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ABSTRACT

An experimental course covering some of the fundamental principles and terminology associated with environmental science and the application of these principles to various contemporary problems is summarized in this report. The course involved a series of lectures together with a program of specific seminar and discussion topics presented by the students, and a limited selection of field and laboratory exercises. Content dealt with the biosphere; energy flow on the earth and in the biosphere; biogeochemical cycles--carbon, oxygen, water, nitrogen, and mineral; general principles of ecology; general population studies; human population studies; basic principles of genetics--biochemical genetics, genetic variation, and natural selection and evolution; and conservation and pollution. Evaluations conducted during the course are reported in detail. These include analysis of affective objectives, cognitive objectives, and the total course. (BL)

ENVIRONMENTAL SCIENCE

AN EXPERIMENTAL PROGRAMME FOR PRIMARY TEACHERS

R.D.LINKE

ENVIRONMENTAL SCIENCE

AN EXPERIMENTAL PROGRAMME FOR PRIMARY TEACHERS

TOORAK TEACHER'S COLLEGE

DEPARTMENT OF SCIENCE

1971

This report was prepared by R.D. Linke in association with the Science Department Staff at Toorak Teachers College, Victoria. The course was conducted by K.A. Boundy, F.J. Hogan, R.D. Linke and J.C. Phillips, under the direction of E. Byrne. The cognitive evaluation test was prepared by I.E. Hawkins.

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INTRODUCTION

I OBJECTIVES This course was designed to develop an understanding of some of the most important problems of our current and continued existence, and through a general analysis of these problems, including food production and population control, environmental pollution and the exploitation of natural resources, to create an awareness and acceptance of the increasing influence of scientific research on matters of social concern, and thus to promote the recognition of both individual and public responsibility with respect to scientific development.

The theoretical course aimed to provide a common background in both knowledge and understanding of the basic principles and terminology associated with environmental science, and to assist in the application of these principles to various contemporary problems. Moreover the analysis of experimental reports by the students, both collectively and individually, and the preparation and presentation by each student of a comprehensive report or a single selected topic of particular personal interest, were intended to promote both rational and meaningful discussion on these important and often controversial issues.

A limited selection of field and laboratory exercises were included to develop the abilities of accurate and selective observation, and the manipulation of environmental variables in experimental situations, and through the analysis and interpretation of this experimental data, to emphasise the general importance of empirical research in environmental science. Moreover, in addition to the objectives above, and in part dependent on them, it was intended in this course to develop in each student a rationally based commitment to the principle of environmental conservation.

II PRACTICAL CONSIDERATIONS An important and obvious consideration in planning this course was the varied background of these students in secondary science. While many had studies matriculation biology, their experience in other areas of science was often limited to much more elementary courses, and some students had forgotten even these. Thus with no common basis of scientific knowledge and experience, it was necessary to devote a significant part of the course to developing this area in order to meet the objectives outlined above, in particular that of rational group discussion.

It is often contended that the more sophisticated levels of cognitive development can only be achieved by a deeper study in some relatively limited field. Unfortunately, due largely to practical considerations of time, numbers of students, and the availability of supervising staff, it was impractical to allow each student the benefits of a more detailed and sophisticated individual experimental project, though it was hoped that this deficit might be overcome in part by the individual preparation and presentation of a comprehensive and analytical report of research publications in a restricted area of common interest.

III GENERAL OUTLINE The course as a whole involved a series of lectures covering some of the fundamental principles associated with environmental science, intended to provide a common basis for the later analysis and discussion of important contemporary issues. Associated with this series of lectures was a programme of specific seminar and discussion topics, generally taken by one of the students and presented on the basis of a comprehensive report of relevant research. This programme was designed to follow the associated lecture series, so that most of the important principles involved in these discussion topics would be covered by every student before the particular seminar was presented.

It follows from these remarks that most of the seminar and discussion topics had to be placed in the latter part of the course where, as a consequence of this, at the focal point of the programme involving important comtemporary issues of both social and scientific significance, there was a shift in balance from predominance of formal lectures to one of student-directed discussion. Unfortunately, because of certain administrative difficulties, this sequence could not be invariably maintained, though in fact no serious practical difficulties arose.

In order to facilitate discussion and promote individual responsibility for literature research, the students were divided into groups of fourteen or less for the entire series of seminar topics. This enabled each student to select a different topic for presentation, and at the same time ensured that a wide range of topics was discussed in every group. In addition to this, an introductory reading list was supplied for each discussion topic, taken from some of the more popular scientific journals and research publications.

	Number of Lectures	Associated Lab/Field Exercises	Associated Seminar/
I THE BIOSPHERE	1		
II ENERGY FLOW			
(1) The Earth	1		1
(2) The Biosphere	1		4(a),(b)
III BIOGEOCHEMICAL CYCLES			
(1) The Carbon Cycle	1		
(2) The Oxygen Cycle	1		
(3) The Water Cycle	1		
(4) The Nitrogen Cycle	1		
(5) Mineral Cycles	1		
IV GENERAL PRINCIPLES OF ECOLOGY	3	I	2,5
V GENERAL POPULATION STUDIES	4	II,III	3
VI HUMAN POPULATION STUDIES	3		8
VII BASIC PRINCIPLES OF GENETICS			
(1) Biochemical Genetics	3		
(2) Genetic Variation	2		9
(3) Natural Selection & Evolution	2		11
VIII CONSERVATION AND POLLUTION	5	IV	5,6,7, 10,11,12 13.

THEORETICAL STUDIES

I THE BIOSPHERE

Definition and delineation. Description of physical features with reference to associated biological characteristics.

II ENERGY FLOW

(1) THE EARTH. Distribution of energy on the earth. Reflection and absorption of solar radiation by the atmosphere, land and ocean. Horizontal and/or vertical circulation of energy in the atmosphere, land and ocean, and interchange between these regions.

(2) THE BIOSPHERE. Fixation, storage and utilization of energy. Interconversion of different energy forms, their distribution in different types of ecosystem or environment, and circulation through the food chains (grazing and decay).

III BIOGEOCHEMICAL CYCLES

(1) THE CARBON CYCLE. Photosynthesis, respiration, and the circulation of organic compounds in the biosphere. Distribution and circulation of atmospheric carbon dioxide, with seasonal and annual fluctuations. Recent effects of fossil fuel combustion on the atmospheric concentration of carbon dioxide and associated particulate matter.

(2) THE OXYGEN CYCLE. The origin and current sources of oxygen. Respiration and oxygen transport at the organismic level. Possible effects of fossil fuel combustion, defoliation and various forms of pollution on the atmospheric concentration of oxygen and sources of production.

(3) THE WATER CYCLE. Distribution of water in various physical forms on the earth. General patterns of atmospheric and oceanic circulation. The role of water in photosynthesis and transpiration.

(4) THE NITROGEN CYCLE. Atmospheric, industrial and biological fixation of nitrogen. Nitrification and denitrification, nitrate assimilation and decay. Agricultural applications of nitrogen-fixing bacteria, and the problems associated with chemical fertilisation.

(5) MINERAL CYCLES. Relative distribution of minerals in the biosphere, lithosphere, hydrosphere and atmosphere. General carboxylation and soluble-element cycles. Distribution and circulation of phosphorus and sulphur.

IV GENERAL PRINCIPLES OF ECOLOGY

Definition and description of basic terms, including population, community, habitat, ecosystem and productivity. Food chains, food webs, and the interdependence of autotrophic and heterotrophic organisms. Physical factors (temperature, light, salinity, acidity, atmospheric and physiographic features) and biological interactions (plant/plant, plant/animal and animal/animal) which may affect the environment.

V GENERAL POPULATION STUDIES

Theoretical models for population growth. Factors affecting population growth, including physical factors (light, temperature, acidity, salinity and atmospheric conditions) and biological factors (plant/plant, plant/animal and animal/animal interactions, including parasitism and predation). Physiological responses to overcrowding. Natural and artificial methods of population control.

VI HUMAN POPULATION STUDIES

The human population explosion and factors affecting human population growth (including medical, agricultural and general technological advances, physiological, psychological and social influences). Physiological and psychological responses to overcrowding in human populations. Human reproduction and methods of population control, including contraception and abortion.

VII BASIC PRINCIPLES OF GENETICS

(1) BIOCHEMICAL GENETICS. Chromosome structure and function, including the composition and replication of DNA. Protein synthesis, and the role of RNA in transcription and translation. The significance and function of the triplet genetic code.

(2) GENETIC VARIATION. Various forms of chromosomal mutation, including deletion, addition, inversion and substitution mutations. Spontaneous and induced mutation, and the role of mutagenic agents, both physical (X-rays, α, β and γ -rays, U.V. radiation) and chemical (nitrous acid, allsylating agents and base analogues).

(3) NATURAL SELECTION AND EVOLUTION. Definitions and description. The effects of positive and negative selection on both dominant and necessive characteristics. The roles of polymorphism and polyploidy in evolution. Artificial selection in plant an animal breeding. Eugenics and theories of human race development.

VIII CONSERVATION AND POLLUTION.

A series of independent case studies of (a) environmental pollution, incorporating such topics as radiation and atomic waste, base metal accumulation (lead and mercury), biodegradation and detergents, and other areas of interest, including those covered in seminar topics, and (b) wildlife conservation, with particular reference to Australian species. Each of these case studies emphasises the necessity for empirical research.

PRACTICAL EXERCISES.

I ECOLOGICAL SURVEY OF AN INTERTIDAL ZONE. This field exercise involved a distribution study of several plant and animal species inhabiting the intertidal region of a marine shore platform. Each student selected a single species then, using a sampling technique appropriate to its size and abundance, counted the numbers in a constant unit of area at various predetermined intervals along a transect across the intertidal zone. The distribution thus obtained was then related to other influential features of the local environment.

II EFFECTS OF ENVIRONMENTAL FACTORS ON POPULATION GROWTH IN YEAST. This experiment involved a systematic study of the effects of variations in temperature, glucose level and aeration on population growth rate and maximum population levels in a cultured suspension of yeast. Each student was responsible for a single culture, with conditions chosen by the group to cover the number of controls necessary to examine independently each of the three variable parameters. Small samples were extracted at regular intervals from each culture, then fixed with formalin and later counted in a haemacytometer. The culture medium was maintained in each case at pH 4.5 to prevent bacterial and fungal growth.

III EFFECTS OF OVERCROWDING ON BIRTH RATE IN DROSOPHILA. This experiment was designed to examine the effects of increasing parental population density on the subsequent birth rate in drosophila. Each student performed duplicate experiments with a fixed number of male and female parents, these numbers being chosen by the group to cover a wide range of parental population density. A complete set of replicate experiments was then made to determine the effects of (a) removing the parents before the development of the next generation, and (b) using non-virgin females in the parental cultures. The amount of food and size of the containing vessel were the same in each of these experiments.

IV ENVIRONMENTAL SURVEY OF A LOCAL SYSTEM. This was an elementary field and laboratory exercise designed as an introduction to the basic principles of systematic observation, and their importance in environmental research. Samples were taken from various predetermined areas of the Yarra river, and on-site measurements made of temperature (air and water) and rate of flow. The samples

were then taken to the laboratory, where measurements were made of turbidity, salt content and total bacterial concentration. The results from each site were finally collected to form a more comprehensive report of this system.

SEMINAR/DISCUSSION TOPICS.

1 ENERGY PRODUCTION. Since most contemporary forms of domestic and industrial energy production involve some risk of environmental contamination, it is now becoming evident that unless the present rate of production subsides, or other sources of power are introduced, the increasing problem of pollution may eventually lead to disastrous consequences. With appropriate reference to experimental and statistical evidence, discuss the conflict between the need for power and the risk of pollution, then describe some practical method to overcome the contamination problem, and outline the difficulties associated with its implementation.

2 THE BALANCE OF NATURE. The "balance of nature", which refers to the stabilisation of populations within a natural community, depends on the establishment of an equilibrium between different levels of the food chain. When this balance is disturbed, either by man or some natural phenomenon, a population explosion often occurs, and may result in the eradication of subordinate species. Describe in detail one of these events and discuss, with reference to any available evidence, the probable reasons for the population explosion and how, if possible, to restabilise the community and restore the original equilibrium.

3 EFFECTS OF OVERCROWDING. It has been observed in many animals that certain physiological changes, termed "stress" responses in mammals, are often associated with overcrowding, and that these may be independent of the availability of food and other environmental factors. It is reasonable to suppose, therefore, that the recent population explosion may induce similar reactions in human societies. Outline and discuss the experimental evidence concerning these physiological reactions to overcrowding in animals, and comment on the implications for the human population.

4 HUMAN FOOD PRODUCTION. With the world populltion already at an alarming level, yet continuing in many areas to increase at an exponential rate, the problem of food supply has become one of the most important issues in comtemporary science. Current agricultural methods must therefore be improved, the productivity of cultivated areas increased, and new areas developed to supply the ever-increasing demand for food.

(A) The application of genetic principles to agricultural ... has greatly increased the potential productivity in many areas of primary industry. With particular reference to one or two examples, outline the underlying principles involved, discuss the method and problems of application, evaluate the effectiveness of the present programme, and comment on the prospective potential of this field

(B) Systematic utilisation and cultivation of ocean resources may stabilise or substantially improve the output of existing marine industries, and perhaps provide many new sources of basic materials for food production. Describe some of the recent innovations and experiments in this area, discuss their advantages and disadvantages, evaluate their current success, and comment on their prospective potential.

5 EXPLOITATION OF NATURAL COMMUNITIES. It has been argued on the basis of recent agricultural experience that prospective agriculturalists should give more serious consideration to the useful exploitation of well-established natural communities, with a view to reducing the risk of [illegible] degradation. With particular reference to one or two examples, discuss the possible agricultural applications of these principles, evaluate and compare their long-term effects with those of conventional methods, and comment on their potential for efficiency and general productivity.

6 WASTE PRODUCT ACCUMULATION. It is unfortunate, to say the least, that the unprecedented technological advancement of the twentieth century has involved such extensive utilisation of irreplaceable natural resources, resulting in an ever-increasing stockpile of waste products which are, in turn, responsible for many of the more serious problems of environmental pollution. With particular reference to one or two examples, discuss the scientific and social implications of waste product accumulation, then outline and evaluate the practical prospects of some method for overcoming these difficulties.

7 AUSTRALIAN WILDLIFE CONSERVATION. It has been estimated that more than thirty species of native Australian animals have been evadicated since European settlement, and that many others are now in danger of impending extinction. With particular reference to one or two examples, outline the history of, and discuss the probable reasons for, the recent population decline, then briefly present the case for conservation, describe some practical method

by which to achieve this goal, and discuss the technical, financial, or social problems which might be associated with your plan of action.

8 CONTRACEPTION. Assuming that there is a definite limit to the number of people who can be adequately maintained on the earth, it seems reasonable to suppose that some general measure of human population control must ultimately be enforced. While abortion is inefficient, and sterilisation often irreversible, contraception, though occasionally unreliable, is generally considered the most promising method of population control, and biochemical means the most practical and efficient method of contraception. Outline in detail one method of contraception, evaluate both its advantages and possible disadvantages, and discuss in brief the scientific and social implications of general implementation.

9 BIOLOGICAL EFFECTS OF ATOMIC RADIATION. The already extensive and increasing application of nuclear power may well affect the natural course of evolution, and ultimately cause a serious threat to human existence. It is often argued, therefore, that the use of nuclear reactors and atomic explosives should be completely prohibited, rather than subjected to dubious restrictions based on some arbitrary level of safety. With appropriate reference to experimental evidence, discuss the principal biological effects of atomic radiation, and the problems associated with the continuation of the industrial application of atomic energy.

10 EFFECTS OF PHENOXY HERBICIDES. Phenoxy compounds, including 2,4-D (2,4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) have been extensively used throughout the world as herbicides and defoliants, but it is now suspected that they may also have seriously detrimental effects on other organisms, and their application in some areas has therefore been recently restricted. Outline and discuss both the advantages and possible disadvantages of these compounds, evaluate the evidence for their current restriction, and discuss the likely consequences of this action.

11 EFFECTS OF DDT. DDT (Dichloro-diphenyl-trichloroethane) has probably been the most useful and widely used insecticide in recent agricultural history, yet the production and use of this compound have now been prohibited in many countries of the world, and its application in others severely restricted. Outline and discuss both the advantages and disadvantages of DDT as an agricultural insecticide, the reasons for, and likely consequences of, its current restrictions, and the future prospects of the search for possible substitutes.

12 OIL POLLUTION. Oil has recently become one of the most important and extensively used sources of power, but every feature of its complex preparation, including extraction, transportation, refinement and ultimate combustion, has been shown to present important problems of environmental contamination. Outline the general problem of oil pollution, then discuss in detail one aspect of this problem, evaluate the appropriate evidence, comment on the conflict between industrial advantage and environmental danger, and suggest some practical method to resolve this conflict of contamination.

13 DRUG ADDICTION. Drug addiction is one of the most important social and scientific problems of modern society, since the use of drugs is generally initiated by choice, but then perpetuated by force of habit, and may eventually lead to death. Contemporary methods of treatment for drug addiction are generally inefficient and often ineffective, partly due to lack of understanding of the complex biological activity of these compounds. Describe in detail what is known of the physiological activity of one of these drugs, then discuss, with appropriate reference to experimental evidence, the current problems of prevention and cure, and comment on the future prospects for present research.

EVALUATION OF AFFECTIVE OBJECTIVES.

The following questionnaire was devised to determine whether the attitudes of students toward the general issues of environmental conservation (E), the social significance of science (A), and the need for empirical research (C) could be reliably assessed by their response to a number of statements thought to be related to each of these areas, and if so, whether any differences in attitude exist between various groups of students. The questionnaire contains three groups, each having ten statements expressing different aspects of a common affective area. Half of the statements in each group are considered to be favourable to the attitude in question, and are therefore scored from one to five (positive direction) with the highest score being allotted for strong agreement. The other statements are considered unfavourable, and marked in the opposite (negative) direction. (Table 1) All of the statement forms and groups are randomly distributed throughout the questionnaire.

ENVIRONMENTAL SCIENCE RESEARCH PROJECT

DIRECTIONS.

The purpose of this project is to determine your opinion about a number of statements related to various aspects of environmental science. Read each statement carefully, then indicate your response as quickly as possible by placing a mark (X) in the appropriate position on the answer sheet, according to the key below. If you change your mind about an answer, just cross out your original response and mark another position. This is not a test or examination, but rather a statement of personal opinion. Please give an answer to every statement, but do not write on this questionnaire.

KEY:

SD - STRONGLY DISAGREE

D - DISAGREE

N - NOT SURE

A - AGREE

SA - STRONGLY AGREE

1. The professional training and specialised knowledge of a scientist does not give him any particular place in general community or political affairs.

2. Expert scientific opinion should not be subject to public scrutiny.

3. It is the responsibility of the manufacturer, rather than the public, to prove that his products pose no threat of environmental pollution.

4. Despite the general desirability of wildlife conservation, it is probably unwarranted in the case of many dangerous species, including some spiders and snakes, even though they may be near extinction.

5. Some study in science should be an essential part of every educated person's experience.

6. No useful social purpose can be achieved by public discussion on matters of a scientific nature.

7. Ecological research can be of little value in directing decisions on environmental issues.

8. The general public should play a major part in determining the priorities of scientific research.

9. Decisions about environmental conservation should be determined by consideration of their immediate importance to man.

10. Aesthetic considerations should not interfere with the development and utilisation of natural resources.

11. There is a need for greater public participation in decisions about environmental conservation.

12. Science is the responsibility solely of scientists, and thus the general public need take no responsibility for its misuse.

13. To increase our understanding of the natural environment should be an important objective of the school curriculum.

14. Industrial research organisations should give at least the same priority to waste product disposal as to other areas of technological development.

15. Specific case studies of environmental pollution and wildlife eradication are the only basis for rational generalisation.

16. Economic considerations should be of less importance in decisions about environmental conservation.

17. The perpetuation of human existence is now completely dependent on conservation of the natural environment.

18. It is an inevitable consequence of any progressive civilisation that some wildlife species will eventually become extinct.

19. Ignorance of technical terminology is no excuse for public inactivity on matters of pollution and conservation.

20. An increase in public interest could prevent the irresponsible application of scientific research from destroying the human race.

21. Now that the immediate threat of environmental pollution is obvious, no further time should be wasted on basic research.

22. It is impossible even to guess the consequences of environmental action until the event has actually occurred.

23. Wildlife extinction is not a recent problem, and since it has never been a serious threat to human existence, there is little cause for concern.

24. The application of scientific research is a matter for industrial organisations, who employ people for this purpose, rather than a matter for public concern.

25. It is impossible to evaluate any environmental situation through observation alone.

26. Environmental conservationists often cause unnecessary hindrance to industrial progress.

27. The government has no right to enforce on individual property owners a policy of environmental conservation.

28. Since it is impossible to account for all the complex interactions of environmental variables, there is really no predictive value in ecological research.

29. There is little point in drug research, since the scientists working in this field are often too greatly influenced by community pressures.

30. The environmental effects of all major industrial undertakings must be constantly reviewed.

TABLE 1

STATEMENT CLASSIFICATION KEY

STATEMENT NUMBER	GROUP	FORM	STATEMENT NUMBER	GROUP	FORM
1	A	N	16	B	F
2	A	N	17	B	F
3	C	F	18	B	N
4	B	N	19	A	F
5	A	F	20	A	F
6	A	N	21	C	N
7	C	N	22	C	N
8	A	F	23	B	N
9	B	N	24	A	N
10	B	N	25	C	F
11	A	F	26	B	N
12	A	N	27	B	F
13	B	F	28	C	N
14	C	F	29	C	N
15	C	F	30	C	F

NOTES ON STATEMENT CLASSIFICATION

The statements in Group A refer to an awareness of the social significance of science, including public interest and participation in areas of common concern, and the social responsibilities of both scientists and non-scientists alike. Group B is concerned with a general commitment to the principle of environmental conservation, and involves political, aesthetic and economic considerations. Group C refers to the necessity for empirical research in environmental science, and to the allocation of responsibility for this research.

FORM indicates whether the statement is considered to be favourable (F) or unfavourable (N) to the attitude or group in question. The responses are therefore marked according to the key below.

FORM	RESPONSE SD	D	N	A	SA
F	1	2	3	4	5
N	5	4	3	2	1

TABLE 2

GROUP ANALYSIS

STUDENT GROUP	NUMBER	STATE UNIT GROUP A MEAN	SD	B MEAN	SD	C MEAN	SD
1A	61	40.0	3.43	35.3	3.49	39.2	3.09
B	31	38.2	3.61	34.0	4.05	39.4	3.25
2A	18	41.0	3.11	34.9	3.87	41.2	1.95
B	55	39.9	4.17	35.3	4.07	39.9	3.08
3	27	42.2	3.86	34.9	3.83	40.6	3.16
TOTAL	234	40.2	3.88	35.1	3.78	39.8	3.15

NOTES ON GROUP ANALYSIS

Student group 1A includes all first year students currently doing Science I and intending to continue with Science II in one of their subsequent years, while group IB contains those not intending to continue with Science II. Groups 2A and 2B involve corresponding divisions among second year students currently doing Science I. Group 3 includes all second year students, both diploma and certificate streams, currently doing Science II (Environmental Science), and group 4 comprises third year (diploma) [illegible] students now doing Science II.

TABLE 3

STATEMENT ANALYSIS - GROUP A

NUMBER	FORM	PERCENT POPULARITY	EDWARDS T-SCORE	PROBABILITY
1	M	87.2	7.09	0.0001
2	M	84.2	6.10	0.0001
5	F	92.7	6.11	0.0001
6	M	96.2	6.86	0.0001
8	F	36.3	6.30	0.0001
11	F	86.8	4.52	0.0001
12	M	94.9	6.22	0.0001
19	F	94.0	6.24	0.0001
20	F	60.3	7.33	0.0001
24	M	82.1	8.10	0.0001

RESPONSE FREQUENCY DISTRIBUTION

NUMBER	SD	D	NS	A	SA
1	80	124	8	20	2
2	67	130	13	20	4
5	3	8	6	105	112
6	102	123	5	2	2
8	6	90	53	67	18
11	4	9	18	130	73
12	111	111	5	5	2
19	4	6	4	120	100
20	9	37	47	96	45
24	59	133	19	20	3

TOTAL NUMBER = 234

MEAN = 40.2

STANDARD DEVIATION = 3.88

SPLIT-HALVES RELAIBILITY = 0.617

TABLE 4

STATEMENT ANALYSIS - GROUP B

NUMBER	FORM	PERCENT POPULARITY	EDWARDS T-SCORE	PROBABILITY
4	M	79.1	5.66	0.0001
9	M	56.8	8.42	0.0001
10	M	76.5	5.81	0.0001
13	F	97.0	3.47	0.0010
16	F	59.8	5.71	0.0001
17	F	50.4	7.07	0.0001
18	M	30.3	7.47	0.0001
23	M	94.0	4.05	0.0001
26	M	66.7	8.02	0.0001
27	F	11.5	-0.20	

RESPONSE FREQUENCY DISTRIBUTION

NUMBER	SD	D	NS	A	SA
4	96	89	16	16	1
9	33	100	18	61	22
10	61	113	26	20	9
13	2	3	2	79	148
16	5	58	31	117	23
17	9	70	37	86	32
18	11	60	24	117	22
23	101	119	5	5	4
26	45	111	49	28	1
27	73	119	15	21	6

TOTAL NUMBER = 234

MEAN = 35.1

STANDARD DEVIATION = 3.78

SPLIT-HALVES RELIABILITY = 0.253

TABLE 5

STATEMENT ANALYSIS - GROUP C

NUMBER	FORM	PERCENT POPULARITY	EDWARDS T-SCORE	PROBABILITY
3	F	81.6	5.18	0.0001
7	N	91.0	4.60	0.0001
14	F	94.0	3.53	0.0010
15	F	26.9	2.46	0.0100
21	N	70.1	6.42	0.0001
22	N	85.9	6.22	0.0001
25	F	59.8	4.11	0.0001
28	N	88.5	6.75	0.0001
29	N	96.6	5.46	0.0001
30	F	96.2	5.95	0.0001

RESPONSE FREQUENCY DISTRIBUTION

NUMBER	SD	D	NS	A	SA
3	8	29	6	100	91
7	122	91	17	2	2
14	5	5	4	91	129
15	17	79	75	56	7
21	47	117	12	24	34
22	65	136	17	16	0
25	4	65	25	127	13
28	58	149	22	5	0
29	127	99	7	0	1
30	6	2	1	61	164

TOTAL NUMBER = 234

MEAN = 39.8

STANDARD DEVIATION = 3.15

SPLIT-HALVES RELIABILITY = 0.126

NOTES ON STATEMENT ANALYSIS.

The popularity of a positive or favourable statement is calculated as the percentage of students who express some form of agreement with that statement, and for negative or unfavourable statements as the percentage of students expressing some form of disagreement. Thus very high and very low levels of popularity are indicative of poor discrimination.

Edwards' t-score* is a measure of the discriminating power of any particular statement, and is calculated as the difference in mean scores obtained on that statement between the upper 27% and lower 27% of students determined on the basis of their scores for the whole attitude scale. Thus a high t-score value indicates an effective contribution by the statement in measuring the common underlying attitude continuum, and a low value may indicate either ambiguity or the measurement of an attitude unrelated to that expressed in other statements. A value of t = 1.75 is often accepted as a minimal lower limit.

The split-halves reliability is determined by the correlation between a students' scores on the odd and even-numbered questions respectively within a particular group. This measure tends to underestimate the actual test reliability, and may be adjusted by using the Spearmom-Brown correction below.

Reliability = $\frac{2Rs}{1+Rs}$ where Rs = Split-halves reliability.

* EDWARDS, A.L. Techniques of Attitude Scale Construction Appleton-Century Crofts, N.Y., 1957.

EVALUATION OF COGNITIVE OBJECTIVES

The following test was designed to evaluate several levels of cognitive processes, including knowledge, comprehension, application and analysis, with respect to various areas of course content, involving basic terminology and ecological principles, experimental data, practical procedures and scientific reports (table 8). Half of the questions are concerned only with knowledge, and progressively fewer items are devoted to the higher cognitive processes. These items are not arranged in random order, and most of the questions pertaining to higher levels of ability are placed in the latter part of the test.

SCIENCE PART II - COURSE EVALUATION TEST - 1971

INSTRUCTIONS TO CANDIDATES

This test consists of 30 items, half of which test knowledge of terminology, principles and experimental procedure, while the rest test your understanding and ability to apply scientific principles or experimental procedure.

Answering:

Indicate your answer by printing the appropriate letter (A, B, C, etc.) in the brackets provided on your answer sheet.

If you think you know an answer, give it even if you are not certain that you are correct.

1. Oxygen evolved during photosynthesis is produced -

   A as a by-product of respiration

   B from water in the leaves

   C by breakdown of carbohydrate

   D from chlorophyll in the leaves

   E by decomposition of the air

2. The environmental factors which influence the distribution of intertidal organisms include -

   A abundance of phytoplankton

   B clarity of the water

   C prevailing atmospheric conditions

   D the number of sea birds

   E all of the above

3. Which of the following are characteristically found in natural communities?

   A interdependent populations

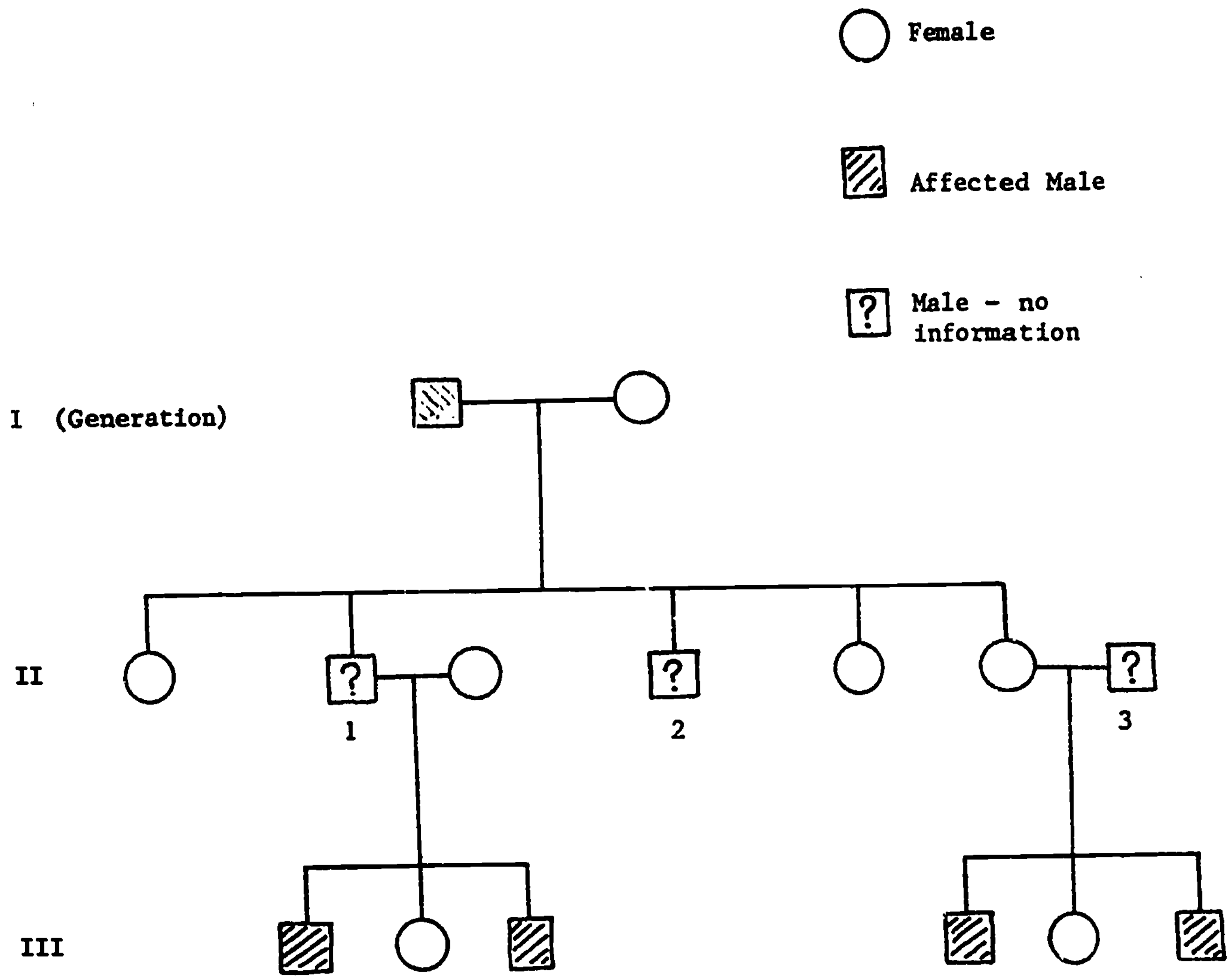
   B both producers and consumers

   C autotrophic organisms

   D more than one species

   E all of the above

4. The following figure represents a pedigree for a rare type of baldness in men, resulting from a dominant gene. No information is available to indicate which men were affected in the second generation.



Which of the men in the second generation is (are) almost certainly affected?

A 1 only

B 1, 2 and 3

C 2 only

D 1 and 2

E 3 only

5. Which of the following is evidence that D.N.A. is the molecule which controls heredity?

A D.N.A. can be seen in a microscope to have a coiled structure

B D.N.A. is the only large molecule in the nucleus of a cell

C Deoxyribose sugar and phosphate molecules are known to alternate along the length of the coiled D.N.A. strand

D D.N.A. taken from a virus can change harmless pneumonia bacteria into an infective form

E The microscope reveals that there is a molecular code along the D.N.A. molecule

6. Evolution can <u>best</u> be described as -

A the survival of the fittest in a population

B the survival of the more advanced organisms

C the process of natural selection

D the change of gene frequency in a population

E the inheritance of acquired characteristics

7. It is suggested that a man possesses a recessive gene for dwarfism. If this is so, then we can infer that -

A at least one of his parents was a dwarf

B at least half his children would be dwarfs

C at least half his sperm would carry the trait

D he would pass his dwarfism trait to half his sons

E if he marries a dwarf, all his children will also be dwarfs

8. A local newspaper reported that it was dangerous to eat mussels from a pier near the mouth of a polluted stream, and so a scientist was appointed to investigate the matter. Which of the following would be the best initial procedure for the scientist to follow?

A Examine any local people, known to have eaten the mussels, for symptoms of poisoning

B Take daily samples of stream water and determine the concentration of pollutants in the stream

C Take regular bacterial counts along the length of the stream and along the shoreline

D Sample the mussel population and test them for the presence of harmful pollutants

E Advise the council to instal water treatment plants near the mouth of the stream

9. We would expect that the total weight of organisms in each of 4 trophic levels of an ecosystem would be related in which of the following ways?

A $P < C_1 < C_2 < C_3$ P = producer

B $P > C_1 > C_2 > C_3$ C_1 = consumer level 1

C $P = C_1 = C_2 = C_3$ C_2 = consumer level 2

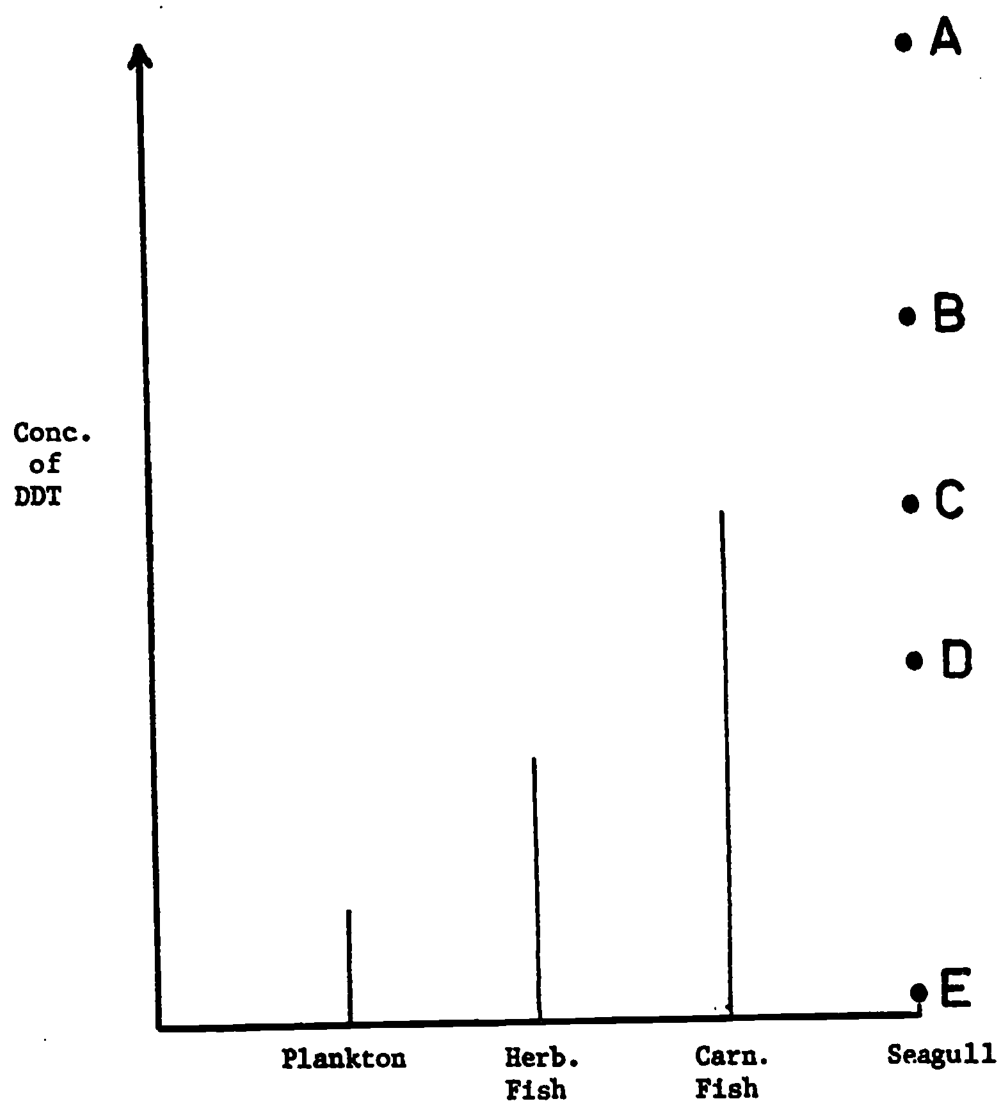
D $P = C_1 > C_2 = C_3$ C_3 = consumer level 3

E $P < C_1 = C_2 > C_3$

10. A scientist investigated the average content of DDT in the organisms of the following food chain.

Planktonic plant herbivorous fish carnivorous fish seagulls.

The following bar graph shows the concentration obtained for the first 3 types of organisms. All 4 organisms had less than the lethal concentration of DDT.



Which letter (A, B, C, etc.) represents the <u>most likely</u> height of the bar, indicating the concentration of DDT in seagulls?

11. A population of spiders in the Himalayas is thought to be indiginous to the highest territory inhabited by any animal. Spiders are carnivorous; therefore this particular population is most likely to obtain food by --

A moving down to lower altitudes each day

B eating each other

C eating insects blown up the mountains by the winds

D adapting to eating plants

E manufacturing organic material from inorganic substances

12. If we make precise quantitative measurements in a laboratory ecosystem, we would find that one essential resource requires constant replacement. Which of the following would this be?

A free energy

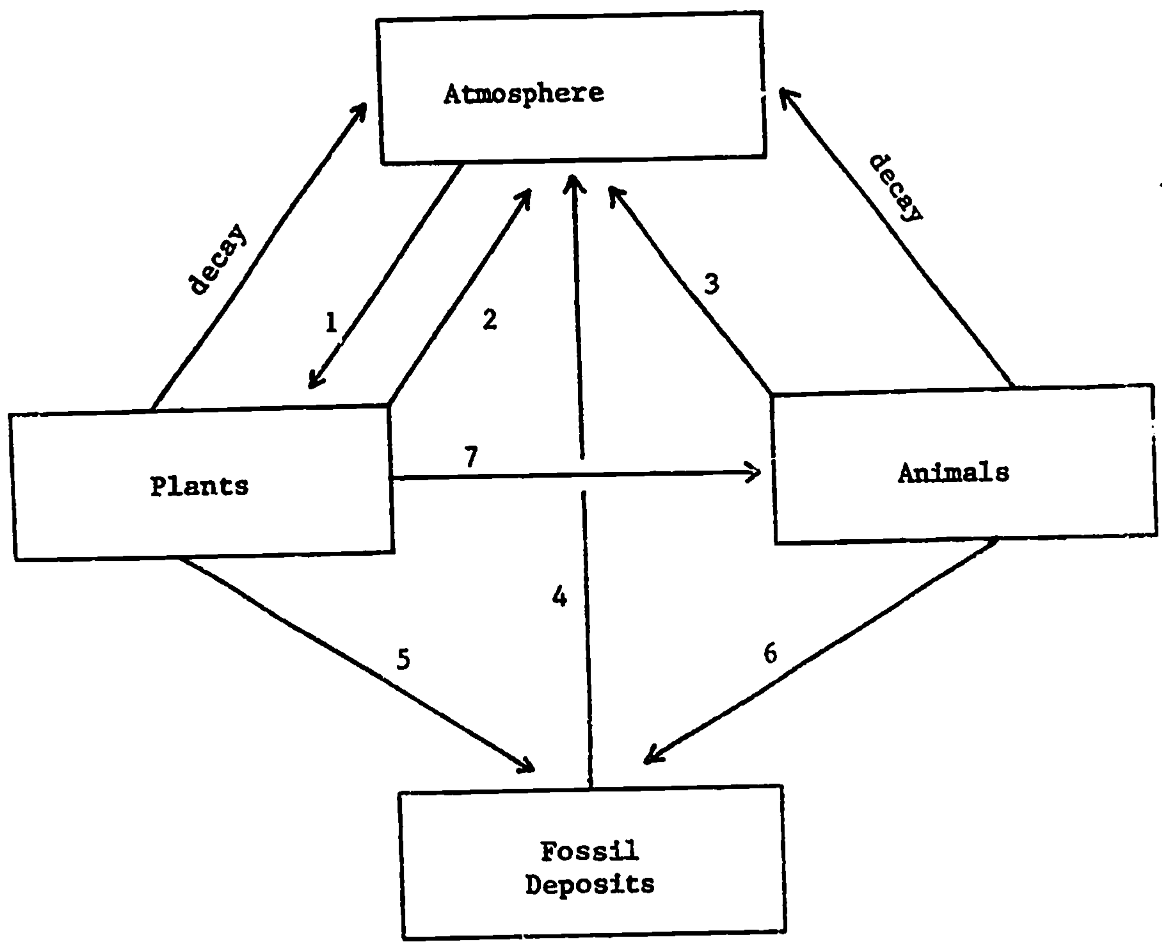
B free oxygen

C potassium in the form of phosphate

D carbon in the form of carbon dioxide

E nitrogen in the form of nitrates

Questions 13, 14 and 15 refer to the figure below which represents a simplified diagram of the carbon cycle in nature.



13. Which arrows apart from those for decay represent processes by which carbon is combined with oxygen to make carbon dioxide?

    A 1, 2 and 3

    B 5 and 6

    C 2, 3 and 4

    D 1, 7 and 3

    E 3 and 4

14. Which arrows represent processes by which pure uncombined carbon is often formed?

A 1, 2 and 4

B 1, 2 and 3

C 3 and 4

D 1, 7 and 3

E 5 and 6

15. The first effect of a sudden blockage in the cycle at point 1 would be -

A a lowering of the percentage of oxygen in the atmosphere

B less plant decay

C a build-up of water vapour in the atmosphere

D a population explosion in animals

E stoppage at all other points in the cycle

16. A germ-free mouse is sealed in a sterile space capsule. The animal's food is a green alga grown in an open tank in which the animal's wastes are all deposited. Distilled water is placed in the tank, and can be obtained through a filter for drinking. The animal is unlikely to survive. Why?

A The alga will be unable to use nitrogen either from the air or the animal's wastes.

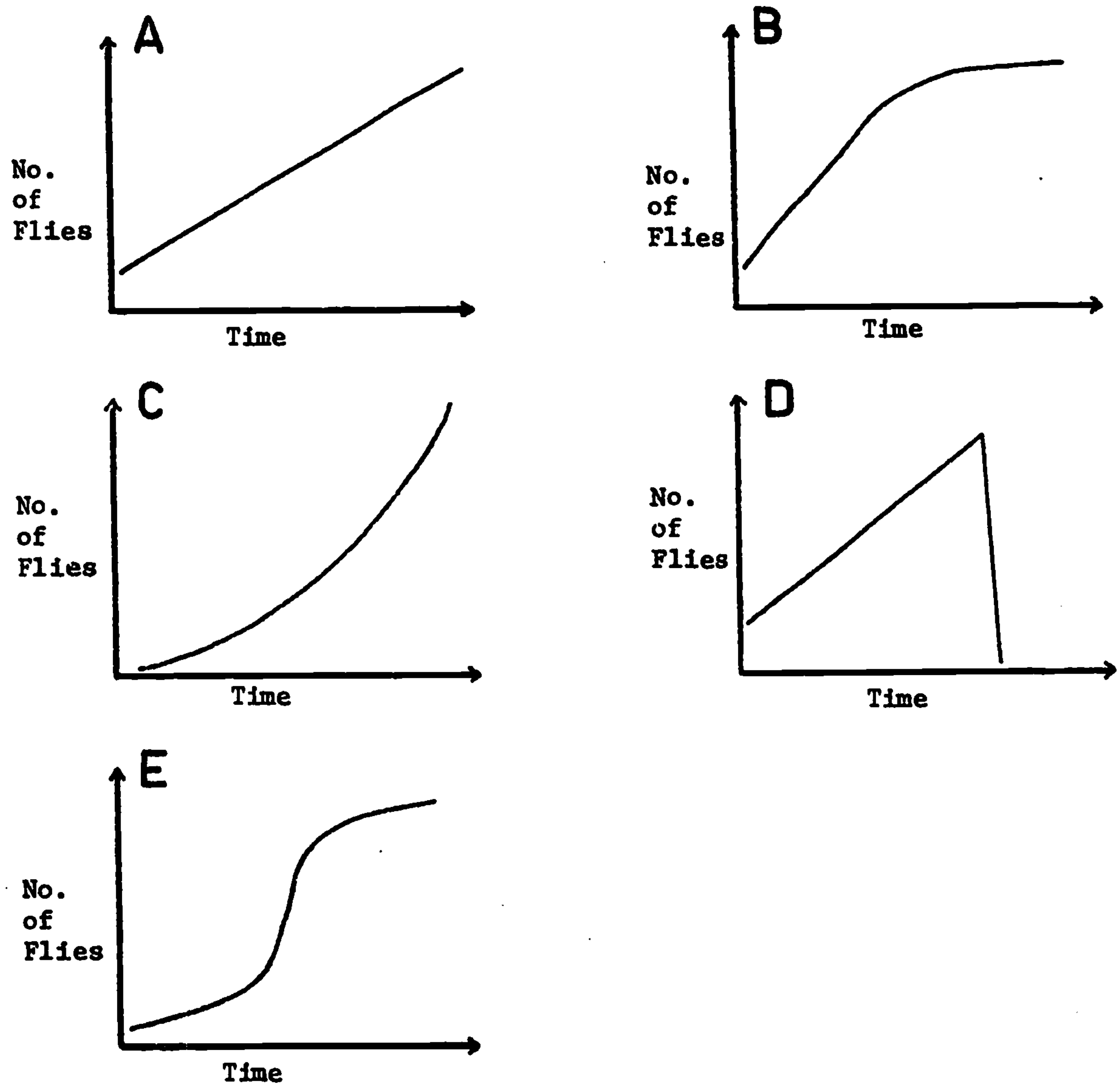
B The alga can supply carbohydrates, but not protein.

C Contaminated water from the tank will eventually cause disease.

D The oxygen supply will be depleted to the stage when the animal will suffocate

E Mice, like all organisms, belong to complex natural ecosystems and therefore cannot survive in such a simple and artificial one.

17. Which of the following graphs is likely to represent the growth of a population of fruit flies kept in a test tube for six months with ample food and ventilation?



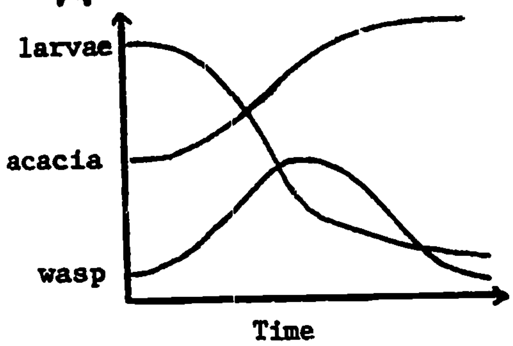
Questions 18 and 19 refer to the following data.

As an emergency measure, a parasitic wasp is introduced to control a plague of butterflies whose larvae feed on a population of acacia plants.

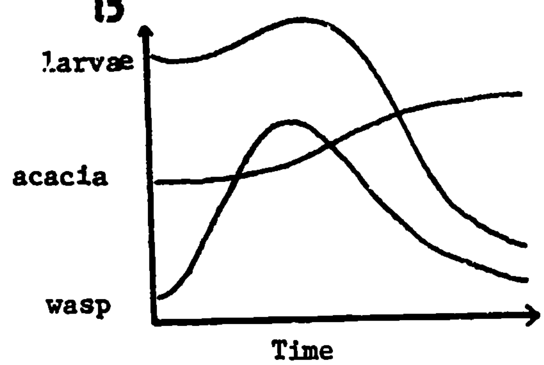
Assume that the wasp feeds only on the butterfly larvae and that the principal food of the larva is the acacia. The larvae are also eaten by birds.

18. If the wasp population became very large, which of the following graphs is likely to represent the change in numbers of the other organisms?

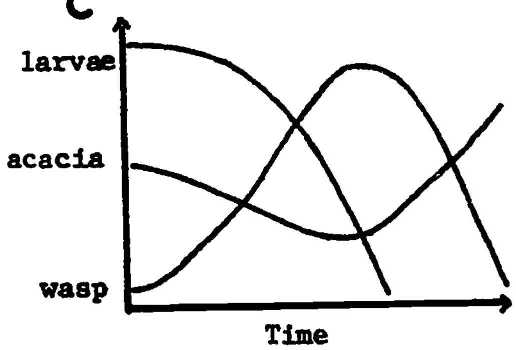
A



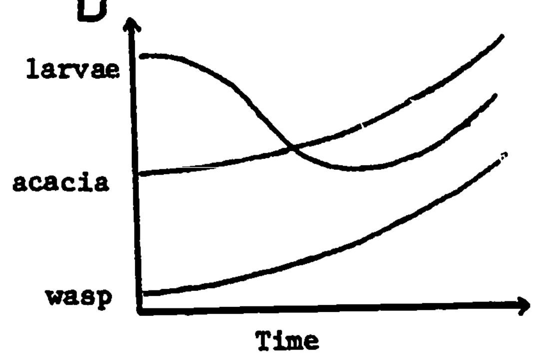
B



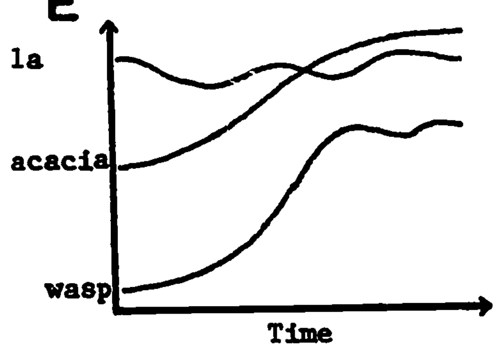
C



D



E



19. Before the wasp was introduced it would have been essential to initiate research into -

A the likely effect on birds in the region

B the rate of flow of energy in the food chain

C the rate of photosynthesis in the acacia population

D the economic value of the acacia population

E all of the above

20. Most houseflies have developed resistance to DDT. This fact could be explained in a set of propositions:

1. All houseflies compete with each other for the environmental necessities of existence.
2. The introduction of DDT produces a new selective factor into the environment.
3. More houseflies are produced than the environment can support.
4. Houseflies better adapted to DDT will survive and reproduce in greater numbers than those less well adapted.
5. There is wide variation among houseflies with respect to DDT resistance.
6. DDT resistance may be passed from generation to generation by hereditary factors.
7. DDT resistance may arise through mutation.
8. An increase in the proportion of houseflies resistant to DDT may be classified as an example of evolution.

The <u>most</u> logical sequence of these propositions would be -

A 6 - 4 - 7 \
1 — 8
3 - 5 - 2 /

B 1 - 3 - 7 - 6 - 5 - 2 - 4 - 8

C 3 - 1 \
5 / 4 - 6 \
7 \
2 / - 8

D 1 - 3 - 7 - 6 \
5 - 4 - 2 / - 8

E 5 - 6 - 2 - 7 \
1 - 3 - 4 / - 8

21. Which of the following is <u>not</u> essential in a permanently closed, balanced aquarium?

A an autotroph

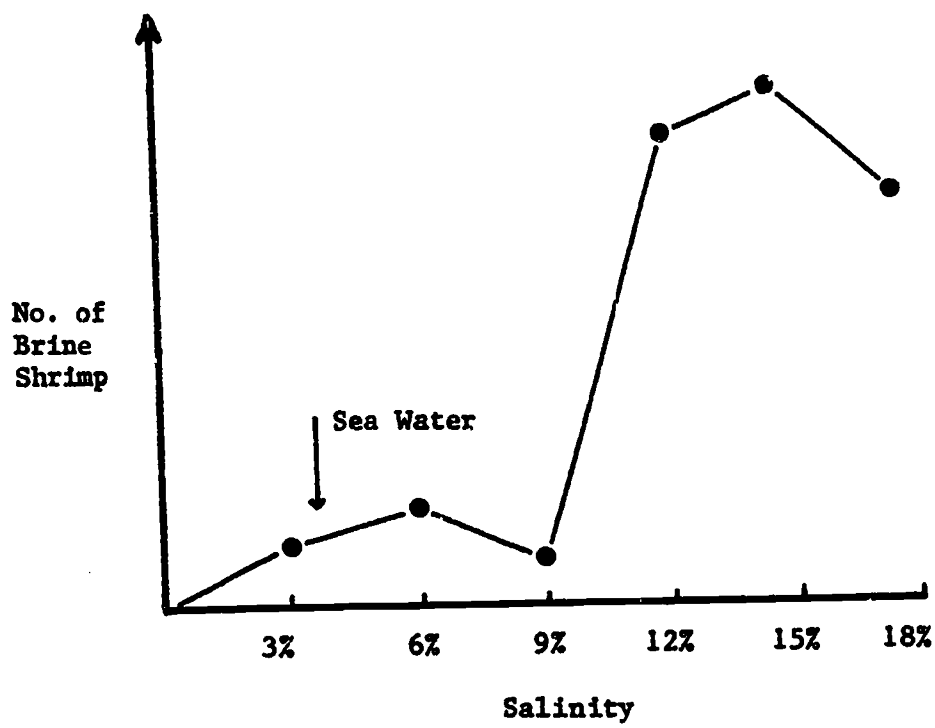
B a producer

C a primary consumer

D a secondary consumer

E a decomposer

22. At the Laverton salt works, sea water is evaporated in closed ponds until it reaches a certain salinity, then moved to the next most inland pond. After passing through many ponds the water reaches the point of super-saturation and salt crystallises out. A group of students investigated the distribution of organisms in these ponds. One of these, Artemia (brine shrimp), a small crustacean, is extremely salt-tolerant. The figure below represents the number of brine shrimp per 100 gallons of water, graphed against percentage salinity.



22 (cont'd)

Which of the following is likely to be the most significant reason in determining the foregoing distribution?

A Brine shrimp reproduce faster with increasing salt concentration

B The shallow pools inland have more sunlight reaching photosynthetic organisms

C The water temperature is likely to increase as we go inland

D There would be changes in the numbers of competitors with increasing salt concentration

E Less sea birds would be found as we move away from the beach

23. In some Asian countries fish farming is becoming important as a source of protein. The table below lists characteristics of four hypothetical fish which could be used to stock a fish farm. All are known to survive and reproduce well under conditions of artificial cultivation, and are equally acceptable to taste.

Fish	Max. Size	Food of Fish
1	3 inches	phytoplankton
2	6 inches	zooplankton
3	6 inches	algae
4	14 inches	smaller fish (1, 2, and 3)

Which fish or group of fishes is likely to be the best for stocking the pond?

A 1, 3 and 4

B 2 and 4

C 3 only

D 4 only

E 1, 2, 3 and 4

24. A male dog was kept in a room at a temperature of 38°C. for two weeks, and at the end of that time the dog was found to be sterile. The experimenter proposed an hypothesis that the high temperature caused the dog's sterility. To defend this hypothesis the experimenter would have to show that -

A the dog possessed genes for temperature sensitivity

B the dog's blood pressure remained unchanged over two weeks

C other mammal species kept in the same room and at the same temperature, also became sterile

D the dog was not sterile prior to this experiment

E the dog's adrenal gland had not increased in size

25. Van Helmont (1662) added only water to a small willow tree cutting, and found that after 5 years growth it had gained 164 lbs., but the soil in the pot had lost only a negligible 2 ozs. in weight. Which of the following explanations best explain the observation of Van Helmont (use only the data available to the experimenter)?

A Water and CO_2 caused the increase in plant's weight

B Water was "split" and CO_2 was fixed, resulting in the increase in plant weight

C Water is necessary for photosynthesis

D Plants are composed entirely of water

E Soil is not necessary for plant growth

26. The table below is based upon data collected by Ryther (1959). He compared the fishing potentiality of the open ocean (75% of the earth's surface) with the shallower coastal zones, where nutrients are circulated more readily. He believes the maximum fishing rate in the coastal zone cannot exceed 100 million tons annually without irreparable damage.

Area	Percentage of Ocean Area	Average productivity in grms. carbon per year per square meter	Average No. of trophic levels, before edible fish can be harvested	Annual Fish catch
Open ocean	90%	50	5	40,000 tons
Coastal zone	10%	100	3	60,000,000 tons

Which of the following is the best general interpretation that can be made on the basis of this data?

A The open ocean, where at present only 40,000 tons of fish are caught annually, has the potential to produce enough fish to significantly reduce food shortages.

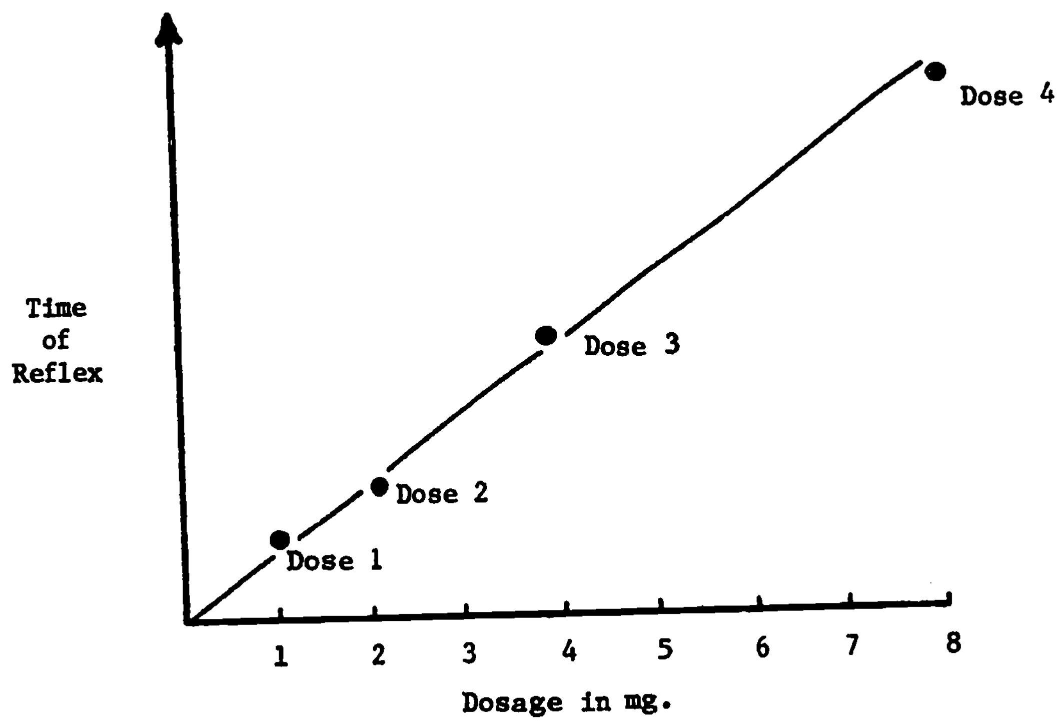
B The coastal zone is likely to remain the main source of fish for human consumption.

C Fishermen probably concentrate on the coastal zone because suitable fishing gear would be too costly and complex if used in the deeper open ocean.

D The productivity of open ocean is half the coastal zone but the area is nine times as great; we could expect therefore that about 450 million tons of fish could be harvested from the open ocean.

E Food chains are longer and productivity lower in the open ocean, so that more care will be required if the ecosystem is to be protected in this area.

27. A drug company wishes to test a new pain-killing drug for side-effects. Increasing doses of the drug were given every two hours to 20 people. These people were tested for average time of reflex response after each dose, each of which was double the previous dose. It was found, when the results were graphed, that there was a simple straight line relationship between dosage and the average time of reflex activity.



Which of the following is the <u>best</u> criticism of the experiment?

A Not all drugs retard reflex activity and the hypothesis is doubtful in the first place.

B Different people should have been used for each successive dose.

C The experiment should have been repeated several times to see if consistent results were obtained.

D If higher doses had been used, even greater effects might have been apparent.

E We have no indication that all people are equally affected by the drug since only average reflex times are shown above.

28. The following is part of an article from the Australasian Journal of Pharmacy, July 1969, heralding a new approach to bilharzia, one of the world's major health problems.

" Unofficially, the London scientists admit that they are awaiting with feverish excitement the first consignments of endod fruit, grown under controlled conditions at the experimental farms of the Haile Selassie University near Addis Ababa.

For the fruit of this humble shrub, which is grown widely in Eastern Africa may enable man to conquer the disease. The harvest is expected shortly.

Bilharzia is a slow, parasitical killer disease which, paradoxically, has been encouraged by the spread of modern farming methods in the developing countries.

There are no immunising drugs against the disease, which can be cured in advanced cases only through lengthy hospital treatment.

The parasites normally take years to kill their victims, who experience perpetual lethargy.

To survive, the bilharzia must have water as well as a human and snail host. Resembling a miniature torpedo, it swims about in tropical waters and enters the human body in a larval state.

It affects the circulatory system, the bladder, liver, heart, lungs or intestines. On maturing, it lays eggs which are then excreted and in turn find their way back into water and on to a suitable snail host.

'Bilharzia is the greatest danger to swimmers in tropical waters,' one specialist told me. 'At least you might have a chance to see the crocodiles before they attack.'

Failure.

There have been many attempts to curb the spread of bilharzia, but all of them have failed.

Thousands of toxic chemical compounds have been tested for killing the snails - and with them the disease - but they have proved either too expensive for application on a wide scale or harmful to fish which provide an important local source of high quality protein.

Biological methods of control, involving the encouragement of snails' natural enemies, usually lead to an equilibrium in the numbers of predators and prey, and thus to the survival of the disease.

Ecological methods, such as the draining of water channels, the lining of water channels, the lining of canals or the simple piping of water call for considerable expenditure - and would in any case be defeated by the constant spread of irrigation systems extending the breeding grounds of the fertile snails.

28 (cont'd)

Public health schemes providing for the chemical treatment of human excrement before its flow into water and put into effect over large areas could break the vicious circle of bilharzia. But their cost, again, would be prohibitively high.

Finally, mass drug treatment of bilharzia-affected populations in the earlier stages of the disease is extremely difficult to organise because many people are reluctant to suffer the unpleasant side-effects.

These include constipation and loss of appetite. Neurological manifestations have also been reported, with patients complaining that trees appear to be moving away as they approach them - until finally they collide with them.

Thus the high rate of infection in many countries with hot climates - over 80 per cent of Africans and 10 per cent of Europeans are infected in Rhodesia, for example - has come to be accepted as part of life in the tropics.

The presence of blood in the urine, associated with urinary bilharzia, is regarded in many places as one of the normal manifestations of adolescence.

Effective.

This, then, is the background to a young Ethiopian bio-chemist's discovery of the toxic quality of endod fruit, which has already been shown to be effective against the snails without undue damage to fish, cattle and other users of water, including, of course, man.

And the hoped for solution is almost poetically apt. For the endod shrub commonly grows along the shores of many bilharzia-affected waters.

The discovery was made by chance at the Assam river at Adwa, Ethiopia, where housewives who cannot afford to buy soap use the endod fruit for the family washing.

The scientist noticed large numbers of dead snails downstream from the wash places.

The connection between the poor man's soap and the dead bilharzia-carrying snails may one day enable man to eradicate this terrible disease which now affects about 250 million people. "

The following statements might be used to summarise this extract.

28 (cont'd)

1. The bilharzia parasite spends its larval state as a parasite of man, but the adult form is parasitic on a snail.
2. Many attempts have already been made to prevent bilharzia by killing the water snail host.
3. Treatment of human excrement could help prevent the spread of water snails, and hence also bilharzia.
4. Besides suffering perpetual lethargy, bilharzia sufferers also experience constipation and loss of appetite.
5. The endod fruit extract may enable scientists to cure sufferers of the bilharzia parasite.

Which of these statements provide(s) a true account of the extract above?

A 1 and 2

B 2 and 3

C 2 and 4

D 2 and 5

E 2 only

Questions 29 and 30 refer to the following extract by Glass, from a book, Science and the Concept of Race (1968), published by Col. Univ. Press.

"In the small populations of precivilized times, the effects of mutation would expectably be more diversifying than today. The probability that the same favorable mutation would arise in two small populations (breeding size, 250) within the same span of 25,000 years, or roughly 1000 human generations, is only 25 per cent if the gene has a mutation rate of 10^{-6} (one in a million). The probability that it becomes established in both populations is very much less. Consequently, in those early times favorable mutations would rarely, if ever, arise and become established in more than one population coincidentally. Today, on the contrary, our breeding populations are so large that any favorable mutation is quite likely to arise in every population quite frequently. In a population of breeding size 10^8 (100 million individuals; 200 million functioning gametes per generation), a mutation with a frequency of 10^{-6} will arise 200 times per generation. "

29. Which of the following statements most nearly expresses the logical conclusion of the extract?

A Evolution would be more rapid today than in precivilized time.

B Our present population is so large that we must begin to take population control measures.

C It is important that we should learn to control the effects of mutation.

D There is less likelihood of new races arising today than there was in precivilized time.

E The present races are more likely to be similar to one another than they were in precivilized time.

30. Which of the following assumptions is (are) made by Glass in developing his argument?

A There has been no marked change in mutation rate since precivilized time.

B All the people in the population pass their mutations to their children.

C The chance of survival of any one individual has remained fairly constant since precivilized time.

D All of the above.

E None of the above.

TABLE 6

COGNITIVE ITEM ANALYSIS I

ITEM NUMBER	TAXONOMIC CATEGORY*	DIFFICULTY (%) SI	SII	Ø (S II)	PROBABILITY
1	1.30	100	84	0.50	< 0.01
2	1.11	34	49	0.35	< 0.05
3	1.11	46	34	0.34	< 0.05
4	3.00	68	74	0.12	> 0.05
5	1.31	80	60	0.26	> 0.05
6	1.11	86	39	0.26	> 0.05
7	1.11	62	53	0.20	> 0.05
8	1.25	20	31	0.53	< 0.001
9	1.31	70	43	0.50	< 0.01
10	2.30	72	41	0.32	< 0.05
11	1.11	88	64	0.37	< 0.02
12	1.31	86	63	0.53	< 0.001
13	1.30	76	52	0.30	> 0.05
14	1.30	36	25	0.28	> 0.05
15	2.30	42	49	0.61	< 0.001
16	3.00	84	86	0.38	< 0.02
17	1.31	86	82	0.37	< 0.02
18	3.00	68	74	0.22	> 0.05
19	1.25	55	50	0.62	< 0.001
20	4.20	66	62	0.31	0.05
21	1.11	58	50	-0.08	
22	2.20	26	47	0.16	> 0.05
23	3.00	42	55	0.11	> 0.05
24	2.20	24	25	0.23	> 0.05
25	2.20	70	97	0.15	> 0.05
26	3.30	76	81	0.29	> 0.05
27	4.20	90	78	0.37	< 0.02
28	2.20	90	78	0.53	< 0.001
29	2.30	86	88	-0.20	
30	4.10	80	84	0.07	> 0.05

TOTAL NUMBER OF STUDENTS:- SI = 50

SII = 68

*BLOOM, B.S. Taxonomy of Educational Objectives (Handbook 1 - Cognitive Domain) Longmans, Green & Co., N.Y., 1956.

TABLE 7 COGNITIVE ITEM ANALYSIS II

ITEM NUMBER	RESPONSE A	B	C	D	E	CORRECT RESPONSE
1	30	11	9	10	8	b
2	17	0	15	1	35	E
3	7	9	0	0	52	E
4	19	34	3	13	0	A
5	2	5	11	27	23	D
6	5	1	28	28	6	D
7	11	0	32	9	16	C
8	7	8	6	47	0	D
9	21	39	2	0	6	B
10	40	26	1	0	1	A
11	3	11	24	16	14	C
12	25	18	7	4	14	A
13	14	5	33	11	5	C
14	4	1	10	2	51	E
15	35	1	8	0	24	A
16	10	4	6	38	10	A
17	3	23	9	21	12	E
18	18	8	30	10	2	A
19	34	9	1	5	19	A
20	9	12	26	15	6	C
21	31	2	.0	34	1	D
22	18	4	2	43	1	D
23	10	8	31	3	16	C
24	6	1	9	51	1	D
25	24	14	19	2	10	D
26	16	13	5	13	21	B
27	3	15	22	1	27	B
28	9	3	8	33	15	D
29	34	0	3	8	23	D
30	11	10	10	8	29	A

TOTAL NUMBER OF STUDENTS (SII) = 68.

COGNITIVE ITEM ANALYSIS III

CONTENT → / PROCESS ↓	Terminology	Ecological Principles	Experimental Procedures	Experimental data	Scientific Reports.
Knowledge	2,3,6,7, 21	1,5,9,11,12 13,14,17	8,19		
Comprehension		10,15,22	24	25	28,29
Application		16,18,23		26	
Analysis		20	27		30

NOTES ON COGNITIVE ITEM ANALYSIS

The Difficulty of each item is calculated as the percentage of students giving a wrong response. Group SI comprises a random sample of fifty students currently taking Science I, and group SII contains all students doing Environmental Science (Science II).

$\emptyset$, which is listed only for group SII, is a measure of the discriminatory power of each item, and is calculated according to the equation below.

$$\emptyset = \sqrt{\frac{X^2}{N}}$$

N = Number of cases used to calculate X^2.
= No. in Upper group + No. in Lower group
= 40.

A significant level of item discrimination is generally indicated by a probability of ≤ 0.05.

COURSE EVALUATION

The following questionnaire was constructed to determine the opinion of students with respect to the interest, difficulty and relevance of the course as a whole, and of each of the integral sections in both the theoretical course and the areas of seminar and discussion topics. Opportunity was also provided for general comments on topics to be included in, or omitted from the course, and for a statement of opinion on the continuation of the course.

NOTES ON COURSE EVALUATION The numbers in each square of this questionnaire represent the actual number of students indicating the respective response. The total number of students was 60, but since there was no compulsion to answer every statement, the total number of respondents in each case showed slight variation. Larger variations were found in section D, since relatively few groups of students had covered every seminar topic.

ENVIRONMENTAL SCIENCE RESEARCH PROJECT - COURSE EVALUATION

A. GENERAL VIEWS. Indicate your response to each of the following statements by placing a mark (X) in the appropriate position according to the key below.

SD - STRONGLY DISAGREE

D - DISAGREE

N - NOT SURE

A - AGREE

SA - STRONGLY AGREE

	SD	D	N	A	SA
1. This course as a whole was:					
(a) uninteresting	31	22	1	11	1
(b) difficult	1	16	5	40	5
(c) not relevant to me as a teacher	19	35	2	10	1
(d) not relevant to me as a person	37	22	3	3	1
2. This course has not changed my attitude toward:					
(a) science	10	29	5	18	4
(b) conservation	13	28	7	18	1
(c) pollution	15	28	6	18	1
3. There was not enough time in this course devoted to:					
(a) laboratory practical work	6	28	2	23	9
(b) field exercises	6	28	4	24	4
(c) student seminars	11	41	4	10	2
(d) lectures on background information	6	18	9	22	13
B. SEMINARS.					
1. The seminars as a whole:					
(a) were uninteresting	28	31	2	4	1
(b) were too difficult to understand	16	42	3	3	2
(c) were not relevant to me as a teacher	19	36	6	3	2
(d) gave no insight into specific social and environmental problems	30	31	0	4	2
(e) provided little opportunity for group discussion	23	32	1	8	2

. My own seminar topic:

	SD	D	N	A	SA
(a) was uninteresting	31	32	0	2	0
(b) was too difficult	15	42	5	2	0
(c) was too vague	17	37	4	5	1
(d) gave me little insight into this problem	30	31	1	1	0
(e) provided little opportunity for discussion	13	27	9	9	0
(f) did not have enough recommneded reference material	13	26	7	10	8

NAME OF SEMINAR TOPIC:

C. COURSE TOPICS. Indicate whether you thought each of the following topics was uninteresting, too difficult, or not relevant to the course as a whole by placing a mark (X) in the appropriate position according to the key below -

D - DISAGREE

A - AGREE

	Uninteresting		Too Difficult		Not relevant to the course as a whole	
	D	A	D	A	D	A
1. The Biosphere.	49	13	38	25	60	4
2. Energy Flow - (a) Photosynthesis	39	25	47	16	59	5
(b) Food Chains	44	18	48	13	60	2
(c) Human food production	55	9	53	8	58	2
3. Biogeochemical Cycles (carbon, water cycles, etc.)	20	41	13	49	51	11
4. Ecosystems.	51	13	52	8	58	1
5. Population Studies - (a) General population studies	50	16	53	7	61	2
(b) Human population problems	61	4	59	3	62	1
(c) Human reproduction	60	3	59	1	59	2
(d) Contraception	60	2	58	0	59	0

	Uninteresting		Too Difficult		Not relevant to the course as a whole	
	D	A	D	A	D	A
C. COURSE TOPICS (Cont'd)						
6. Genetics -						
(a) Biochemical genetics (structure and function of chromosomes)	45	16	34	30	53	11
(b) Instructional Program (DNA/RNA)	43	18	37	28	50	14
(c) Mutation (and recombination)	52	8	43	18	51	10
(d) Natural selection	55	2	50	6	55	3
D. SEMINAR TOPICS (Consider only those you have attended).						
1. Energy and Pollution	32	3	30	2	33	0
2. The Balance of Nature	43	10	54	6	48	1
3. Stress	51	11	48	8	56	2
4. Genetics in Agriculture						
5. Marine Farming	38	10	42	6	46	1
6. Exploitation of Natural Communities	14	3	16	1	16	0
7. Waste Product Accumulation	49	7	46	7	52	1
8. Australian Wildlife Conservation						
9. Contraception	41	2	42	0	40	1
10. Nuclear Power	20	6	16	8	20	3
11. Herbicides (2,4-D and 1,4,5-T)	28	7	27	7	32	2
12. Insecticides (DDT)	20	3	19	3	21	0
13. Oil Pollution	14	5	15	4	20	0
14. Drug Addiction	60	2	58	2	59	1

E. GENERAL COMMENTS.

1. Outline below any topics you would like to have

(a) included in, or

(b) omitted from

this course.

(a) INCLUDED

Brain-washing & Indoctrination
Human Transplants.
Suspended animation

(b) OMITTED

Biogeochemical cycles (X3)
Ecosystems (X1)
Pollution (X1)

2. Select one of the following alternatives and, if possible, give the reasons for your selection.

I would recommend that this course be -

(a) continued as the only course in the second year Science program;

(b) continued, but in association with other alternative courses;

(c) discontinued.

Selection: (a) 12

(b) 55

(c) 1

Reasons:

3. Other comments.

GENERAL ANALYSIS AND DISCUSSION.

I AFFECTIVE EVALUATION. Since practical difficulties prevented the use of a pretest/posttest design, various groups of first - and second-year students not doing this Environmental Science course were used as controls. The mean results and standard deviations shown for each group in table 2 indicate no obvious trends or significant differences between control and test groups for any group of statements. Either, then, the test was insensitive to existing differences in attidude, or no such differences exist. Whatever the case, it seems reasonable now to examine the discriminatory power and response frequency distribution of individual statements, as well as group reliability, on the basis of total student response.

Although the statements in Group A show good discrimination and group reliability (Table 3) most of them show a very high level of popularity, indicating that they are discriminating largely between different levels of agreement or disagreement, rather than between these two affective extremes. Thus the discriminatory power of these statements may be largely artificial, in the sense that the two levels of agreement or disagreement can not be clearly defined nor therefore universally understood and accepted. This inter-level discrimination can be substantiated by an analysis of the response frequency distribution (Table 3). Similar results of good discrimination scores at high levels of popularity are also evident in several statements from group B (Table 4) and group C (Table 5).

The reliability measures of statement groups B and C are both unacceptably low, though the popularity levels and discrimination scores for individual statements are generally well within the acceptable range. This may be an indication of general ambiguity, as is probably the case with statement 27 (Group B/Table 4), which might have been interpreted as a statement of legal fact rather than personal opinion, but is more likely to suggest that many of these statements are not seen by the students to reflect a common underlying attitude. Rather it seems that several of the statements

from groups B and C are interpreted as individual issues and thus evoke a pattern of responses inconsistent with that defined by those who prepared and accepted the questionnaire. If this is the case, it may be questioned that a general attitude toward environmental conservation even exists, and suggested that individual issues of environmental concern will evoke different responses in the same person, depending on his assessment of the priorities involved in each, essentially separate situation. In terms of course objectives, this would suggest a greater emphasis on the analysis of individual issues of environmental concern, and on discussion of the various factors involved, rather than a more general and superficial approach to the advantages of environmental conservation.

II COGNITIVE EVALUATION. It can be seen from the item analysis results in Table 6 that most of the questions involving only knowledge (Taxonomic category 1) were less difficult, if only slightly so, for the second-year science students than for those doing science I. Moreover these questions in general show significant levels of discrimination ($P < 0.05$) within the SII group of students, and are therefore useful evaluative items. The questions on higher cognitive abilities, however, generally show no consistent differences in difficulty between SI and SII groups, and fail to give any significant discrimination between the upper and lower sections of the SII group. It is difficult, therefore, to make useful generalisations about the effectiveness of the Environmental Science course in this cognitive area, though it is interesting to note that the questions on comprehension and application of experimental data (25,26) were both more difficult for the SII group than for SI. This may be somewhat distrubing in the knowledge that these areas were an important part of the SII course objectives, but it should be emphasized that the SI "control" group had not done the same course as that of the SII group in the previous year, and that these objectives were now also part of the SI course. Despite the inconclusiveness of these results, it seems obvious that much more emphasis must be given to those objectives based on higher cognitive abilities, in order to achieve the important aim of rational and analytical discussion on matters of environmental concern.

III <u>COURSE EVALUATION</u>. The course evaluation questionnaire was designed simply to give an idea of how the course was seen by those who studied it. Most of the students thought the course was generally interesting, though often difficult, and relevant in both a personal and professional sense. Many thought that more time should be devoted to field and laboratory exercises, and lectures on background information, though the latter had already been given a major part of the total course time allocation. The student seminars generally received a very favourable reaction, and did not appear to involve the same degree of difficulty encountered in many of the lecture topics. The initial sections of the course, and in particular that dealing with the biogeochemical cycles, were often thought rarely irrelevant. The section on biochemical genetics evoked a similar response, and was thought by several students to be irrelevant to the course as a whole, but was not listed among those topics recommended for omission in question E1. Although a number of students recommended that this course be continued without option, most were in favour of continuing the course in association with other alternatives. It is interesting to note, however, that the reasons for this suggestion indicated a general reaction against universal or compulsory courses, rather than any specific dissatisfaction with this one, or a desire in these students to chose any of their recommended alternatives in preference to this course.