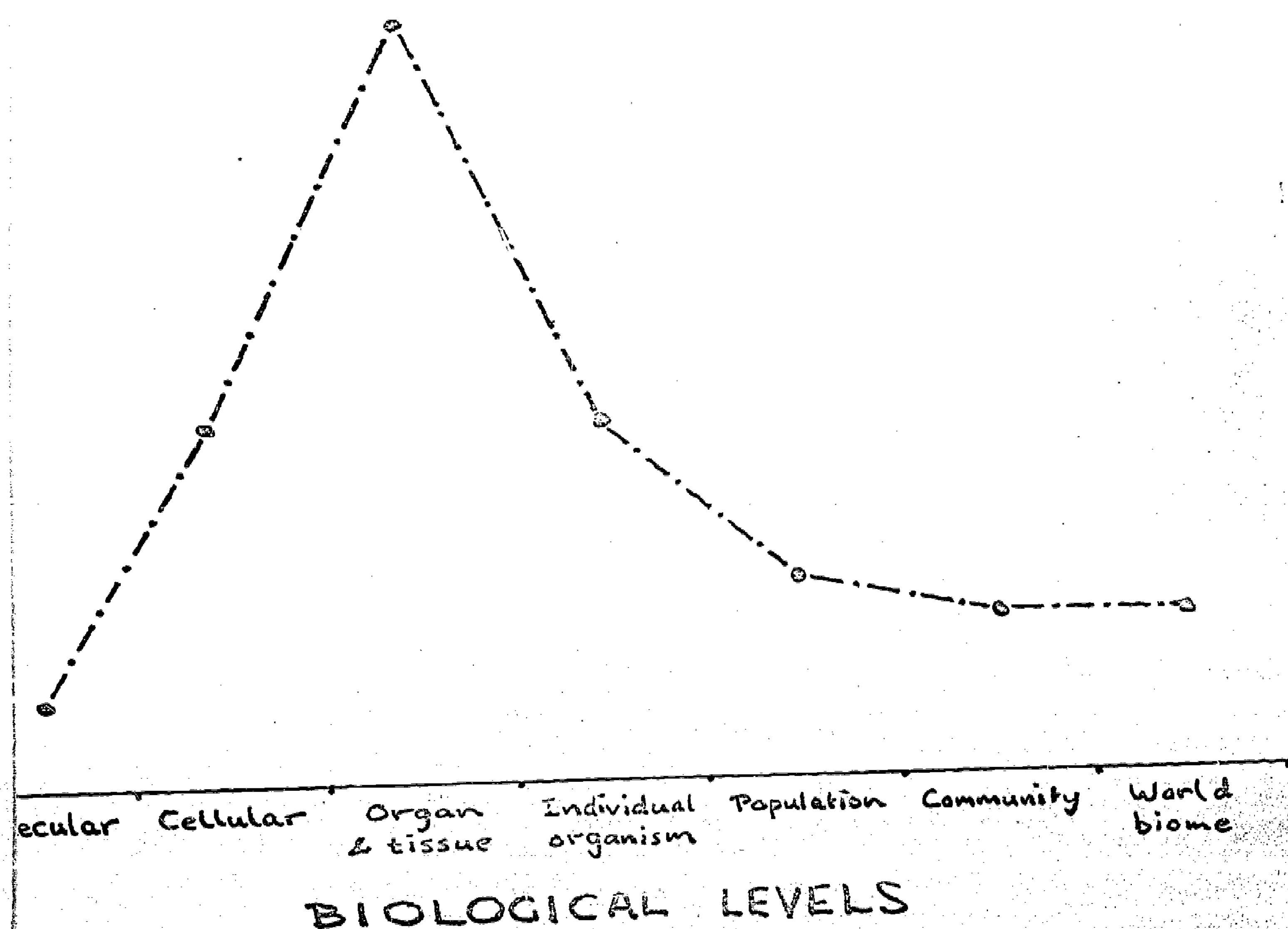
The 'Web of Life' (1) was, of course, based on the American Biological Sciences Curriculum Study (BSCS) materials, and such a birth was almost certainly the main reason for the strong syllabus-text union. American teachers, and Australians involved in the early trials of American materials, were confronted with textbooks which implied the syllabus. Thus the trial was primarily a trial of books, and only secondarily of the syllabus. However, experimentation and comparisons were possible at that stage because teachers were given the choice of covering roughly the same content areas from three different angles with three different emphases - the 'blue', 'green' and 'yellow' versions. The small size of student population in Australia would not have made the provision of such choice econimically feasible in this country. The Australian version did, however, retain the 'package deal' format (syllabus, text, practical manual and teachers guide) and as with the American materials, this format seems to have been one of the major factors in gaining a ready acceptance of the 'Web' by teachers. Other factors which have lent weight to the impact of BSCS materials on teachers and classes have been the use of an enquiry approach and an emphasis on levels of biological organization which have often been ignored, in the past, by authors. In addition, each of the American versions had a strong appeal because of the definite theme running through it. J.J. Schwab, in his "Biology Teachers' Handbook", has made a profile of level emphases in each of the three American versions.[2] The biological level which received the greatest emphasis was given a score of 5 and the other levels given a value between 0 and 5 depending on their relative emphasis when compared with the major level. A similar process was carried out with a number of conventional texts and an average profile for a conventional text was obtained. Subjective opinions and objective chapter-section counts were combined to give these profiles. Figures 1 and 2 indicate some significant differences between "conventional" and BSCS text materials.

Not only was there a shift in emphasis from the traditional organ-tissue theme in each of the BSCS texts, but also, each of them achieved a more even balance of levels.

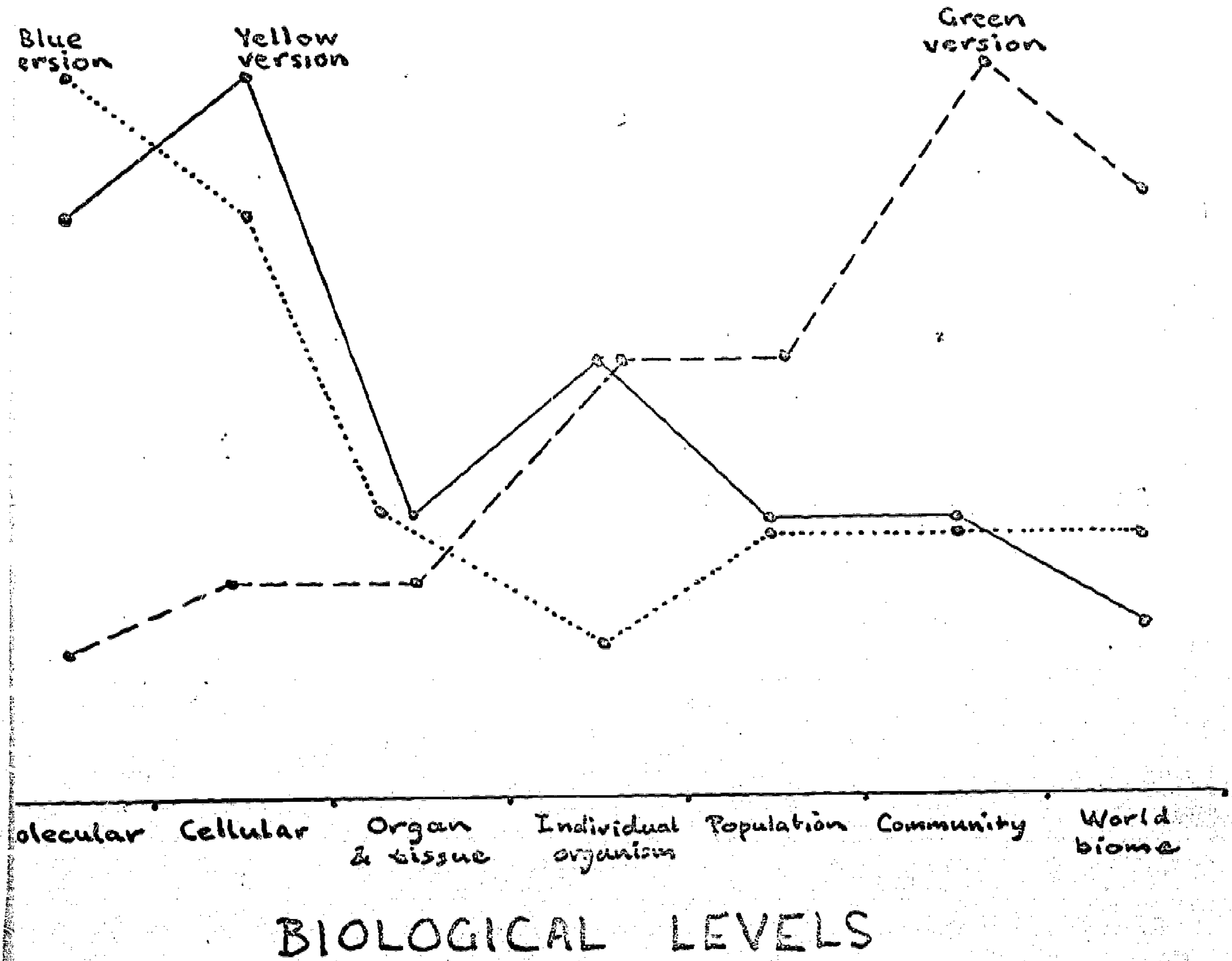
I have attempted to construct a similar emphasis profile for the 'Web of Life' by making chapter-section counts. On completing this profile, I felt the obvious thing to do was to superimpose it on the profile from the American Green Version, on which the Australian 'Web' was so obviously based. Figure 3 makes this comparison.

I was astounded at the discrepancies between the two and immediately felt a compulsion to look at the 'Web' profile with that of the "conventional" pre-Sputnik American biology text, Figure 4.

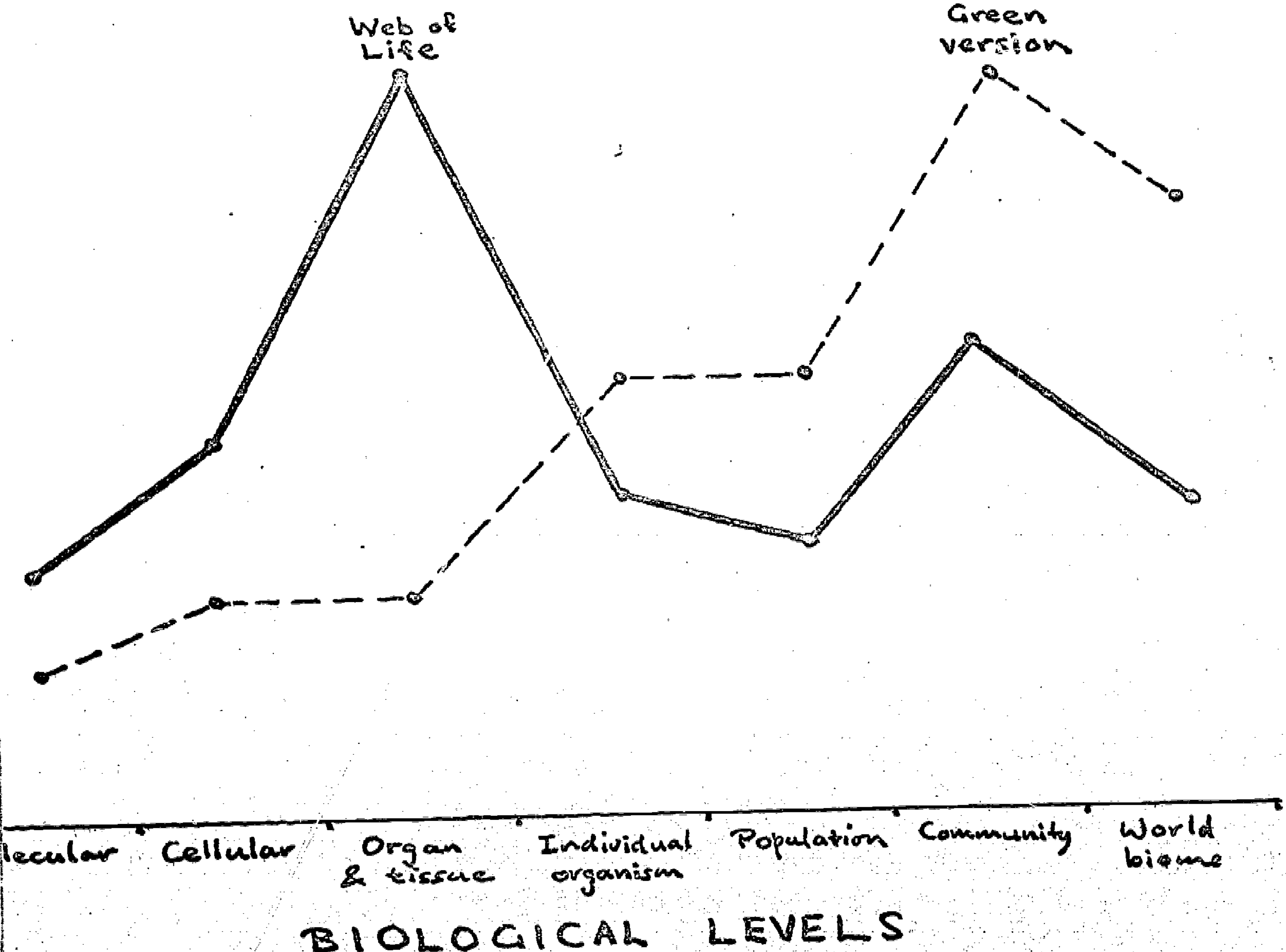
Apart from the 'Web's' ecological hump, the profiles are remarkably similar. Perhaps this is not so surprising when we remember that the 'Web' was not simply an Australian adaptation of the Green Version, but rather an adaptive expansion of it which took in some of the characteristic approaches of both Blue and Yellow versions. It was bound to



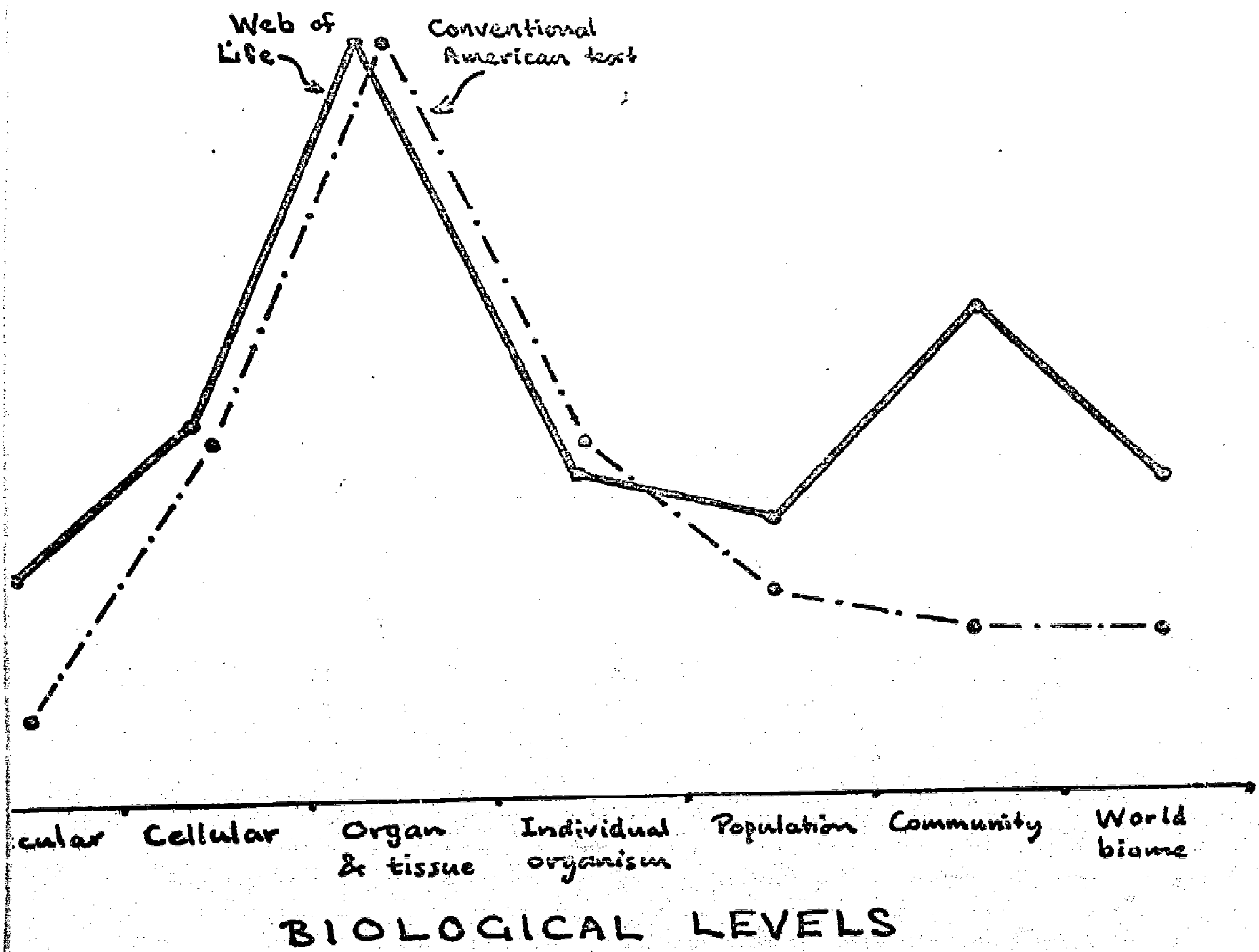
. 1. Emphasis Profile of "Conventional" American Biology textbooks.



ig. 2. Emphasis Profiles of American BSCS Biology textbooks.



g. 3. "Web of Life" and BSCS Green version compared.



4. "Web of Life" and "Conventional" American text compared.

appear, in some respects, as a sort of compromise. Although it has very definite themes in parts, the book as a whole has less continuity in theme than any of the three American texts. Does this matter? Who can say? After all, with 42 chapters divided into two distinct batches, it is really two books in one. Its comprehensive nature and sheer wealth of information would lead me to choose the 'Web' as a shelf copy for my library before the American Blue, Green or Yellow. Perhaps students think similarly - the availability of second-hand copies of the 'Web' seems to be extremely low in schools. However, I think I have detected among my students a longer time lapse before they feel they are "in step" with the 'Web' than ever occurred in my classes using the Green version. Maybe this tentative, highly subjective observation has some basis. Perhaps the time lapse is due to the difficulty in identifying a theme running from front to back cover. One thing seems certain - the 'Web of Life' lacks, in part, one of the features which gave the American texts their initial appeal.

'WEB OF LIFE' MATERIALS

In a course where the materials govern the syllabus, lay down a programme and direct teaching methods, the actual books and manuals warrant close examination. I am certain that many of you have made your own careful analysis and evaluation. I have tried to temper my own prejudices, by basing this evaluation on discussions with students and other teachers. Some of these discussions have involved whole classes, some have been individual and many were tape recorded for subsequent analysis.

When students and teachers compare the 'Web of Life' textbook with other science texts, two things seem to stand out as highly significant in their minds. The first is the attractive format of the book. Pupils are proud to take it home; its photographs, diagrams, and charts invite perusal; parents, brothers and sisters pick it up and read it; students from other subjects are jealous. The second significant point arises after reading a chapter or two. There seems to be a lack of precision - fact-lists, definitions and summaries are missing. This, of course, is a cunning plot on the part of the authors. But it does worry new students (and new teachers) - revision and learning for factual tests becomes a difficult and somewhat obscure task. However, I am certain that the authors have employed this approach to avoid mere verbalism and to accentuate the importance of experimental work. The text's lack of precision, by promoting an initial feeling of insecurity in the student, almost forces class discussion - this interpersonal learning situation which has been an integral part of all the BSCS courses. I must point out that generally the text imprecision worries students less as the year progresses. Some students take a few weeks to become accustomed to the new approach, many require a term, and some take the best part of a year. Possibly, a reasonable compromise would be the inclusion of a summary at the end of each chapter - as in the early BSCS Green Version. I feel that this would avert some of the initial insecurity, while still promoting the view that text, teacher, practical work and discussion are all important sources for information and attitudes.

Does the different nature of the 'Web of Life' textbook lead to increased individual reading by students in comparison with other texts? I expected that it would. My discussions with students have suggested that they nearly all have a "flick through" the book soon after they get it; they read the physiology chapters avidly - particularly the one on human reproduction; but they seem reluctant to make full use of the excellent index and catalogue of living things. Perhaps this reflects an omission in our junior secondary science courses - a failure to instruct pupils in the use and value of an index.

The Students' Laboratory Manuals and some of the experiments have come under fire for a number of reasons. Many teachers object to the format. I think it looks like an afterthought - secondary to the text rather than being of equal importance. Certainly it could be more compact (by using smaller print and less empty space); easier to follow (by using more diagrams and less words); and more convenient to use in a loose-leaf system (by starting every experiment on the right-hand side of a new page). These changes are only necessary if we contend that carrying out experimental investigations is more important than deciphering experimental instructions. I think it is.

Several students have informed me that they object to some of the experiments on the grounds that they are " a bit rigged". This surprised me, but they pointed out that the answers to questions are frequently hinted at, that by reading ahead and coming back, even the novice student can often fill in all the correct answers - without actual experimentation. Probably this criticism is not well founded for most of the investigations, but it seems that if some students detect even the slightest suspicion of bench work being a "put-up job" they are likely to reject our claim that we are providing them with a science course based on enquiry.

TEACHING METHODS

The introduction of BSCS biology courses in South Australia has been accompanied by some radical changes in teaching methods. The unusually rapid acceptance of these methods has, I think, arisen mainly from two powerful influences - the Teacher's Guides and Inservice Conferences. The 'Web of Life' Teacher's Guide is particularly comprehensive - even more so than its American counterparts. Not on y does it outline aims and objectives of the course, and suggest methods for using the text and laboratory manuals, but it also includes specific chapter guides which programme all activities in the course, from beginning to end, in minute detail. It is a "bible" to new teachers, but tends to be progressively ignored as a teacher gains experience. Like the laboratory manuals, perhaps it is too wordy in parts. In particular it seems to lay such a stress on "major ideas" and "single propositions" that many teachers have misunderstood the authors' intention, and duplicated copies of this teacher information for students to "learn".

Initial inservice training of teachers involved in pilot BSCS projects in S.A. was little more than the informal exchange of ideas -

mutual help, animated discussion and desperate grasping for reassurance. A small but enthusiastic group of teachers, lecturers, inspectors and examiners gradually put more structure into this training until by the time the 'Web' was released in 1967 new or uninitiated teachers were being thrust into Inservice Conferences of a most unusual nature. They were placed in the shoes of the student and forced to experience the new materials and teaching methods from his viewpoint - the practical work, discussions, text interpretation, the highly structured discussions referred to as "invitations to enquiry", more discussions - the lot! These conferences almost certainly played the major role in the nearly universal adoption of BSCS-advocated enquiry and discussion methods of teaching. The old converts were regularly brought back to conferences to help spread the good word. Efficient evangelism or skillful brainwashing? I'm not sure - but it was certainly both skillful and efficient. Many teachers in S.A. are now questioning the methods which they so eagerly adopted. Some have abandoned "invitations to enquiry" and now put a limit on free class discussion. A few have completely reverted to the traditional teaching methods of chalk-and-talk-and-duplicated-notes-and-drill. Why have teachers done this? It seems to me that many young science teachers are extremely conscientious and highly self-critical. An initial poor response in class discussion is frequently attributed by the teacher to his own inability to handle the novel situation. So he reverts to conventional teaching methods with which he has had more "success". There is certainly a need for continual help and encouragement.

Nevertheless, let's hope that we don't try to insist that everyone teaches to exactly the same pattern and programme. In a course where the teacher is required to fill such a variety of roles, I think it is important that the teacher be given the right to select the methods, and balance between them, that best suit his own personality and abilities. And if he considers that for him some conventional techniques are necessary, he should be able to incorporate them into his programme without being made to feel that he has failed or is letting the team down.

EVALUATION

New material, new objectives, new approaches and new techniques make new means of evaluation highly desirable. Objective test items of the multiple-choice type have become very popular in S.A. for evaluating the progress of students using BSCS materials. The teacher of a few years standing, with his own test items plus his file of swapped tests from other teachers, is in a happy position; but the novice teacher is desperate. Sets of high quality objective test items covering all parts of the course are urgently required. Fortunately, the diagnostic tests which ACER is preparing will be ready in 1971.

SCOPE FOR RECOMMENDED COURSE

A recent meeting of the Biology Teachers Association of S.A. considered the suitability of the 'Web of Life' part I as a Leaving course, and the 'Web of Life' part II as a Matriculation course. It was a fiery meeting with a large proportion of the biology teachers in this State participating in the discussions; and a number of general and specific points emerged. There was general agreement that part I comprises a coherent and relevant course of study for students at Leaving level - although a few thought that a Biology course that does not mention the cell is a disgrace, and a few would like to insert a slab of human physiology into the present course.

Part II of the book received much more criticism than part I. Although most agreed that the amount of material in part II was too great to be adequately covered in one year, there was no universal agreement on which sections are absolutely essential and which ones could be omitted. However, four chapters were the subjects of very heated debates.

Chapter 28 on "Chemical Co-ordination" was blasted from many directions. It was claimed the method of treatment was so inconsistent that the chapter is of doubtful value. Students find the details of the relationship between electromagnetic spectrum and the response mechanism in plants extremely difficult to comprehend. On the other hand, the treatment of the endocrine system seems to be very superficial - all the glands are dismissed in a page and a half. It was suggested that the chapter needs to be completely rewritten.

Chapter 29, "Internal Regulation", had as many ardent defenders as it did critics. Some were perfectly happy with it as it stands, while others said they would prefer to see the important feedback concept introduced incidentally elsewhere in the book - perhaps in sections on population, reproduction, evolution and the nervous system.

Many felt that some of the best sections of the book have been ignored by the S.A. Matriculation Biology syllabus. One such Cinderella section is Chapter 30, "Scavenging Systems". This chapter covers important areas of current medical research such as the antigen-antibody mechanism, problems associated with immunity to disease, and tissue grafting and organ transplantation. These things are relevant to the student - they may touch on him or his family directly and they are certainly brought to his notice frequently by the mass media - yet we ignore them in the S.A. course.

Chapter 31, "Recognition and Learning" had many proponents for similar reasons. Some of the topics covered are: interpretation and experience, innate behaviour and learning, insight, memory and the significance of language. These things are closely allied to what the pupil has been doing for a number of years, is attempting to do now, and will be doing for the rest of his life. Once again, relevance - but we ignore the chapter.

In my opinion there are a number of important social problems with significant biological components which are treated superficially or ignored in the 'Web'. One such area is the effect of man on his environment. There is an excellent brief treatment of the problems of pollution and conservation at the end of part I in Chapter 16. This was probably adequate for 1965 when the book was written, but it certainly seems inadequate in 1970 in the light of current and growing public awareness of these problems. This of course is a publishing problem rather than purely an editorial one. Some controversial social issues seem to have been completely ignored. Voss and Brown in "Biology as Inquiry" made an observation about the American BSCS materials which could be applied to the Australian 'Web of Life'. They say, "The BSCS materials have excluded references to alcohol, narcotics and tobacco and their effects on the human body. However, many other biology texts include information on these topics."(3) It cannot be denied that in complex twentieth century human societies these issues are real problems. And scientific research is being carried out in each of these fields. Perhaps the authors have ignored the issues because they feel a full discussion of them would involve moral judgments - and this would go against the grain of pure science. Have they acted wisely, or have they made a serious omission? Should not a complete science education include discussion of man's uses and abuses of scientific advances as well as an analysis of the advances themselves?

THE FUTURE

In South Australia, the Public Examinations Board Biology Committee has established a sub-committee to investigate the need for syllabus changes in the Leaving and Matriculation courses for 1972. The 'Web of Life' editorial group, headed by David Morgan, is working towards a major revision of their materials for release in 1973. Hopefully, the P.E.B. sub-committee's recommendations will reflect the opinions of teachers in this state, and undoubtedly it will communicate its suggestions to the editorial group. Presumably, similar mechanisms are or will be operating in other states. But the final decisions, of course, lie with the editors. And these are vital decisions for the future of biology education in Australia, because if history repeats itself, they will not only effect the content of published materials but will also particularize the actual syllabuses adopted by the State Examination Boards. Thus it seems imperative that each of us with a concern for biology education should somehow convey our feelings and proposals to the editorial group.

When a science textbook is being published for the first time, or being subsequently revised, there is a serious time-lag problem. This problem is accentuated with books for senior science students in a country of comparatively small population. Such is the case with the Australian 'Web of Life'. It is to be revised in 1970 and 1971, will be released in 1973, and for economic reasons will probably still be going in 1977. By then, some of the seven-year-old ideas will almost certainly be showing their age. How can a book such as this be kept up-to-date?

As a possible solution to this problem, I would like to suggest the publication of "Stop Press Newsheets". I am not suggesting highly specialized supplementary booklets, nor am I suggesting an apology for being backward, but rather, short, simply-written news-sheets of perhaps four or eight pages, aimed at and distributed to the student, and released only when needed. These could present new ideas or updated hypotheses, provide confirmation data as it comes available, and would keep the textbook relevant by expanding its discussion on popular science topics. If such a mechanism were now in operation, possibly our pupils would be more aware of modified ideas on DNA replication and protein synthesis, new ideas on the significance of cultural evolution, and, of course, recent facts, figures and predictions on environmental pollution. While providing a means for the rapid adaptation of course and materials to the needs of our student community, such a scheme would also emphasize the emphemeral and progressive nature of science. There are, unfortunately, several practical problems. The cost of the materials would have to be increased - but I think they can stand it. Collecting information, editing the newsheet and distributing it to schools would be an enormous task and would almost certainly require permanent staff. However, I feel that it would be well worth the money and effort. It would make a good package deal even better. Perhpas the Academy of Science, the Commonwealth Government or State Education Departments could be encouraged to subsidise such a scheme.

CONCLUSIONS

It seems to me that the nature of science courses in grades 11 and 12 is extremely important. It can provide a basis on which future knowledge, opinions and attitudes in the field of Science are built - regardless of whether the student goes on with further study or not. In my opinion, the 'Web of Life' materials, despite some shortcomings, have made a greater contribution to science education at Leaving and Matriculation level in South Australia than any other currently available materials in any of the sciences. Certainly some will disagree with my evaluation, but perhaps others will feel that the 'Web' has had such an influence in South Australia or interstate.

However, before we give all the credit for the spread of high school biology to BSCS in general and the 'Web of Life' in particular, I think we should recognize that there was already an awakening of interest in biological science among university students, teachers college students, and teachers in the early nineteen sixties. So, like a surfboard, the 'Web' was launched on a rising wave of enthusiasm. But unlike a surfboard, the 'Web' has probably shaped and augmented that wave. It seems that our surfboard is now approaching the beach - the 'Web' is nearing the end of its first run. We've had an enjoyable ride on a wave of biological enthusiasm, but now many of us are starting to question the course and materials and methods we are using. Is the wave starting to break up? If there are faults in courses, materials and methods, this is not necessarily disastrous, because we will soon be going out to pick up another wave, and on the way we will have the opportunity to modify the shape of our board. Let's hope it matches the new wave.

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EVALUATION OF N.S.W. SCIENCE COURSES

J. E. Stock

The N.S.W. senior science courses have a feature in common which makes them different from the other senior science courses which are being discussed at this conference in that they are composite science courses, containing physics, chemistry, biology and geology in them. When I use the word composite however I use it in two different ways. The difference is illustrated by comparing the structure of the level 3 science course with that of the level 2 courses. In the level 3 course the physics, chemistry, biology and geology components are interwoven to form a truly integrated science course. In the level 2 courses, often described as multistrand science courses, the physics, chemistry, biology OR geology components (only one of the last two is selected by the student) are set out in separate blocks of material and integration, where it occurs, is in the hands of the teacher.

I would like to emphasize that in trying to provide this kind of science course at the senior level in N.S.W. we have attempted to do something that is very difficulty - some would say it is impossible. I do not intend to underestimate the difficulties we have faced and if you read the daily papers you will already be aware of some of the problems that have been experienced with these senior science courses. I do not intend to defend the courses as they exist at the moment and in this evaluation I shall be recounting some of the specific criticisms made by teachers of these courses, at least the level 2 courses which have been most heavily under attack.

Some of these criticisms come from a detailed survey conducted by the N.S.W. Department of Education in 1967 which sought the opinions of teachers who were involved in teaching the level 2 courses at that time. In spite of the difficulties that have been experienced, I would defend the desirability of teaching biology within the overall framework of a course in science in the senior years at school.

Because of the unique character of these courses I have chosen to evaluate them firstly in terms of the philosophy or idea embodied in teaching biology as a component of a course rather than as a self-contained course, and secondly in terms of the nature of the biology component considered as a course. Thirdly, I have seen fit to include some comments on the future possibilities of teaching biology in a composite framework, in view of the fact that in N.S.W. at the moment the senior courses are in a state of flux. It is proposed to introduce trial courses into some schools next year - one of these will be a new multistrand science course. In addition separate courses in physics, chemistry, biology and geology will be trialled.

Philosophy of teaching biology as a component of a course rather than as a self-contained course.

One very important feature of the present arrangement is that the majority of students studying science at senior level study some biology. Personally I think this is a very good thing. The only students who do not study some biology are those who elect the geology component in preference to the biology component in the level 2 courses and this is a comparatively small number. If I were designing a course in science for senior years myself I would design one that had biology as an essential component. I believe there are urgent and compelling reasons why biology should be considered an essential component of all school science courses. Some of the reasons have been made very clear in discussions at this conference.

You might well ask whether students like being forced to study biology in a science course structured in this way. In the survey I mentioned earlier biology in terms of its popularity ranked highest followed by chemistry, physics and geology in that order. I think there may be some evidence to show that biology studied in this framework has done a disservice to physics and chemistry! Certainly the interest and involvement of students in the biology section has been most significant in spite of the deficiencies in the biology content selected as I shall point out later.

One of the problems we face in choosing to teach biology as part of a course is a limitation in terms of the actual time given for teaching it. If you think of the figures given in the status report you will realize that the time allocated to biology in each of the courses is as follows-

level 3 - approx. 2 periods per week

level 2S - 1.2 periods per week

level 2F - 1.8 periods per week

level 1 - 2 periods per week

I do not mean to suggest that the biology component is strictly treated in the number of periods each week that I have given above. Ideally the material is treated in blocks of time. The figures given above are merely an indication of the relative amount of time that is allocated to the teach ̧ of the biology component. The greatest amount of biology is taken by the student who takes level 1 and therefore level 2F as well - he gets a total 3.8 periods of of biology per week. The point I am trying to emphasize is that when biology is taught in this framework there is necessarily a limitation imposed in terms of the time available for the teaching of biology. This does not mean however that it is impossible to teach biology in less time but it does mean a careful selection of appropriate content on the part of those who construct the syllabus.

A number of advantages accrue from teaching biology in this way. I have already mentioned the large numbers of students studying some biology. What is most significant is that this number includes a high proportion of very able students who under previous systems would have studied physics and chemistry only. This means that some of the best students in science are studying biology at level 2F and level 1. The less able student however has not been sacrificed for the level 3 course is provided for him, as well as the student who is perhaps more interested in the humanities but who still wishes to take a science subject. Biology in the past was more often taken by girls and/or the less able student. It was often regarded as a soft option. It is interesting now to see the number of boys who are studying level 1 biology but they are not doing it at the expense of preparation in physics and chemistry.

Science taught in this framework emphasizes the similarities between the different branches of science rather than their differences. Biology depends heavily on physics and chemistry. Take for example the subject of cellular biology which requires a basis of chemistry for its proper understanding. When a student gets to this section of the biology component he has already covered the necessary material in the chemistry component. What he has learnt in one part of his science course prepares him for study in another area.

I agree with other speakers who have expressed the sentiment that school courses should not be considered preparatory for university study. Biology has always been a natural subject for capturing the interest of a student, even when it was taught in the "bad old way". But what happens to your student who has been captivated by his study of biology over two years and then decides that he would like to follow it up by further study at a university, only to discover that this is either impossible or else extremely difficult because further study demands a knowledge of physics and chemistry he does not have? I believe we do him a disservice by failing to prepare him in this way. The student who goes on to study science at a university is better prepared if he has studied physics and chemistry. A student studying biology as well, demands a school course in senior years, if it has to include all three sciences as separate subjects, that is far too heavily biased in science especially if, as is likely, adequate preparation in mathematics is required as well. In our level 2F science course the student is prepared in physics and chemistry with some biology and if he takes level 2F mathematics as well he is given credit of three subjects for the purposes of matriculation. This I believe provides adequate preparation for the student who requires it while at the same time avoiding undue specialization.

There are certainly disadvantages in teaching biology in a composite framework. This would appear to be so for a student wishing to study biology as a subject without having to study physics and chemistry. When these courses were first introduced into N.S.W. schools in 1966 some schools panicked believing that many girls would not be able to succeed in them because of the compulsory physics and chemistry components. Some seized upon the idea of offering agriculture as an alternative course with the rather surprising result that this subject was introduced into a number of city girls' schools. I am not criticising this course as a course in agriculture but I doubt if it was ever intended to be a substitute for a biology course as we know it. Experience has shown that when a study of physics and chemistry is tempered by adding a treatment of biology to it, many students almost to their surprise have been able to achieve a satisfactory standard over the whole course.

One difficulty which has been very real is the question of who teaches the courses. In all instances I know of, the level 3 course is taught by one teacher and this works well. How the level 2 courses are taught depends very largely on the school and the staff that is available. Ideally I believe each course should be taught by one teacher. In many cases however it is not. When these courses are taught by a number of teachers the courses are rather fragmented. Teacher competencies should be exploited to the full but often the specialist in one area better uses his skills and special preparation to help another teacher less well prepared in that area. Where this has occurred in a school, eventually an integrated science teacher has emerged. I do not believe in forcing teachers to teach courses they do not feel competent to take, but with help and encouragement over time and with the right type of inservice courses available a teacher can equip himself outside his special training at the university. In Australia we seem to place too much emphasis on the initial training of the teacher ignoring the real benefit of subsequent training through experience and inservice courses. Some schools have adopted approaches involving team teaching while still encouraging teachers to teach across disciplines. Nevertheless in N.S.W. I believe we have not tackled the problem of the preparation of an integrated science teacher at the preservice level and I think there is need for very clear thinking and co-operative planning on the part of teacher educators in science and the schools.

Nature of the biology component considered as a course

I have already mentioned the difficulty arising from the limitations imposed by time in selecting appropriate content. You might well ask what criteria were used in selecting biology content for these courses.

The aim of the level 3 course as stated in the syllabus is t provide a "deeper understanding of man's place in nature and the impact of science on man and his culture". The biology content selected was in terms of its relevance to this general aim. Thus topic 4 which includes most of the biology describes "the story of evolution, especially the evolution of man; considers the adaptive diversity of living things throughout the surface layers of the planet and gives some explanation of evolution through an understanding of genetics."

The selection of biology content for the level 2 course was much more difficult. As is pointed out in the introduction to the biology section of the level 2 syllabuses "the plethora of facts in modern biology makes a severe selection of topics necessary. Those selected reflect both the nature of investigations into problems of biology and something of the great revolution that biology is now undergoing, probably the greatest in its history." The level 1 course includes material that grew out from the level 2F material and intensified the general treatment of topics selected on the basis of the criteria just outlined.

As far as the level 2 courses are concerned the selection of content should have been even more drastic than it was. In the survey I have mentioned, it was reported that 82% of the biology items were taught without being associated with practical work. Teachers gave two reasons for this - firstly, insufficient time due to the need for covering too much material and secondly, the nature of the material selected did not lend itself to appropriate experimental work at the school level. The consequence of this has been that the material has been treated all too theoretically with little involvement of the student in satisfactory practical experiences.

This emphasizes the need for defining the aims of a course more clearly. If an aim is to provide opportunity for students to discover things for themselves through practical exercises, the content selected must be such as to make the achievement of this aim possible. Because our aim was to provide an up-to-date biology course, it of necessity resulted in selecting material that seemingly could only be treated theoretically in schools.

Some further results of the survey are worth mentioning -

fields of biology and geology were taught by a significantly higher proportion of unqualified teachers

in general, in the course as a whole, the least popular items were those containing material new to the schools

Comments by teachers recorded -

a very interesting course.

too theoretical for secondary pupils, not enough practical work to sustain interest.

the biology course is disappointing because of the scarcity of suitable practical work.

practical work took too much time.

syllabus is far too full.

These comments, I believe, reflect two weaknesses in the level 2 courses - the inclusion of too much content and the failure of that selected to allow satisfactory practical experiences for students.

Future possibilities of teaching biology within a composite course

Whatever else has eventuated in N.S.W. from our attempts to put biology into a composite science course, one thing has emerged that is very significant. It is the general agreement not only amongst biologists but amongst physcists and chemists as well that biology has earned a place in a composite science course equal to that of physics and chemistry. Thus in preliminary discussions in the new multistrand science course to be introduced next year in certain schools, it has been agreed that in this course of 12 periods per week, physics, chemistry and biology (or geology) should each have an equal time allocation. In terms of future planning then, we now have to think in terms of preparing a biology component which has a time allocation of 4 periods per week. With clearly defined aims and this longer time available there is an opportunity to prepare a course which I believe will interest and challenge pupils and teachers alike.

It is unfortunate that in Australia while we hear so much about the American science curricula like B.S.C.S. biology, CHEM Study Chemistry, Harvard Project Physics etc., we hear so little about other important curricula in the American scene. One of these is the Portland Project which provides a curriculum in integrated science for the last three years of high school. The first project attempted an integration of physics and chemistry only, but encouraged by its success then attempted another course with the integration of physics, chemistry and biology. While I do not see the Portland Project as the ultimate in integrated science programmes I believe it does point a way to going about integration. Another curriculum operating locally in the Monona Grove High School, Wisconsin, approaches integration in an entirely different way by looking at some of the "big ideas" or concepts in science and then developing a course in science through these ideas. The diversity of programmes in the United States has shown that there are many ways to go about integration. In N.S.W. we have only just started in attempting to teach science in this way at the senior level.

AN EVALUATION OF SENIOR ZOOLOGY IN QUEENSLAND

W. Stephenson

Zoology in Queensland is a two year course at the end of which an external examination set by the University acts both as a leaving and matriculation examination on the basis of points gained on a seven point scale, a seven being the highest level pass. The Zoology course is taken by most students after three years of a Junior Science course (Intermediate) during which a considerable amount of Biology is included as part of Science A.

The Syllabus

The syllabus covers a broad range of topics in considerable depth. Zoology is by no means hard but it is bulky and demands a considerable amount of knowledge (useful or otherwise) being amassed by the students. A synopsis of the syllabus, is as follows:-

(a) Introduction: Characteristics of living things as a whole. Plants vs animals. Concepts of metabolism. Taxonomy briefly.

(b) Cells and tissues: Functions of organelles. Main types of tissues.

(c) Invertebrates: Stress on "types" of the main phyla with considerable reference to local species.

(d) Vertebrates: Amphioxus, shark, frog and mammal in detail, the theme being conquest of the terrestrial environment and evolution.

(e) Genetics: DNA, genes, mitosis and meiosis, mono- and dihybrid crosses, blending inheritance, linkage.

(f) Evolution: Evidence for and theories of evolution and the evolution of man

(g) Ecology: Continuation of Junior Science work

(h) Animals in relation to man: Pests, parasites, domestic animals, poisonous animals. Conservation.

There is no fixed order of approach. This is left to the teacher and can be varied each year. (This avoids the problem of falling into a rut) The course is not of the group orientated discovery type but this can be incorporated into the course where possible. Practical work is suggested but this is by no means self-limiting and where possible, instructive and enjoyable extra practical work can be attempted. In the past, teachers in Queensland have been loath to do much practical work on animals, perhaps because of lack of facilities, or suitable training, or interest. (Some teachers are forced into teaching Zoology because there is no one else available). Practical work is directly examined. This involves photographs of animals, sections, dissections etc. Practical books have to be submitted to the Senior examiner and/or laboratories have to be inspected. Questions are often biased towards practical work e.g. "in the mammal you dissected, demonstrate where....." (Unfortunately students occasionally quote Homo sapiens - one wonders who, where and how?) Excursion work is often examined directly or indirectly e.g. "on your excursion....." (I suspect however that such questions could be easily bluffed).

A text is suggested: "Zoology for Senior Forms" by Stephenson, Bleakly, Endean, Thompson and Kikkawa. Any suitable text could be used. A discussion of the textbook itself will be given later.

There is a small section on conservation which is especially relevant in Queensland at the moment. Most students are avid conservationists; many of mine belonging to local societies. The course, especially in the invertebrate section, is written for local animals and this overcomes the problem of students applying structures of "foreign" species to the wrong animals e.g. confusing different genera of earthworms. The problem of rote learning (in excess) is probably one of the worst facets of the Zoology course as it exsits; however, there is generally an underlying theme or story. For example, no one would expect a student to learn off the cranial nerves of a shark but if these nerves are grouped into similar types and a reasonable dissection done, the problem is lessened. I feel that there should be more stress on man as an animal (I realise that man can not be dissected and the rat can, but to base the bulk of mammals on the rat just because it is available for dissection is not necessary.) There is little on marsupials, the Great Barrier Reef, animal behaviour etc., all of which I consider to be very important. Marine Biology as a whole interests students in Queensland. Further, the syllabus does not cater for weaker students who easily become snowed under early on and can't see the wood for the trees. The course as it exists gives students no idea of what a controlled experiment is or how to make use of keys, skills which are very basic to any life scientist. There are many areas where the syllabus can be improved; as it exists it has many deficiencies which can be rectified by good teaching methods and a "liberal" interpretation of the syllabus.

Student Numbers

It is fairly obvious from figure 1 that Zoology has a healthy growth rate, especially when compared with Botany and Physiology in the past. Student numbers in Zoology got a considerable boost after the introduction of Biology in the Junior science A course in 1964. Reasons for the low popularity of Botany and Physiology are not obvious but I could make some guesses viz (a) boys at least are probably more orientated towards animals, perhaps considering plants beneath their dignity (a pity, and easily rectified); (b) a lack of qualified teachers - the Physiology course for Senior was exceptionally tough and failure rates were high. This tended to turn students and teachers away from the subject; (c) Physiology as a subject is not offered at the first year University level, thus eliminating many potential teachers. (Zoology I is a fairly adequate background for the teaching of Senior Zoology although it lacks method knowledge required for practical work.)

B.S.C.S. has reduced the number of students and teachers in Zoology and will continue to do so; the level at which the decline in Zoology will halt can only be guessed - I suspect about 1000 candidates. Zoology is the most popular science subject after Maths I, Chemistry and Physics. With the relaxation in prerequisites for matriculation in Science, Zoology would become even more popular.

The Problem of Making Zoology Attractive

The first step would be to change the syllabus along the lines I have suggested. (I don't know if other teachers would approve of my suggestions totally, but most would agree in part.) Practical work must be increased well above the present minimum level and must be made attractive and varied; this could lead to the development of attitudes and techniques at the expense of rote learning. Frequent field trips are necessary. In this light, our school is building a field station on an island close to Brisbane. The University has a field station at Dunwich on Stradbroke Island which it makes available to all schools for Biology excursions. Unfortunately this has led to problems of depletion of local environments due to overcollecting.

Examinations

Two 2 hour papers are set. Paper I is an essay (extended response) section. A choice of 4 out of 7 questions is given. Paper II is totally compulsory containing 24 short questions to be answered in about 10 lines each, and a section which directly examines practical work. Almost all questions are of the knowledge type, often on fairly minor details rather than overall concepts, e.g. "what are the main phases in a typical oestruc cycle", "give four characteristics of all enzymes", and "what is meant by fixation as applied to histological preparations". I might hasten to add that when a good question is set which involves skills in the higher domain, all the students fail and the teachers complain!

Text Book

The recommended text is "Zoology for Senior Forms" (Stephenson *et al.*) The text is the only one written specifically for the course but there are many other useful and recommended texts. On the whole the text can do with considerable improvement; the diagrams are often confusing and difficult to interpret, being either too simple or too complex. The whole book is in black and white which does little to motivate students - animals are particularly suitable for coloured photos. For the average student, the text is not easy to read although this does not apply to all sections. It would be handy if after each section there were some questions or places where student response could be tabulated (perhaps a companion guide would be suitable). A text must be attractive and stimulating if it is to be read for any reason other than for passing exams. Teachers should have had a say in compiling the text before it was produced.

Student Response and Criticisms

We are concerned with educating young people and their education and enthusiasm are more important than the subject itself (I prefer to think I am teaching boys Zoology rather than Zoology to boys). Every year I do attitude tests among my own students and try to vary my approach, methods etc. in the light of their criticism. This makes the student feel that they have a say in how things are run. For example, if a suggestion is made that they would like to see what the motor end plate of a neuromuscular joint looks like, I will buy slides of this, and, I hasten to add, remind them that this is something they wanted to look at and it has been provided. I do not pretend that my attitude tests are "good" or representative but the results of some of these tests are given below.

Why do students take Zoology in the first place?

(i) Many students take Zoology because they want to take a University course which involves Zoology e.g. Medicine, Agricultural Science, Veterinary Science etc.

(ii) Many are interested in animals as a hobby and want to learn more about them

(iii) Some, of course, take Zoology as a sixth subject, because they have failed in Maths or Science B at the Junior level.

What have students got out of Zoology?

(i) Most, find it interesting. They can learn a lot about the sorts of things they see around them and a lot about themselves.

(ii) Students enjoy the field trips both academically and socially.

(iii) Some like Zoology because it is not "cut and dried". Many enjoy the "rave" sessions when we have a free for all discussion on anything vaguely zoological.

(iv) Unfortunately, some students say they get nothing out of Zoology at all, but I suspect that these students get nothing out of anything.

How could zoology be improved?

Some general student criticisms are:-

(i) Less rote learning

(ii) Open book exams

(iii) More appealing text with colour plates

(iv) More field trips

(v) More work on familiar animals especially man

(vi) Perfumed air pumped through the laboratory!

Liason between Examiners and Teachers

1. Annual examiners meetings are held for the discussion of the papers as a whole and the spread of results. After this, individual examiners criticisms are given to teachers so that their teaching

methods can be improved and misconceptions can be ironed out. Comments are also available on the general standard of the practical books collected as a sample.

2. Teachers have a say in what alterations should be made to the course content. So far, this has been done in a very minor way. If the examiner took notice of every suggested deletion, the course would read "Zoology is the study of animals" and some wouldn't be sure of that.
3. Vacation schools have been planned but haven't eventuated through no fault of the examiners.
4. Evening classes are held in higher levels of Zoology at the University to give teachers and others an opportunity to get a degree and more knowledge.
5. Members of the University staff inspect laboratories and give general advice.
6. Teaching materials are lent by the University to responsible teachers e.g. sampling apparatus, collecting materials etc.
7. University staff visit country centres demonstrating suitable methods for particular parts of the course.

The University is keen to perpetuate Zoology and it is the fault of the teachers if they do not make use of the help available to them.

The Future of Zoology in Queensland

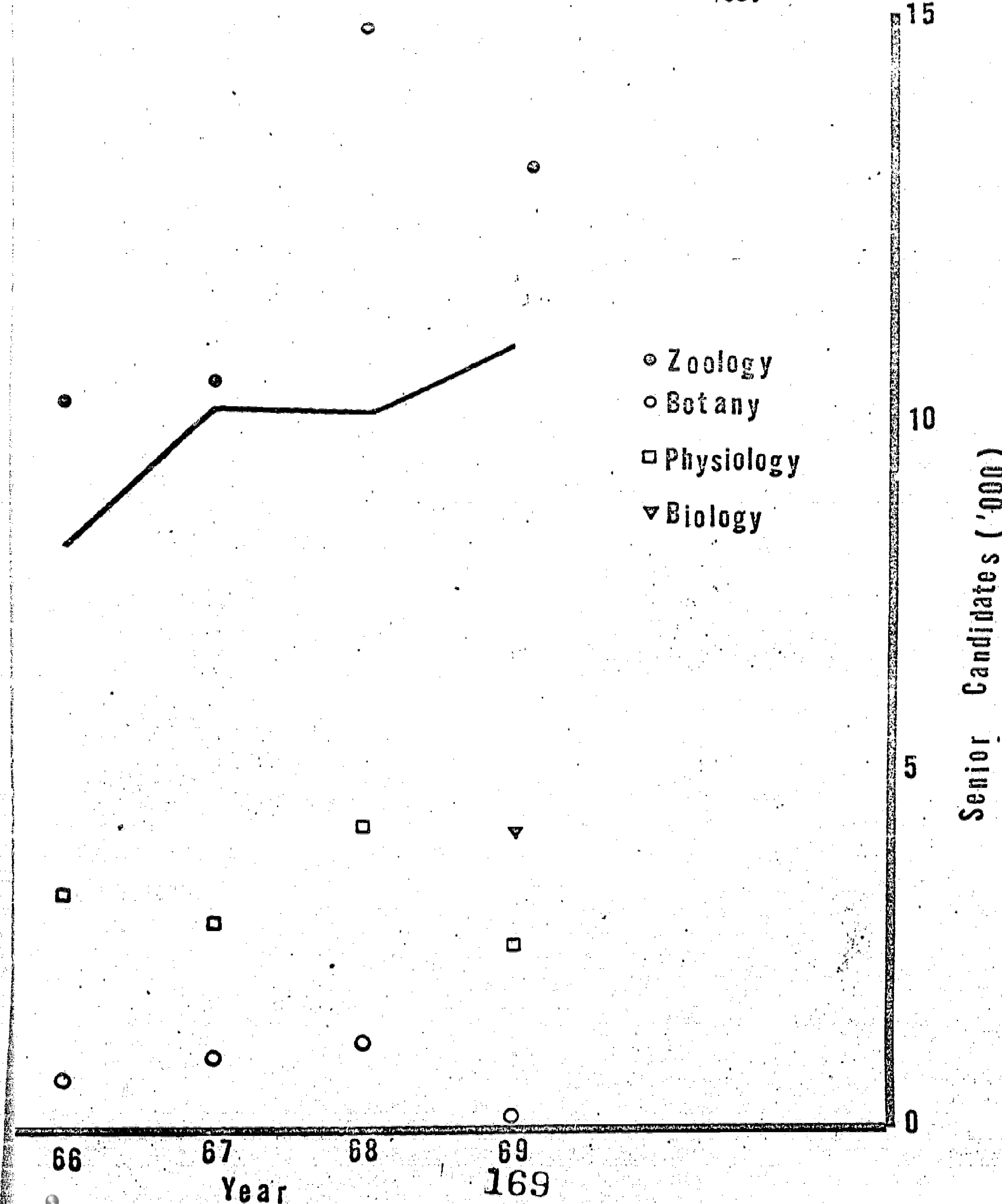
Zoology as such will continue indefinitely in Queensland. As I have already suggested, teacher and student numbers will drop due to the effect of B.S.C.S. The recommendations of the Radford Committee will be of considerable interest. Teachers will then be able to design their own courses and examine internally. I do not pretend that designing a suitable syllabus will be easy. As a general comment, the sort of approach I think is required is:-

(i) To list the aims of Zoology teaching (this is fairly easy to do.)

(ii) To suggest the best possible method of attaining these aims (not easy at all)

I believe that the best type of course would be one where the student rather than the teacher is active, where students learn from their own observations, draw their own conclusions and improve their own methods. I do not believe however, that a teacher can expect everything from the students, and think that he should feel free to make suggestions and throw spanners in the works so long as this is not too often or too obvious.

Both Zoology and B.S.C.S. in Queensland are good courses in their own right but will be good only if they are taught by dedicated, enthusiastic teachers.



BIOLOGICAL SCIENCES—SENIOR

AN EVALUATION OF THE PILOT COURSE IN LEAVING HUMAN BIOLOGY IN W.A.

N. Katavatis.

I wish to point out that the statements I make are not my own ideas entirely, but the ideas of the teachers actually teaching this subject. I prepared a 25 item, 3 page questionnaire which I sent off to 26 people. Seventeen of these were returned fully completed. This was an excellent response considering that only about a dozen or so schools are participating in our "pilot course". At this rate I feel I am able to speak on behalf of the Human Biology teachers of Western Australia.

I will attempt to elucidate on this course and assess the strengths and weaknesses of Human Biology as currently given in W.A.

Therefore, this talk will be divided into four parts -

1. The origin and brief history of the course.
2. The strengths and weaknesses of the course.
3. Teacher training for this course.
4. Summary.

The origin and brief history.

In the latter part of 1968, Professor Allbrook initiated the Human Biology course, by preparing a syllabus for the Public Examinations Board of W.A. and the P.E.B. in turn authorized the holding of an examination at Leaving level in 1970 for those schools wishing to participate as "pilot schools". The subject was offered as an alternative to Leaving Physiology and Hygiene (P. & H. is not a matriculation subject.) An in-service course was arranged by the Adult Education people for January, 1969, and in due course a copy of the syllabus and an invitation to the in-service course was sent out to all secondary schools.

The first in-service conference was fairly well attended and apparently quite successful. However, the outcome was that only 9 government schools and a few independent schools decided to participate and commenced teaching Human Biology at sub-Leaving level. Now in 1970, the pilot schools have Leaving classes, and so the first Leaving Human Biology exam will be conducted at the end of this year. Unfortunately, the total number of students that will be sitting is small, therefore, it is unlikely that any valid information will be obtained with regard to the impact and value of this course as a biological science subject. The implication is that the experimental population should have been larger.

Strengths and weaknesses of the course.

The teachers involved in this experimental course are very enthusiastic. They feel Human Biology is a subject for every student. As indicated in the outline, for practical purposes, the course may be divided into two parts

(a) a study of man

(b) a study of man in his environment, but the whole strength of this course lies in its ability to draw these two parts into one. Human Biology is a study of men rather than man.

If a good balance is maintained between these two, the course tends to link the sciences to the humanities and this will lead to self awareness, and to a deeper knowledge of man, of man's responsibilities towards himself, t wards his fellow man and towards his environment. This should make for a better world and a better future for the human race. The aim of the syllabus is to present the modern concepts of man's interaction with his environment and this promotes a modern dynamic approach to the study of man.

The first part of the course includes familiar topics such as the chemistry of living matter, the biology of cells, the structure and function of the organs, genetics and the life cycle of man. These topics involve a fiarly detailed study of the anatomy and physiology of man. Thus, physiology is a maj r part of this course and is designed to enlighten young people, to give them a broad, sound knowledge of the human body. This part of the course facilitates communication in adult life;

an understanding of reproduction, embryonic development, childbirth, indeed a scientific approach to sex education within the context of the course;

an appreciation of the changes which occur in growth, from birth to adulthood - both physical and psychological; Puberty changes and the problems of adolescence;

a responsible understanding of individual differences and sex differences;

an appreciation of future achievements in medical science.

People in this modern age are still very naive about the mechanisms of their own bodies. Thus, the importance of the study of man cannot be overstressed.

The second part of the course includes the following topics and these have been numbered according to the syllabus.

(6) The origins of man.

To develop this topic an absorbing study of the Primates has been included. This constitutes a fascinating study, hitherto completely neglected in schools. Briefly the primates are classified and then specific examples are taken and studied for their physical and simple behavioural characteristics.

Generally such headings as Location, Locomotion, Anatomical Features (e.g. Brain size, hand shape and relative limb size), Adaptation, Feeding Habits and Social Behaviour are used.

In the classroom, reference books, magazine articles, 16 mm films and 35 mm coloured slides are used to introduce this work.

Then for field work the specimens at the Zoo are studied. Individual behaviour and social patterns are observed. This work is closely supervised and follows the observational methods recommended by the Director of the Zoo, Mr. Spence, who is a primatologist of note.

Also, the study of "fossil man" is included in this topic. This constitutes an absorbing and fascinating study for both the teacher and the student. The other topics are

(7) Variations between men.

(8) Scientifiic study of man's ecology.

(9) Mental, bodily and community health.

The former two may be considered by some as Social Studies topics, but the scientific treatment of them certainly brings them within the scope of this course.

These topics will help the student's "out of school" life, by the fact that he will develop better attitudes and values, a far better understanding of peoples of the world and knowledge of man's place in his environment. Topical issues, such as conservation, water and air pollution, birth control, abortion, promiscuous behaviour, drugs and alcohol, smoking, racial problems are all relevant and important to this course. The consequence of such studies is that the student is beginning to take a voluntary interest in T.V. programmes and newspaper reports relating to these subjects. Some English teachers have even reported that English expression has improved amongst those students who are doing Human Biology.

The syllabus covers most aspects of Human Biology. It indicates that most sections may be taught at an elementary level, without going into too much depth at any one point and that there is scope for a teacher to increase the depth to which any given topic is taken. From the teachers' point of view the syllabus is too extensive. There is a certain vagueness of terms which may lead a teacher to devote too much time to a particular topic, at the expense of other more basic topics. No doubt, this difficulty will be overcome in time. However, at this time, the teachers of Human Biology do need direction and guidance as to which aspects of the course are basic and therefore require greater attention. This could follow the pattern of the "web of life" course which clearly indicates the basic topics. But, on the other hand, too much direction maybe a definite hindrance to the development of this subject, which arouses one's enthusiasm, by virtue of its vast scope and possibilities as a subject which catches the interest of students of all levels of intellectual ability and curiosity. Further, the syllabus states that "In general the opportunity is given for students to use the scientific methods of observation and deducation even if they are not 'scientists'". As a matter of fact it may be better to play down the study of scientific methods and laboratory techniques in Human Biology.

Of general interest to all science teachers is the question of whether all science courses should be geared to the study of scientific method. Should every branch of science have the philosophy of science or the logic of science as one of its major aims? Maybe it should be reserved for physics and chemistry which are pure sciences and pre-requisites for the biological or applied sciences; or maybe scientific method should be taught to the brighter students only as a separate subject which may encompass the science subjects they may be studying. Too much emphasis on scientific method is apt to dampen the enthusiasm of the weaker student for any science course.

The major weakness of the Human Biology course is that there is not enough time to develop it to the extent necessary to make the students of today well-educated, adaptable, tolerant citizens of tomorrow as well as giving them the necessary detail on the physiology of their own bodies.

Teacher Training

Two conferences have been conducted by the Adult Education Board. These were very successful. The background information supplied was valuable. There was a certain reluctance on the part of the lecturers to state precisely what is required at this level.

Regular meetings are held. These are useful for comparing approaches and progress made. A sub-committee has been set up to assist the chief examiner in making up suitable examination questions. One of the satisfying outcomes of these meetings is the fact that the

Public Examinations Board has been persuaded to depart from the traditional method of assessing candidates by a solitary three hour exam. It has agreed to allow the teachers to assess 40% of the candidates' Leaving Examination mark.

It is inevitable that teachers of any new subject will complain and criticize, and teachers of Human Biology are no exception. Certainly teachers in the "pilot schools" have complains and teachers who take this subject for the first time in the future will complain about many things:

- lack of assistance and guidance
- shortage of equipment, teaching aids etc.
- inaccessibility of places to visit - zoo, museum etc.
- the absence of one text book to cover the whole course (It is far better to use the library extensively than to rely on one text book.)

But surely the hallmark of a good teacher is his willingness to take up the challenge of a new syllabus, such as this one - to prepare materials, to attend meetings and conferences, to exchange materials and ideas with others. These efforts can only result in a feeling of achievement. And of course, there is always the possibility that some of this zeal and industry may be reflected in his students' work.

Summary

Briefly, an attempt has been made to evaluate Human Biology from the teachers' viewpoint. It is a rewarding and worthwhile subject. It is an education for a new modern society. It is a subject of the utmost importance, especially at a time when the whole world is stirring and awakening to the danger of allowing our environment to be polluted at, what the experts call, a terrifying rate. And pollution is not our only problem. There are many problems which need immediate attention if man is to survive on this earth.

SECTION IV

BACKGROUND PAPERS

Modern biology teaching techniques, in common with those of the other science disciplines, emphasize discussion methods and laboratory experience. In addition, much attention is given to the nature of the inquiry processes in science. To assist conference members in their discussions, background papers reviewing the current literature on the topics were commissioned by the organising committee. These papers were not formally read, but were distributed at the commencement of the conference for participants' information.

The major conclusion, that can be drawn from these reviews is that "more research is needed": there is no consistent evidence that the use of the laboratory or many of the "inquiry techniques" results in students attaining the abilities that the techniques are designed to give, and little of the evidence available on the use of discussion as a teaching technique has been obtained from the school classrooms.

Some of the ambiguity is a result of poor experimental design, but even in the best designed studies it is extremely difficult to control all extraneous variables when comparing two or more teaching techniques. This problem is referred to by both Atkinson and Johnson.

A second common difficulty faced when reading the research literature is mentioned by Lucas: the imprecise terminology makes it difficult to compare different studies. One man's "discovery learning" is another's "guided-discovery" or, even, "inquiry training".

A third important difficulty that occurs when reading the results of educational experiments is one of generalizability: is it valid to extrapolate the results of a well-controlled, reproducible study concerning, say, the worth of laboratory instruction in senior high school chemistry in the United States to a junior secondary school biology class in Tasmania when the cultural background, educational system and the pupils' stage of concept development may all differ? These limitations need to be kept in mind when the three reviews are read.

Although there are only a few immediately applicable conclusions that can be drawn from these reviews, they are a useful summary of the current research and will dispel many of the glib assumptions often made when teaching techniques are discussed.

THE VALUE OF LABORATORY WORK TO THE TEACHING OF SCIENCE IN GENERAL AND BIOLOGY IN PARTICULAR - A LITERATURE REVIEW.

JOHN M. ATKINSON

"The laboratory is where the work of science is done, where its spirit lives within the persons who work there, where its methods are transmitted from one generation to the next. One does not really learn science from books; one learns science by asking nature the right questions. And the laboratory is the place where one learns most readily what questions can be asked fruitfully, and how they must be put. It is where one learns why science insists on precise measurements, accurate observations, and conciseness and clarity in communication."

This statement by Bentley Glass (9) is representative of the view taken by most recent and current writers about the place of the laboratory in the teaching of the sciences. Authors of science method texts (10,21, 28,29,32,33) place strong emphasis upon the importance of laboratory activity for the attainment of generally-agreed objectives of science teaching, and those responsible for the "avalanche" of contemporary science curriculum projects base their courses heavily upon assumptions of educational benefits accruing from such activity.

Information about the history of laboratory usage in Australian science courses appears to be scarce, but it can fairly safely be assumed that it has reasonably paralleled the situation in the U.S.A. This has been described by Hurd (11).

In the U.S., laboratory work was sometimes included in those science courses that existed in the 18th and 19th Centuries, but it was not until the latter part of the 19th Century that the laboratory really came into prominence. The growth in the use of the laboratory at this time stemmed largely from the "mental discipline" theory of psychological development, by which laboratory work was seen as providing excellent training in observation, will-power and memory. (11, p. 18). Laboratory work in the biological sciences concentrated on morphology, whilst in the physical sciences students performed "experiments" which purported to "verify" the laws of physics and chemistry. (Sund and Trowbridge (32), p.90, note that nearly fifty per cent of the one hundred or more exercises in physics and chemistry which were prescribed in 1886 by Harvard University for performance by intending entrants were still retained in the courses of study of secondary schools sixty years later).

During the decades that followed intermittent recommendations for a more truly experimental approach to the study of the sciences came from individuals and committees. Despite these suggestions, the biology curriculum committees which sprang into existence in the U.S. following public recognition of the technological advances of the U.S.S.R. (as evidenced by the launching of the "Sputniks" in the fifties) still found passive observation of dead organisms typical of laboratory work in the subject.

In Australian schools, until the last few years (and right up to the present in some cases) laboratory work was commonly isolated out from the rest of the course in any science as "practical work", often bearing little or no relationship to the "theory" currently being studied.

In the last decade or so science educators in many countries have adopted courses with major objectives in both "content" and "process" dimensions. In an effort to grapple with the educational problems occasioned by the vast expansion of scientific knowledge and the rapidity with which this knowledge changes, attempts have been made to identify the fundamental principles which form the underlying conceptual framework of the sciences, and to base content upon these principles. There has also been a recognition that to cope with the impermanence of the present state of scientific knowledge the student must have a real understanding of the ways in which scientific knowledge is acquired and modified - that is, of the methodologies of the scientist. Thus the present trend is towards an "inquiry" approach centred on the laboratory, on the assumption that the student will most readily come to an understanding of the processes of science by "sciencing" himself.

In attempting to evaluate the importance of laboratory work to the attainment of science teaching objectives there are many questions one might ask. Some are:

1. Is laboratory work in itself essential for achieving certain objectives?
2. Is laboratory work the most appropriate way of providing experiences essential to the attainment of certain objectives?
3. What type(s) of laboratory work is/are most effective in achieving desired outcomes?

There are two ways in which one can attempt to answer such questions. The first is by reasoned argument based upon a combination of experience and intuition, and much of the present rationale for laboratory work rests upon such a basis. The argument for laboratory work as a means of familiarising the student with the process of science has been outlined above. Claims which can be argued for laboratory work include the following:

(i) Science is observational and experimental - science courses should reflect this.

(ii) Laboratory work is a major source of motivation for the student.

(iii) Laboratory manipulative skills can only be learnt by actually practising them.

(iv) Laboratory work enables the student to bridge the gap between abstraction and physical reality.

(v) Concepts are developed to greater depth as a result of laboratory work.

The scientist in each of us recognises the part played by experience and intuition in problem solving, but looks for more concrete evidence before even tentatively accepting or rejecting a proposition.

The second way of looking for answers to our questions about laboratory work then is to examine research evidence. At first sight this would appear to be the most likely approach, but to date it has not been highly successful in providing firm answers. As will become apparent, the difficulties of research in such an area are considerable, and research has been limited.

Remarking on the trend to make laboratory experiences central to instructional procedures in science, Ramsay and Howe (27) point out that "direct research on what these experiences should be, how they should be organised, and where they function best, is indeed meagre." Comments of a similar nature appear in practically every available review of research in this area, and in many research papers themselves.

Furthermore, some of the most defensible research on this topic has been carried out at tertiary level, and the applicability of the findings of these studies to science teaching in the secondary school is open to question in terms of stages of intellectual development.

Bradley (3) has attempted to review the research evidence in order to make recommendations concerning the necessity or otherwise of including laboratory work in general education science courses at the college level. He reports an earlier survey by Cunningham (6) of thirty-four studies in the period 1930-46 and suggests (p. 60) that the results of these investigations "justify the view that individual laboratory method does perhaps develop laboratory resourcefulness and manipulation of laboratory materials better than the lecture-demonstration method." The fact that this is all he could conclude is a little disturbing, to say the least.

Bradley goes on to critically examine six studies (2,12,13,16,34, 35) concerned with the lecture-demonstration vs. individual laboratory method variable, four at college level, two at high-school level.

Each of the six investigators concluded that the laboratory method was superior in one or more respects: scientific attitudes and certain abilities in problem solving for general education in biology (2);

instrumental situation, single measuring techniques and problems involving apparatus (16); long-range comprehension for high-ability students (34); exercise of individual differences (12); knowledge and method of handling new problems (13); laboratory manipulative and comprehension skills (35).

Likewise, each investigator concluded that the lecture-demonstration method has advantages, particularly in regard to low-level cognitive performance such as recall of information.

Again, most reports contained conclusions contending that students achieve equally well on criterion tests of various kinds irrespective of treatment.

Bradley suggests (3, p. 65) that

"although most of the data seems valid, the diversity of findings appears to cast some doubt on the validity of the tests, the adequacy of controls of such factors as instructor conditions, the use of small unrepresentative groups and no retrial of experiments. There also seems to be no standard lecture-demonstration or laboratory method. The conclusions reached by the various studies offer support for both methods and are scarcely definitive."

His final conclusions (p. 66 are as follows:

" (1) No one method can be considered superior in all cases. The objectives of science teaching, the ability level of the students, and the facilities available should largely determine the method used.

(2) Where cost per student is a major concern, the

lecture-demonstration method seems to offer the best advantages.

(3) The problems of the lecture-demonstration method versus some kind of laboratory method still seem unsolved and as complex as ever. It appears that there shoule be more careful experimentation involving careful control of non-experimental factors. More reliable testing is needed before any definitive answer can be given."

In a study involving twenty biology classes (randomly selected from four senior high schools) and sixteen teachers, Sorenson (31) investigated the change in critical thinking (as measured on a number of well-known published tests) in students studying two of the BSCS Laboratory Blocks by a laboratory-centred method or, alternatively, a lecture-demonstration method. He found significant gains in critical thinking, understanding of science and dogmatism (or, rather, the avoidance of it!) in the laboratory-centred group, but no significant change in the lecture-demonstration group.

Atkin and Burnett (1) in a review of science education refer to the work of Kruglak in a number of investigations into the results of instruction in college physics employing individual laboratory work, demonstrations, or neither (14 - 19). Atkin and Burnett comment on the excellence of Kruglak's research designs and suggest (p. 1197) that

"the fact that, as a whole, little difference in learning (except for laboratory skills) seems to result from the instructional approaches used may only indicate the complexity of research into methodology and the probable existence of multiple and uncontrolled variables."

In view of the current emphasis on the "process" approach to science teaching and the accompanying tendency to view the laboratory as the place where the student may most naturally be introduced to the experimental method of problem solving, it is not surprising to find that a number of recent studies have attempted to investigate the outcomes of different types of laboratory experiences.

Ramsay and Howe (27, p. 76) comment that studies by Charen (4), Rainey (26), Mark (23), Marin (22) and Lennek (29) lend support to the trend to provide "open-ended" laboratory activities in that they indicate that "students can take a more active part in formulating their experimental procedures without suffering any major consequences in terms of achievement."

A study by Montague (25), comparing nine experimental groups of college freshmen chemistry students experiencing open-ended experiments with nine control groups experiencing the customary laboratory manual experiments over a period of ten weeks, found the experimental group to perform significantly better in tests of both problem-solving in a laboratory situation and critical thinking about everyday problems.

There have been many studies of this kind in the area of biology. Mason (24) investigating the relative effectiveness of a "scientific-thinking method" and a descriptive method of teaching biology, found that the laboratories of the two methods were equally effective with respect to the acqusition of factual information and the development of scientific attitudes, but the scientific-method approach was more effective in teaching certain abilities associated with scientific thinking.

In another study Schefler (30) compared an inductive laboratory approach to the teaching of genetics to freshmen biology students with a traditional lecture and illustrative laboratory approach. There were two experimental classes and two control classes. Each of the two instructors involved took one experimental class and one control class. In none of the measures employed (knowledge of genetics, understanding of science methodology, interest in and attitudes to science) was there a significant difference between the gains of the two groups. The fact that regardless of method, the students of one instructor performed better than those of the other instructor on the test of subject matter points again to the difficulty of controlling the teacher variable in studies of this nature.

Coulter (5) has carried out a study employing two modes of laboratory work in comparison with one mode of demonstration in ninth grade biology. An inductive laboratory group designed, carried- out and interpreted their own problem-solving experiments; an inductive demonstration group was treated similarly with the exception that the teacher performed as demonstrations the student-designed experiments; a deductive laboratory group was "taught" a principle or generalisation by the teacher, then given a designed activity to substantiate or check it. All groups were taken by the one instructor and used the same course of study. Coulter reported no significant differences between groups other than that "students who performed experiments were more positive in their reaction towards instruction than those who watched demonstrations" and that there was "some indication of the inductive approach being more conducive to teaching aspects of scientific inquiry."

A recent investigation by Yager (36) attempted to control some of the variables which in past studies appeared not to have been adequately controlled. A laboratory group of Grade 8 students performed fifty of fifty seven laboratory exercises in the BSCS Blue Version individually or in groups. In the "demonstration group" only one experimental set-up was employed for each exercise, the experiment being performed by either the teacher or selected students. (The teacher, however, sometimes supplied conflicting data for discussion). A discussion group did not observe or perform any of the exercises but discussed all of them as "second hand data."

All groups employed an inquiry approach and were similarly treated with respect to factors such as class period times and lengths, tests, lesson format, unit sequence, etc. The three teachers involved were rotated between groups about every four weeks [such a strategem has little effect on the outcomes of instruction (7)] and are described as markedly similar in background, philosophy and technique.

No significant differences were found in any dependent variable other than laboratory skills.

The following comments which were made by the investigators in discussing the results of the study are quoted at some length as they may be of considerable significance.

"This study suggests that one should be cautious about insisting on laboratory facilities and materials with the idea that these will insure desired outcomes or even a "good" science program... This is not to say that all laboratories should be abandoned... In fact, (for) some teachers (if not most)... it may be easier to approach biology as inquiry with actual work in the laboratory by all students...

"The results of this study indicate that desirable outcomes result in a science class even though the laboratory is limited. <u>If these results were verified with some similar experiments</u> [my emphasis] the implications with all of the so-called newer approaches to secondary science would be open to some question since all utilize the laboratory as a central activity for individual students. Perhaps instead of an emphasis upon the laboratory per se there should be an emphasis upon the very nature of the scientific enterprise which could or could not include the frequent use of the laboratory for every student...

"This study also suggests that science curriculum workers might well devote some time and effort to the structuring of some new courses that would deemphasize the laboratory. For certain students a verbal (nonlaboratory) approach may be the best means of stimulating them to understand and to appreciate science. Some students (especially at advanced levels) may find the laboratory to be a waste of time and merely a means of slowing their pursuit of new theories and concepts. The laboratory certainly should not discourage creative work in science."

Yager et al. appear to have conducted their investigation with considerable sophistication. It must be rembered, however, that this was but one study involving only sixty students and three teachers, and in one school - a very limited sample on which to base major decisions. Furthermore, as in virtually all of the studies which have been considered, immediate outcomes have been the only ones investigated. It would seem not improbably that the use of the laboratory could have long-term implications. Again, students in all these studies will be affected by their previous experiences. Students in control groups will, in practically all cases, have had previous exposure to laboratory activities and this may well affect the results of the investigations, even when outcomes are measured in terms of gains over the duration of the study.

An investigation which may be significant and which will certainly be popular with anti-vivisectionists is that of Fowler and Brosius (8) in which the effects of various immediate outcomes of performing (a diverse series of four) dissections compared with viewing films of the dissections were studied. No significant difference between treatments was found on tests of understanding science, science attitudes and even manipulative skills. The film group was superior on tests of factual knowledge and problem-solving. As the published report lacked adequate details of procedure or statistical data, the reliability of this study cannot be assessed.

Atkin and Burnett (1, p. 1197) summarise the research position as follows:

"It is probably that well over 100 studies have been made which attempt to compare the results of lecture demonstrations with those of individual laboratory work... Most have found no significant differences in terms of the instruments and measures used; some have shown a superiority of the lecture demonstration technique, and some have shown individual laboratory work to be superior. Why there have been such variations in results is an open question. It is clear that many of these studies have been poorly designed. It is equally clear that the instruments and evaluative techniques employed have varied in nature and reliability, as well as in what was assessed and with what emphasis. In any event, these studies have left us with little light on the possible superiority of one method over the other even in terms of clearly specified instructional objectives."

It is apparent, then, that research can provide no definite answers at present to questions like those raised earlier in this paper. Although a figure of "well over 100 studies" may appear considerable, these investigations have been diverse in kind and limited in scope; many are of questionable validity and there has been virtually no attempt at replication of results. The difficulties of research of this nature appear thourghout this paper - ensuring control of all extraneous variables, developing valid and reliable criterion tests, obtaining sufficiently broad samples of data and establishing replicability are all serious problems confronting the investigator.

In relation to the questions raised the evidence available would appear to suggest tentatively that:

1. Laboratory work may be essential to the attainment of only relatively minor objectives such as laboratory manipulative skills.
2. Nevertheless, laboratory work may for many teachers and many students be the most satisfactory way of achieving certain major process goals of science teaching.
3. Laboratory activities which embody an open-ended inquiry approach may be more appropriate for attaining process goals and appear no less effective in the achievement of content objectives than more traditional forms of laboratory work.

In the face of the inconclusive nature of the evidence available, it may be that it is not so much the type of classroom activity, in itself, which is the dominant factor in determining educational outcomes. Rather, it could be the nature of the teacher-student interaction, the kinds of experiences which students have within the framework of the class activities provided, which is the vital ingredient.

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DISCUSSION IN TEACHING BIOLOGY.

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There has been an increase in awareness of the importance of discussion techniques in education over the last few years. A considerable amount of research has been conducted on discussion groups but most of this has been directed towards adult groups. There appear to have been relatively few research papers published on the use of group discussion in universities and schools and pathetically few on its use in teaching biology.

Most recent research into discussion group dynamics and outcomes has had its origin in the need to solve leadership problems and the attempt to break new ground in psychiatric therapy. But despite the relevance of much of this work to education there has been relatively little carry over its results and implications into research in the classroom situation. A number of the more important books and articles dealing with experiences, experiments and methods for discussion groups generally are given in the bibliography.

The research on group dynamics which has the greatest relevance to education is perhaps that conducted on the "T", or training groups, developed by the National Training Laboratory in America. The "T Group" is a face-to-face group set up to aid its members to learn about social phenomena by analysing what is taking place in the group. The groups have no leader, rules or agenda and they aim to influence the attitudes and behaviour of their members in a number of ways : by increasing awareness of their own feelings and of the feelings of others; by becoming more aware of the complexity of the communication process; and by generally increasing interpersonal competence.

The innovators of the "T Group" recognised the overlap in the values of science and successful social relationships and among their objectives they list three of the basic qualities of science: the obligation to face all of the facts involved in a problem and its solution; objectivity toward the collection and treatment of data; and the obligation to collaborate with other investigators in the pursuit of truth. "T Groups" appear to have had considerable success in achieving their aims and their use has increased greatly over the last few years. An account of "T Group" theory and research is given in Bradford et al. (8).

The extensive use of discussion methods in the BSCS course was a deliberate decision reflecting the aims of the course. These are concerned primarily with the aquisition by the students of attitudes and intellectual skills rather than with learning a large amount of factual information about biology. It has been shown repeatedly that attitudes and intellectual skills are aquired more effectively in group discussion than by other pedagogic methods.

Asking and answering questions is a process which begins early in life and continues for as long as intellectual life continues. From it develops the give and take of conversation and the more organised discussion. Any process which results in questions being asked, particularly unexpected ones, rather than simply stating facts, was found by Berlyne (6) to result in improved learning and increased interest in the topic. Inhelder and Piaget (12) believed that in order to teach others to reason logically it is indispensable that there should be established between students and teachers "those simultaneous relationships which characterise the co-ordination of viewpoints."

Beard et al. (5) believe that discussion is one of the most educative processes since it enables students to analyse differences in views and opinions and leads them to revise their position and to integrate what they learn with what they already know. It contributes to the development of new concepts from already familiar ones and from those imperfectly understood from reading.

In a comparison of the effectiveness of a lecture demonstration teaching period with a problem solving discussion procedure in a college science course, Barnard (3) found that the discussion method proved superior on measures of problem solving and scientific attitude, whereas the lecture method proved superior on a test of specific information. On the other hand Dawson (9) found the two methods to be equally effective in courses in elementary science as measured by a test of recall of specific information but the discussion method gave significantly superior results on tests of problem solving abilities.

Barnett (4) found that discussion group activity led to increased critical thinking and also had an influence on the behaviour of some members of the class in becoming less aggressive. He suggested that an admixture of free discussion can improve the effectiveness of other types of teaching by clarifying the thought of students and enabling them to unravel confusions. In a very readable and important book Abercrombie (1) argues the importance and traces the origin of some of the unconscious preconceptions which influence judgement and decisions and which can be exposed by discussion methods. She gives an account of a series of experiments in free group discussion and its use in the training of medical students. Discussion group participation led to the clarification of ideas and the development of more critical attitudes. This resulted in the students performing significantly better in situations where they were called upon to interpret and analyse information placed before them.

In a recent study of school children comparing the effectiveness of reading and discussion in addition to classroom instruction, Fisher (10) found that students' attitudes towards a socially deprived sector of the community were changed most effectively when discussion methods were used.

Discussion methods not only appear to be more effective in influencing attitudes but they are also preferred by students as a teaching experience. Hallworth (11) found that although attainment gains were similar among discussion and control groups, children in discussion groups enjoyed the work more and their attitudes to the subject studied improved significantly more than did the controls. The children also learnt to co-operate better with one another and the number of isolates in the class fell markedly.

Rasmussen (14) also found that students using group discussion methods found their course more interesting and believed they had learnt more and that it would be of more practical use to them, although when compared with controls who did not use discussions, no significant differences were found in the amounts learnt. In a survey of university students Stones (16) found that there was a clear-cut preference among them for the discussion type of teaching situation.

A good deal of work has been done on group dynamics and the optimum conditions for conducting group discussions. The optimum size of groups for the most effective discussion appears to be between seven and nine; a smaller number than seven limits the resources of the group too drastically, while a larger number does not allow for sufficient active participation by each member and many members tend to become shy in larger groups.

Steinzor (15), Abercrombie (1) and others have stressed the importance of the spatial factor in group work. It is important for members of the group to be seated in a circular pattern so that each member is able to see every other member. Furthermore, the actual position in the group of people with different personalities can have a marked effect on the nature and degree of their contribution to the discussion. People sitting opposite each other tend to interact more with each other than with those on each side of them. Steinzor suggests that reticent members should therefore be placed opposite talkative ones and monopolists should be seated in adjacent positions.

Group discussion can be conducted with or without a tutor or teacher being present. If the teacher is present he must be careful not to dominate the discussion. Teachers generally tend not only to hold the floor too much when they are leading groups but they may also inhibit the students from participating fully. If the group is run in the absence of a teacher the purpose of the discussion must be well established and adequately understood by the participants. Unless the participants can see a clear purpose in the discussion there is a tendency for interest to wander and participation to be desultory. Powell and Jackson (13) analysed a series of recorded leaderless meetings of University students and showed that interaction was vigorous and animated and there were remarkably few instances of factual mistakes being allowed to pass uncorrected. The students enjoyed working in this way and claimed that their understanding of the subject matter was notably improved by comparison with most conventional tutorials. But as Powell and Jackson point out it is quite useless to assign students to groups and simply tell them to discuss. Careful preparation is absolutely essential.

There is no doubt that discussion in small groups can be very time consuming and may appear to be wasteful. A group discussing a topic with inadequate factual knowledge may generate heat but not add much in the way of light. But if it leads the members to realize their ignorance and search for the needed information, something will have been accomplished, and students certainly need to be trained to settle arguments by looking up information in books instead of just talking.

For influencing attitudes and subsequent behaviour discussion groups tend to be more effective than other teaching methods. But it must be remembered that a badly organised group can be both frustrating and a waste of time as surely as can a bad lecture [see Bloom (7)]. Students, on the other hand, enjoy group methods and think they learn more this way than by other methods and they show more interest in their work and become more deeply involved in it. As learning is best achieved when teaching methods arouse most interest and most activity on the part of the learner, one would expect more effective learning when discussion methods are used. That this is not always apparent when different teaching methods are compared, does not mean that this is not so, it may merely mean that our evaluation methods are inadequate. It is notoriously difficult, as Williams (17) has shown, to control all variables and obtain a valid comparison of different teaching methods.

As the accumulation of scientific knowledge continues it becomes more and more apparent that the aquisition of any particular knowledge is an insufficient definition of education. Rather, the major residue of anyone's formal education may well be taken to be the attitudes and habits of inquiry and learning he has developed.

We need to know much more clearly than we do at present just how it is that people learn how to learn and how learning experiences exert their effect on subsequent growth and development. There is little doubt however, that discussion can play a very useful and productive role in the educative process.

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RESEARCH ON "INQUIRY", WITH PARTICULAR REFERENCE TO BIOLOGY TEACHING

A. M. LUCAS

This paper describes the uses that are made of the term "inquiry" in the science education literature, examines the way "inquiry teaching" is used in biology courses, looks at the research on "inquiry teaching" and finally discusses Invitations to Inquiry in relation to these studies.

WHAT IS "INQUIRY"?

Arnold Grobman, (12) who served as director of the Biological Sciences Curriculum Study (B.S.C.S.) from 1959 until 1965, defines "inquiry" as "the processes of science which constitute the key to its success. It consists of the techniques of asking questions of nature and of evaluating the replies," (p. 291). But this is not the only use of the term. Rutherford (21) points out that it is necessary to make a distinction between "inquiry as it appears in the scientific enterprise" and "using the method of scientific inquiry to learn some science."

Most of the "new curricula" in science have used inquiry in the first of Rutherford's senses. In some courses students are expected to

> "inquire into inquiry", since by doing this the learner becomes aware of what he knows, how he knows it and how to go about acquiring new knowledge for himself. In

effect, inquiry training shifts the learner from a consumer of knowledge toward being a producer-consumer (9).

Schwab (23), in his introduction to the Invitations to Equiry published by the BSCS, makes it clear that his purpose in teaching science as inquiry is not to "learn some content" but to "understand enquiry". That is

> to teach science as enquiry means, firstly, to show students how knowledge arises from the interpretation of data. It means, second, to show students that the interpretation of data - indeed, even the search for data - proceeds on the basis of concepts and assumptions that change as our knowledge grows. It means, third, to show students that because these principles and concepts change, knowledge changes too. It means, fourth, to show students that, though knowledge changes it changes for good reason - because we know better and know more than we knew before (p. 46).

But it is important to realise that some very important assumptions underlie the current emphasis on "inquiry as it appears in scientific work". Firstly, it is tacitly assumed that all scientists within a given field will use the same methods of designing experiments; secondly, it is assumed that there is only one logical model of inquiry for all branches of science. These are probably not valid assumptions: Connelly (5) has analysed research reports in ecology and identified at least eighteen patterns of inquiry that are used. "A pattern of enquiry is a process in which principles of enquiry are specified to problem areas giving rise to a set of logical conditions for enquiry" (6). Connelly (5) identifies four principles common to all biology (antecedent-consequent, structure-function, homeostatis and regulation) and five problem areas in ecology (classification and taxonomy, nutrition and metabolism, genecology and distribution) giving twenty possible patterns of inquiry. However, no research papers were found in the categories homeostatis - classification and taxonomy and regulation - classification and taxonomy. He points out (5, 6) that statements resulting from work using each of the patterns of inquiry are not equivalent in logical status.

Similarly, when the implied account of the nature of scientific inquiry in the CBA, CHEM Study and PSSC texts is analysed in terms of the inquiry systems used in the disciplines it is found that

> none of these programmes illustrates the variety of principles of inquiry and the effects of choice of such principles on the furtherance of inquiry. PSSC also misrepresents the character of the body of physical knowledge (8).

A review by Robinson (20) gives a more detailed account of the philosophical analyses of the modes of inquiry used in science and their implications for science teaching.

If these authors are correct, a science curriculum which attempts to show students how science is conducted will fail if only one "method of science" is considered in the course. Newton also claims that the inquiry approach to teaching is dishonest to the nature of science since it gives the impression that "science is just a way of attacking problems or a method of understanding the world", and neglects the fact that science is also an "enormous, impressive, and extremely useful collection of facts principles and concepts which, because of the way it brings order to the world is both intellectually satisfying and practically useful." (17)

However, Newton is probably knocking down a straw-man in this criticism: few, if any, of the new curricula set out to teach philosophy or process of science alone, and they all teach at least some of the facts, principles and concepts of science. Even in one of the purest forms of inquiry learning, Suchman's "inquiry training" technique, the pupil is expected to form concepts (3).

"INQUIRY" IN BIOLOGY TEACHING.

In common with the other "new" science courses the Biology courses developed by the BSCS emphasise laboratory work so that students will have the opportunity to undertake inquiry in a facscimile of a research situation. One major innovation, the Invitations to Inquiry were prepared for use in biology, and published by the BSCS in the Biology Teacher's Handbook. (23)

> An invitation is essentially a semi-structured discussion based upon a biological problem. It consists of a series of questions to be posed by the teacher and suggests to him a variety of responses to be elicited and expected from the students. ... The goal is to develop skill in

probing or searching as a cough intellectual game. (12, p. 291)

Schwab (23) claims that

> The invitation to Eqnuiry teaches enquiry in two ways. First, it poses example after example of the process itself. Second it <u>engages the participation</u> of the student in the process. Thus for the less able student there is one channel toward understanding - the Invitations as examples of enquiry. For the more able student there are two channels - the Invitations as examples of enquiry and his <u>own</u> contributions toward solving the problem each one poses, (p. 47, Schwab's emphasis).

Morgan <u>et al.</u> (16) have prepared <u>Invitations to Inquiry</u> that are integrated into the Australian adaptation of the BSCS materials. Their <u>Invitations</u> differ from Schwab's in the way in which they are designed as an integral, but not completely essential, part of a particular course: Schwab claims his <u>Invitations</u> are "freed from dependence on the particular text book the teacher may be using", (23, p. 48)

Hurry and MacKean (13) have produced <u>Enquiries in Biology</u> which was inspired by Schwab's work, but their <u>Enquiries</u> are presented in a format that allows students to have individual copies of the relevant information. (Schwab's format, although designed to be read out to a class, can be adapted in this way, and many teachers in Australia duplicate the relevant portion of the Australian <u>Invitations</u> and hand it out to students.)

RESEARCH ON "INQUIRY TEACHING".

An examination of the current research literature unfortunately bears out Brandwein's comment that

> there is little or no valid evidence that instruction and practise in the art of investigation in the elementary or high school years produces better students, better scientists, or better learners. ... Most practitioners in teaching merely assume that school science would be improved if students learned through investigation, (2).

One of the problems in assessing the literature is the conflicting terminology used by different curriculum development groups. The terms "creativity", "discovery" and "inquiry", for example, are used by different authors to describe essentially the same teaching techniques (Lucas, unpublished manuscript). Brandwein believes that this is due to changes in terms which are in vogue: "too often, in education we go from word to word, rather than from work to work", (2).

This survey is mainly concerned with reports claiming to deal with "inquiry"; some reports of research on "discovery learning" and "understanding the scientific enterprise" are included, but no special search has been made for such reports.

Ryan has shown that elementary school teachers can be trained to use an inquiry technique in the classroom by a short inservice training course. Judging by analyses of the teacher's classroom behaviour after the course, the most effective method of inservice training is to focus on the <u>teacher's behaviour</u>, rather than on the <u>materials</u>, to be used in classrooms following inquiry methods.

A number of reports claim that pupils could be taught to understand and/or use some inquiry techniques after "inquiry training." Barker, in an uncontrolled study, was able to train students to generate hypotheses by viewing single topic films in chemistry, (1). Gibbs, in a controlled experiment, showed that using the inquiry technique outlined in Teachers Guides to BSCS single topic films improved the quality of hypotheses produced by viewers, (11). In an uncontrolled study using interview results as criteria, elementary school students were given "a basis for analysing social situations and a strategy for inquiry" when inquiry methods were used in sociology, (10). Ramsey and Howe (18) report that Price could not detect any transfer of "manipulative data gathering activities" to a test situation outside the classroom. In the same review (18), Raun is reported as showing that there were no consistent changes in "inquiry strategies" from grade-to-grade in students using the American Association for the Advancement of Science course Science - A process approach; however, Ramsey and Howe also report studies by Scott and Sigel that indicate that "inquiry trained pupils" learn physical science concepts as well as or better, than normal classes. Thomas and Snider taught eight-graders by two techniques: "teacher centred exposition" and "guided discovery". They found that the more able students taught by the traditional approach were better able to learn the c ontent of the course (i.e. "had greater factual conceptual achievement") whereas the discovery group developed better inquiry skills, (24).

Studies of inquiry learning in non-science subjects are also reported in the recent literature. Collins in a controlled experiment with an accelerated geometry class used discovery methods to teach the students to solve problems in logic. One group was confronted with a problem in logic in which the conclusion drawn from an argument strongly challenged the pupils' values. The control group, who were presented with problems of the same logical type which did not challenge their values, were just as competent in their ability to "state the heuristics of the problems" given as a post-test, but the strong confrontation group were significantly better in solving the problems in logic used in the post-test, (4).

The "inquiry-discovery" group was not significantly different from a more conventionally taught class in Milgram's study of Jewish elementary school children being tuahgt the concepts of evil, (15).

In the only study of the use of Schwab's Invitations to Enquiry reported in Education Index in the past four years, Meyer could find no difference in "understanding of science", "critical thinking ability"and "biology knowledge" (using the Test on Understanding Science, the Watson-Glaser Critical Thinking Appraisal and the BSCS Comprehensive Final respectively) between one of his classes taught in the same way with the addition of one weekly session using Schwab's Invitations. However no effort was made to integrate the Invitations with the appropriate topics and the tests did not measure the ability to manipulate quantitative data, a skill dealt with in the Invitations, (14).

In other studies using TOUS it has been shown that a) the CBA and CHEM Study courses produce greater understanding of science than conventional chemistry courses (Troxel); b) History of Science Courses can have a similar effect (Oliver); c)PSSC may produce greater gains in understanding science than traditional physics courses (Crumb) although Trent could not find any differences in his study comparing Physics courses (19). However, studies using TOUS may not be valid tests of students' understanding of the methods of scientists if there are, in fact, diverse patterns of inquiry in the different scientific disciplines, (7).

USEFULNESS OF "INVITATIONS TO INQUIRY".

Since there is no consistent evidence that inquiry methods produce an understanding of the inquiry process, give the student the ability to inquire, or help him learn the concepts of the subect, is there any justification of continuing to use *Invitations?* They *are* used in South Australian schools, and most of the *Invitations* prepared for the *Web of Life* course, (16) were rated as very useful by more than thirty percent of the 71 teachers who replied to a questionnaire distributed to all Biology teachers in the State at the end of 1969 (Lucas, unpublished data). Only six of the Invitations were rated as of no use by more than two teachers. The comment that "*Invitation* discussions appear to be more lively than simple problem discussions" may account for part of this acceptance of *Invitations*: students may appear to learn more.

Much more experimental work needs to be done before we can decide whether, and under what conditions, *Invitations to Inquiry* are a useful technique. But if Gennaro's and Yager and Wick's findings (18) that a "multidimensional" approach to Biology teaching produces greater understanding of the nature of science can be replicated, Invitations may form one useful "dimension" even if, in themselves, they have little effect.

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Young, D. D. "Enquiry: a critique" Science education, 52, 138 - 142, 1968.

The following book was not available until after this paper was written. It contains a short statement of the rationale of inquiry learning in biology, extensive examples of the use of guiding principles of inquiry, and discussions of the use of behavioural objectives to design evaluation instruments. In addition chapters refer to the use of classroom discussions for inquiring into inquiry. An extensive bibliography is included.

Bingman, R. M., (Ed.) Inquiry objectives in the teaching of biology. Mid Continental Regional Educational Laboratory. Position paper 1, 1, 1969.

SECTION V

WORKING GROUPS

Three separate working groups were established to discuss particular aspects of biological education in secondary schools. The reports of these groups were presented to the whole conference at the last session and the recommendations that they contain approved. The reports of the working groups on Evaluation, Materials and Methods and Content were prepared by Mr. H. D. Batten, Mr. L. T. Bamford and Mr. I. R. Mosel respectively.

EVALUATION OF THE AIMS

Some confusion surrounded the area to be investigated by this working group, however it was agreed that it would be most useful to review the various forms of evaluation applicable to the teaching of biology.

The term evaluation is applied by several sources to fit different situations. Two publications from the recent ASEP Guidelines Conference were found useful in exercising the mind in this regard. These publications available from the Chairman of each State Advisory Committee for the Australian Science Education Project are *Evaluation - Perspectives and Possibilities* and *The Kinds of Services and Evaluation Procedures that could be provided for in the Australian Science Education Project*.

Review of forms of Assessment.

1. Biology Readiness Materials.

   A set of these materials has already been prepared for the 'Web of Life' course and is available from A.C.E.R. Such materials take the form of multiple choice items, testing basic skills, ideas, and concepts, a grasp of which is considered desirable before students begin work on various sections of the course Associated with these items are remedial activities written in programmed form. (See Gardner, *J. Biol. Educ.* 3, 1969).

2. Mastery of terms

   These items were intended to measure a mastery or comprehension of a word or phrase in its appropriate context; generally at a

relatively simple level. e.g. consumer, energy.
A list of suitable words/phrases should be readily available from teachers involved in the subject. It was considered that these tests should not ordinarily be used for grading purposes. There may be some advantage in these materials being teacher-free, perhaps to be administered by the children themselves at home after reading the text etc.

3. Diagnostic Test Battery

Here again some test forms are soon to be available for the 'Web of Life' course. (Six tests for Part 1; nine for Part 11 - including an Achievement Test). They are multiple-choice in form and based specifically on materials just studied.

Generally diagnostic materials require an understanding of concepts and single propositions. Remedial aids are associated with these tests, and they include longer response items. There is a lack of these materials available for other courses and the construction of such materials was considered a fairly urgent task.

4. Achievement materials

(a) The use of this type of test material may well be applied to the evaluation of the course itself and may, in special circumstances, be used to identify individual student "gains" in all the behavioral skills in the cognitive area thought appropriate to biology students.

In regard to the "gains" made by the individual student it was thought possible to construct content free tests of aptitude in biological material, perhaps even from existent Commonwealth Secondary Scholarship Examination materials.

(b) The application of achievement type materials to obtain an absolute measure of a pupil's achievement was considered in two parts:

(i) In the external examination system, the group was firmly of the opinion that such tests conflict with the basic aims of biology teaching. A written examination can only test a limited number of aims and therefore is quite unsuitable as a single total measure of the course achievement. A further complication is introduced in Grade 12 when the instruments of evaluation are also used as instruments of selection for tertiary institutions. The splitting of these two functions is already under serious consideration.

(ii) Out of the external examination environment, the group divided on the need to retain these tests to achieve gradings or ranks. Some members considered achievement tests desirable for the benefit of students - giving incentive to improvement and partly fulfilling the educator's duty to parents. Others questioned these statements about "incentives", e.g. when a pupil is continuously below satisfactory levels of performance, and would prefer to establish a system of recording "gains" made by individuals.

Teachers of biology should be encouraged and instructed in the possibilities of forms of assessment other than formal written tests. Such items include multiple-choice materials, short-answer questions, essays, assignments, laboratory reports, individual or group laboratory projects, checklists for laboratory work and skills, and for discussions. These methods of assessment which indicate whether the student has coped with the total materials may be added together by weighing them in terms of the course objectives.

5. Affective domain

This domain relies mainly on subjective estimates made by the teacher and generally is included in the forms of assessment previously noted.

The group suggested that the development of suitable attitude scales should be encouraged.

Forms of Items

The group firmly recognized that course objectives can only be assessed when both multiple-choice and longer response questions are used.

In the longer response form, some members felt there was value even in knowledge type essays for assessing communication skills. Other group members argued strongly that the basic skill of communication can only be tested in analysis-synthesis type essays and that knowledge objectives, if applicable, are included in these forms. Assessment of knowledge in itself is probably more appropriate to multiple-choice em forms. The open-ended essay was considered useful in ranking;

however, it was recognised that the reliability of marking procedures of these materials needed careful investigation. There is now significant evidence concerning the values of multiple marking of such pieces of work. Further, two shorter pieces of communic_tion provide more reliable evidence of a child's skill in communication than does one longer essay.

Recommendations

The working group were firmly of the opinion that the whole aspect of evaluation of biology courses, 'Web of Life' and others, should now be considered carefully and a systematic and organized approach taken in regard to the development of appropriate materials.

It was recognized that the A.C.E.R. had administered a project to develop Diagnostic Test Materials which included contributions from Victoria, South Australia, Queensland, and Tasmania. This situation, it was felt, could be regarded as a model for future developments. The matter was felt to be urgent as course modifications were now being considered in several States.

This working group recommends to the Academy therefore, that an investigation be made of possible fund sources to establish a programme for the construction, trialling, and dissemination of evaluation materials appropriate both for whole courses and course parts.

MATERIALS AND METHODS

This group spent most of its time discussing the variety of materials that are useful for biology courses at the senior level of the secondary school. The discussion is reported under the headings used in the group.

1. Text Books.

In a rapidly growing discipline, school text books are rapidly out of date, with, in many cases, incorrect or inadequate explanations of phenomena being presented. Very few teachers have the opportunity to read the current scientific literature, and they are forced to rely on the students' and other texts to update their knowledge. The group supported Mr. Hutton's suggestion (see page 142) of a newsletter or leaflets being produced for pupils as well as for teachers. There was a strong feeling that such leaflets should be directly related to each particular text and should be the responsibility of the producers of the text.

2. Laboratory Manuals.

Laboratory manuals were felt to be useful, but it was thought that they should contain a large number of exercises. The teacher could then choose which exercises his clas will perform.

Many group members felt that instructions in laboratory manuals should, whenever possible, be given in a pictorial form. Whenever this is not possible, the group felt that the procedure is much clearer if set out in numbered steps.

In addition, it was felt that long term laboratory-centred exercises, similar to the B.S.C.S Laboratory Blocks, written for Australian students would be useful with the more able or repeating students.

The group felt that the supply of materials for use in the laboratory exercises was not a function of course designers.

3. Audio-visual aids.

It was brought to the attention of the group that many visual aids for senior biology courses are now becoming commercially available, at least for the Web of Life course. However, there is a demand for locally produced film loops to illustrate and help develop some of the concepts of Australian courses. The production and supply of such films should be investigated by course developers.

Some discussion was given to video-tape and electronic video recording, but it was pointed out when this report was made to the whole conference that the supply of 16mm colour movie film may be (almost) as cheap as and more effective than production and distribution of video tapes.

Tape recordings, or grammophone records stamped on paper, of scientists with something topical and relevant to say about some aspect of a course may be useful and it was felt that production of such materials should be investigated.

It may be possible to approach industry to produce and distribute wall charts relevant to a particular course. The charts produced by Esso Petroleum describing the geology and paleontology of the Bass Strait oil fields were mentioned as examples of the type of chart which could be useful.

Audio-tutorial systems (see Australian Science Teachers Journal, 16, part 1, 1970 for a discussion and description of the methods used in this technique) were described and the group felt that these techniques should be investigated in terms of providing individual instruction and as a remedial teaching device for slow learners.

4. The group felt that Invitations to Inquiry were a useful resource, but that they were more useful for some teachers than for others. A rigorous investigation of the worth of the present Invitations was suggested. It was suggested that the proposed leaflets (see 1, above) could form the basis of an open-ended discussion, if careful prepared questions were asked in the articles.

5. Professor Johnson's background paper was considered and the group felt that the involvement of the student in the work was the main advantage of using a discussion technique. This raises one major problem: questions which will involve an able student often do not suit a slow learner. The group felt that course designers should provide problems and questions graded in difficulty to cater for the differences in student ability.

6. Since field stations are felt to be a major asset in biology teaching, the group recommended that the Australian Academy of Science support the establishment of Field Study Centres throughout Australia. Similar support should be given for the establishment of outdoor laboratories for schools. In lending such support, the Academy should be asked to ensure that collecting of specimens in such centres is actively discouraged. It was suggested that ature Walks might be a suitable method of using such Field Study Centres.

CONTENT

The group discussing this subject felt that it would be more profitable to produce a list of conceptual themes which should be part of any school biology course rather than to agree on a long list to specific topics and examples which might be included in a course.

The conceptual themes that the group decided would form a framework upon which to build a course are listed below:

DIVERSITY

CONTINUITY

HOMEOSTASIS

EVOLUTION

INTERRELATIONSHIPS

CULTURE

ADAPTATION

The group meant "Homeostasis" to include cellular, physiological and ecological mechanisms that cause the systems to tend to equilibrium conditions; "Interrelationships" to refer to the interactions between different organisms of the same or different species, and between organisms and their abiotic environment; "Culture" to be a biologists view of human culture, man's culturalevolution, (including the development of language and tools) and his institutions and antifacts; and "Adaptation" was seen as those features of morphology, behavior and processes of organisms which fit them for life in their environment: such adaptations may be evolutionary or physiological.

It was made clear that since there is a considerable degree of overlap and interaction between these themes they should not be thought of as a list in order of priority or as themes to be treated sequentially in some other order, but as a framework upon which a course could be built. It was felt that the ideas of scientific process should permeate the whole content of the course.

There was much discussion of the treatment to be given to man's place in the biosphere in a school biology course. As Boyden points out (p.108) this is one of the interfaces of biology with other disciplines, and we can treat the role of man from the social scientists' or the biological scientists' viewpoint. The group agreed that important decisions by man are needed if some of the problems of the world are to be solved. There are biological principles and scientific methods of investigation which can be employed to solve those problems which are in the province of the biologist, and there is a whole range of human interactions, and interactions between man and the rest of the biosphere that require the social scientists special competencies for study. However, the dividing line between these two areas becomes blurred in such "problems" as exploitation and pollution of the environment, drug usage, population growth and the economics of food production.

There was strong agreement that such topics should be discussed in the school situation, but the group initially divided on the place of such studies in a Biology course. It was finally agreed, however, that the rhetoric used in discussion of these matters is ch that scientific attitudes and processes are often ignored or neglected when discussing such topics as "pollution". This term is an emotionally charged word; what man often does is change certain features of the biosphere. It was felt that Biology teachers would have the greatest effect in producing citizens aware of the way man has helped bring about conditions which may threaten his survival by retaining an objective, balanced view of the world, but at the same time arming their students with reliable, documented information about the effects of man's activities. When discussing the consequences of addition of DDT to the environment, for example, data on the mortality of insectivorous birds, and on the effect of cessation of DDT application on the incidence of malaria in Ceylon should both be given.

RECOMMENDATIONS

The recommendation made after each of the discussions have been collected here for reference. They have been stated briefly, and an explanation of them may be found in the appropriate discussion report.

The conference recommends that

1. The following broad objectives should form a framework within which courses and materials for biology teaching should be developed:

   (a) Biology courses at all secondary levels should be planned so that man's place in, and interaction with, the biosphere permeates the whole course.

   (b) All biology courses should show something of the processes and logic of science, not as a separate topic, but within the framework of the course content.

2. The following inter-related conceptual themes should form the framework of any biology course:

   (a) Diversity

   (b) Continuity

   (c) Homeostasis

   (d) Evolution

   (e) Interrelationships

   (f) Culture

   (g) Adaptation.

3. A programme for the construction, trialling and dissemination of evaluation materials appropriate for whole courses, and particular parts of courses should be established.

4. Producers of Biology textbooks should provide newsletters at regular intervals for students and teachers using their course to provide accurate, current explanations of topics treated in the texts.

5. "Laboratory Blocks" be written for Australian conditions.

6. Course developers investigate the production and supply of film-loops and audio-visual aids to illustrate and help develop concepts in the course.

7. Problems and questions graded in difficulty should be provided as part of biology courses.

8. The Australian Academy of Science support the establishment of Field Study Centres with the proviso that collection of specimens in such centres be actively discouraged.