AN ASSESSMENT OF AN ATTEMPT TO IMPROVE A GROUP-INSTRUCTIONAL METHOD OF TEACHING EMPLOYED IN THE TRAINING OF PRIMARY SCHOOL TEACHERS

A thesis presented for the degree of Master of Arts in Education in the University of Canterbury, Christchurch, New Zealand

by

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Chapter 1

INTRODUCTION TO THE THESIS

This study is concerned with assessing the validity of the contention that the effectiveness of a teaching method utilized by lecturing staff within the Primary Division of a Teachers' College might be increased by modifying the instructional techniques employed in accordance with selected "laws of learning".\(^1\) The scope of the enquiry is limited in that only one method of teaching is selected for examination and modification.

Past attempts to gauge the effectiveness of particular teaching methods used in Teachers' Colleges by comparing them directly with other teaching methods employed in the same environment have proved to be singularly ineffective.\(^2\) Thus the writer has superimposed upon an existing and accepted set of teaching procedures such activities relating to "establish---


ed generalisations" concerning the facilitation of learning as might be expected to effect learning outcomes differentially in terms of the selected, stated goals of a course in science teaching for primary teacher trainees.

An examination is made of the effects of augmenting a comprehension type (reading-for-meaning), small-discussion group, instructional method with problem solving/discovery activities, or, in parallel, with supplied concrete objects; at a second level, problem solving/discovery activities and concrete objects are presented simultaneously as additions to the basic teaching method.

The results of modifying the teaching method in the stated ways are compared in terms of the students' measured capacity to recall learned facts and principles in the short term, by examining evidences of the students' ability to apply learned principles to new problems in the long term and by attempting to measure the students' stated commitment to various related procedures for the teaching of children.

The research is seen by the writer as an attempt to relate models of instruction and some generalisations about the facilitation of learning derived, in the main, from

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research findings, to the day-to-day teaching tasks of lecturers in a Teachers' College.
Effectiveness of Teaching in Teachers' Colleges – An Area of Concern

At all levels in the schools attempts to increase the effectiveness of teaching in terms of learning outcomes continue to be made. A universal shortage of teachers coupled with a growing demand for the products of education has led to an intensification of the search for improved and in some cases, new methods of teaching.

Teachers' Colleges in New Zealand no less than other educational institutions have been inconvenienced by high student-staff ratios and more uniquely, by the problems associated with the diversification of the curriculum for teacher training, by an influx of numbers and of new and often inexperienced lecturers, appointed in anticipation of translation from a two year to a three year period of training, and through the growing expectation that at least a proportion of

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4 Extensive changes in the curriculum of the primary schools have required corresponding adjustments to be made to courses related to studies of the school curriculum within the Teachers' Colleges, particularly in the subject fields of mathematics and science.
the staffs of the Teachers' Colleges should assist in administrative tasks, initiate research programmes, prepare reports, and papers for presentation and publication and take part more frequently and intensively in the in-service training of teachers.  

Concern about the effectiveness of teaching methods in these circumstances is related to the spirit of self-criticism so prevalent in the Teachers' Colleges, to a desire to realise more substantially the goals of teacher training and to a recognition of the necessity for creating conditions in which the most effective use may be made of the time during which lecturers, in their capacity as teachers, are able to be with their students. Particular concern is frequently voiced about the relationships between teaching methods employed and the complex objectives of particular studies and, indeed of the courses taken as a whole.

Teaching Methods at Present Used in Teachers' Colleges

Ussher and Borland have observed that:

"The traditional approach to teaching in Teachers' Colleges ... is that of the formally presented lecture, supplemented by seminars, discussion groups, practical

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work, supervised study, and opportunities for individual assistance from tutors. 6

In New Zealand the emphasis on the use of the formal lecture is attested to by an examination of a random selection of College Calendars and Handbooks. Reference to 'lecture programmes', 'lecture rooms', and 'courses of lectures' are frequent. In practice it has been largely through this method of teaching that lecturers have attempted to stimulate thinking, present organised bodies of information and prepare students for examination.

More recently, less traditional methods involving task-centred discussions, investigatory and expressive activities and various forms of individualized instruction have been increasingly favoured by some lecturers. 7, 8 Movement towards the use of these "new" methods has been given impetus as a result of the re-examination of purposes and methods which took place before the introduction of the three year period of initial training. Some positive attempts have been made to introduce teaching procedures which have been claimed to facilitate


the realization of particular objectives. Such methodological innovations are frequently allied with commitment to a particular philosophy of education rather than to systematic attempts to measure outcomes in terms of objectives.\(^9\)\(^,\)\(^10\)

The variety of methods which may be used is limited by the size of classes and fixed allocations of time (as for lecture periods) for particular teaching intervals and courses, i.e. by the organisational structure of the Teachers' College.

**Reasons for the Selection of the Course in Science Teaching for Particular Examination**

The author has chosen to conduct, within the context of the course in the teaching of science, an investigation which sets out to assess the effects of attempting to increase the effectiveness of an instructional method, largely because of his association as a lecturer with the science department of the Teachers' College. The problems which the study seeks to explore are of constant concern to the teaching members of a College department who are currently replanning courses in


\(^{10}\) Ussher J. and Borland N., "Lecturing Techniques in a Three Year Course", *New Zealand Teachers' College Association Journal*, No.4, 1966, p.15.
accordance with new emphases and directions in science education for both children and primary teacher trainees.

**Place of the Course in Science Teaching in the Curriculum of the Teachers' College**

Courses are offered in Christchurch Teachers' College which examine the content and teaching methods of the primary school curriculum. *Understanding the World - Nature Study,* the prescribed syllabus of instruction, is studied during sixty lecture hours. Similar courses of study are offered in other areas of the curriculum. Studies of the school syllabus, which are mandatory for all students, are supplemented by courses of a general nature which deal with educational psychology and sociology.

**Objectives of the Course in Science Teaching**

The objectives of the course in the teaching of science are related to those of the Teachers' College as a whole which are briefly, to develop competent primary school teachers whose training, in general, has been undifferentiated either with reference to preparation for teaching at a particular level of the primary school or with regard to having been

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12 *Christchurch Teachers' College Handbook, 1966,* pp. 18-19
prepared for the specialised teaching of any one subject rather than another. With particular reference to science teaching, competence would be deemed to include a detailed knowledge of relevant teaching methods and, at least, a minimal understanding of the content matter of the primary school syllabus.

The specific objectives of the course in the teaching of science are:

1. To develop some factual knowledge of pertinent areas of science. There is a stress on biological science because of its closer links with the *Nature Study Syllabus* of instruction in the primary school which is biased towards the study of living plants and animals.

2. To inculcate an elementary understanding (where this is lacking) of those general principles of the sciences which are regarded as being of major importance.

3. To develop a knowledge of and an enthusiasm for appropriate teaching methods.

4. To promote an interest in and knowledge of sources of reference which will be useful to the student during his or her career as a primary school teacher.  

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Thus in summary, the course is designed to be both informative (i.e. its objective is to furnish the student with a limited body of factual knowledge related to a number of general principles of science) and at the same time, inspirational (i.e. it sets out to develop attitudes to the subject and to its teaching which are deemed to be desirable in terms of current practice).

**Instructional Methods Adopted in the Course**

Methods of teaching have been adopted which, it is considered, will secure the preferred outcomes. In particular traditional lecture, field investigation and laboratory school methods, have been replaced in part by instructional methods which involve students in observation and/or discussion in groups of five or six. Such group sessions occur during approximately half of the sixty lecture hour course and are each of eighty minutes duration.

The use of "team-discovery"/discussion teaching techniques is claimed to promote the acquisition of science facts and principles, strongly motivate students towards reading further into the topic under consideration and towards searching for additional corroborative evidence, and facilitate

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the development of students' understanding of methodology through repetitive experiences with approved methods of teaching.

While these ends may have been achieved through the use of the group instructional method, it was of crucial interest to the author of this study that no attempt had been made to continue to refine this "new" teaching procedure so that within its limitations use of the group instructional method would enable the objectives of the course to be attained more effectively.

**Summary**

A variety of factors have given rise to concern about the effectiveness of teaching methods used in the Teachers' Colleges. Some more recently developed methods of teaching have been adopted but, in general, established traditions of procedure and the organisational structure of the College limit the extent to which innovative practices in teaching may be implemented. At the present time there is an evident need to improve the effectiveness of instructional procedures both "new" and "traditional", which are currently employed on a priori grounds. Systematic attempts to do this have not been made.
Chapter 3

THE REVIEW OF SELECTED LITERATURE AND
A DESCRIPTION OF THE PROBLEM

I INTRODUCTION

Studies from which the present research has been derived are described under three main headings. Some assertions and generalisations (set mainly within an historical context) which appertain to the improvement of instructional methods are reviewed briefly under the title "General Background". In a second category investigations which have sought to assess (by comparison and otherwise) the effectiveness of various modes of instruction are summarized. A third section of the chapter is devoted to an examination of a contention that there is point in altering single modes of instruction in such a way as to facilitate certain desired learning outcomes.

As a whole and when considered with reference to the particular conditions obtaining in the Teachers' Colleges, the notions described in the literature point to the necessity for the examination of the specific problems outlined in Chapters 1 and 2 and described in detail in the latter section of Chapter 3.
II REVIEW OF SELECTED LITERATURE RELATING TO THE PROBLEM

General Background

Attempts to devise or improve methods of instruction appear to be as old as man and the claims made by the protagonists of new or modified methods no less ancient. Gage cites the examples of Protagoras, Socrates, Isocrates, Comenius, Pestalozzi, Forebel and Herbart "...who were teachers by vocation and without exception believed that they could justify their method by theory, not only of learning and teaching, but of truth, beauty, and goodness as well."\(^{16}\) Their devotion to particular sets of procedures did not, of course, result from a considered acceptance of methods whose learning outcomes had been measured and compared, but rather because they were great "protagonists and antagonists"\(^{17}\) of the "spirit of their ages".\(^{18}\) Certainly, this condition has been obscured by the rise of modern scientific empiricism and its application to studies in educational psychology. Recently (i.e. since the 1920's) exponents of particular methods of instruction have

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\(^{17}\) Gage, p. 1.

tended to utilize the strength of figures to support their claim, and as Wallen and Travers\textsuperscript{19} have reported, have more than often been either unable or unwilling to examine and concede the effect of the value positions (in terms of philosophical stands, dedication or opposition to traditional practices, or personal strengths, weaknesses or needs) which underlie their assertions.

**Attempts to Improve Instructional Methods**

In the period between the wars and especially since the 1920's empirical investigations of the effectiveness of instructional methods have proliferated. Summaries and descriptions of the outcomes of many of these investigations have been made by numerous writers including Wallen and Travers\textsuperscript{20} and Lumsdaine,\textsuperscript{21} with particular reference to science education by Watson\textsuperscript{22} and to teaching at tertiary level by McKeachie.\textsuperscript{23} Much of the research into the effectiveness of teaching methods has been undertaken by comparing differing methods of instruction and by examining and measur-

\textsuperscript{19} Wallen and Travers, in Gage, pp. 452-465.

\textsuperscript{20} Wallen and Travers, in Gage, p. 464.

\textsuperscript{21} Lumsdaine A., "Instruments and Media of Instruction", in Gage, pp. 583-571.

\textsuperscript{22} Watson F., "Research on Science Teaching", in Gage, pp. 1031-1056.

\textsuperscript{23} McKeachie G., "Research on Teaching at the College and University Level", in Gage, pp. 1113-1164.
ing the extent to which they were gauged to have promoted differentially certain stated learning outcomes. Useful summaries of the literature in this area have been presented by the writers cited above. During the past decade the validity of comparing the effectiveness of teaching methods in this gross manner has been challenged frequently. Wallen and Travers ascribe the origins and design of much research concerned with comparing teaching methods to needs generated by "philosophical traditions, cultural traditions, the needs of teachers...". 24 They claim that there has been a tendency "to pick and choose elements from the behavioural sciences that appear to fit with the philosophical traditions of teacher education". 25 Their view is supported by De Cecco who maintains, by way of example, that John Dewey's description of the use of problem solving methods in teaching was "his philosophical attempt to remedy the deficiencies of rote memorisation". 26 He (De Cecco) states that: "the modern psychologist has come to Dewey's support by attempting empirically to specify these conditions which are most

24 Wallen and Travers, in Gage, p. 464.
25 Wallen and Travers, in Gage, p. 464.
conducive to discovery and increased learning". 27 Many workers have continued to prepare papers in this field characteristically comparing 'do-it-yourself' or 'programmed' or 'mechanically assisted' learning with learning through traditional, didactic or recitation methods. Such comparisons of teaching methods appear to be both spurious and opportunist...

... since teaching methods have arisen largely outside of a scientific context, studies which compare the effectiveness of one with another can hardly be conceived as constituting a programme of scientific research. 28

More useful attempts to improve instructional methods have involved analysis of a single method of teaching. Studies of verbal and non-verbal interaction between teachers and pupils have indicated that learning increments may be substantially increased when teachers obtain knowledge of interaction processes and act upon this knowledge. Summaries and descriptions of such studies have been prepared by Crispin, 29 Nuthall and Lawrence, 30 Hunter, 31 and others. In

27 De Cecco J.P., Human Learning in the School, p. 211.

28 Cronbach L., "The Role of the University in Improving Education", Phi Delta Kappan, June 1966, pp. 539-545.


this case the research is associated with a single instructional mode i.e. to the "... formal lesson with talkative teacher centre stage." It is linked with the:

... traditional emphasis upon information, intellectualization and instruction as opposed to shared experience, pupil initiated activity, and less easily measured emotional outcomes of classroom interaction.

The success of such studies relates to the specificity of the area of application of the research findings. It appears then, that the more valid and fruitful categories of research may be those which do not set out to demonstrate the superiority of any one instructional method to other methods and which relates to specific instructional methods employed in specific learning situations.

A further criterion for assessing the significance of a research programme is outlined in the section of Chapter 3 which follows.

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33 Brew, in Webster, p. 93
Providing a Better Theoretical Basis for Attempts to Improve Instructional Methods

Uneasiness about the validity of both past and present research related to instructional methods has prompted several writers to review the present situation and to postulate more appropriate directions for future investigations. A spokesman for the Canadian Teachers’ Federation\(^{34}\) states that the function of educational research is to:

Determine, within a given framework of resources and restrictions those programmes which are optimum in achieving stated aims with specified groups of students, and again, that:

one characteristic of the research is that he should have some definite intention to achieve such (optimum) programmes or at least to improve upon existing programmes.

These assertions which superficially give mandate to fortuitous research are modified by the authors recognition that:

Some theoretical depth is necessary if the teacher is to recognise the free variables, that are present in the teaching situation and to know what alternative values these free variables may take. For example, hypotheses concerning appropriate motivational techniques are likely to emerge only if the teacher has some acquaintance with themes which explain the dynamics of human motivation. \(^{36}\)

\(^{34}\) Role of the Classroom Teacher in Educational Research, Research Division, Canadian Teachers’ Federation, Ottawa, 1961, p. 11.

\(^{35}\) Canadian Teachers’ Federation, p. 13
The notion that suitable research programmes are most likely to evolve from knowledge and application of instructional theories (which have presumably been derived empirically) is carried further by Wallen and Travers who consider that research on teaching methods should "contribute to an organised body of scientific information, i.e. to 'principles of learning' derived from fundamental, empirical studies."³⁶ They comment on the tendency of workers to refer to past studies "as if they constituted a unified body of scientific knowledge",³⁷ and describe efforts to compare the effectiveness of teaching methods as similar to those "made by a medieval physician to determine which of two herbs had the greater curative value, when he had no knowledge of chemistry, physiology, or pharmacology involved".³⁸ Wallen and Travers also note that "statistical sophistication cannot make up for what may be termed the theoretical naivete reflected in the concepts which the studies involve".³⁹ In general their criticism of past and much current research is founded, as is


³⁷ Wallen and Travers, in Gage, p. 466.

³⁸ Wallen and Travers, in Gage, p. 466.

³⁹ Wallen and Travers, in Gage, p. 466.
the stand of Cronbach on the assumption that enquiry is centred on variables which have been derived intuitively rather than empirically. As previously noted, an examination of studies described by Wallen and Travers, especially those in which the effectiveness of traditional and progressive methods of teaching have been compared, supports this view.

A similar stand is taken by Lumsdaine, who notes that:

The precision and applicability of experimental findings are likely to be augmented to the extent that the specific methods chosen for manipulation are defined in terms of theoretically oriented variables, and not solely in terms of gross physical characteristics of instructional media. 41

Scandura and Anderson claim that "teaching should be treated as a technology based on a science of learning". They are supported by Watson and Cooley who assert that:

The principle task of educational research is the development of reliable predictive systems based upon laws

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40 Cronbach L.J., *The Logic of Experiments on Discovery*, Unpublished Paper, prepared for a conference under the chairmanship of Evan Keislar, held in New York City on January 28-29 1965. The conference was arranged by the SSRC Committees on Learning and the Educational Process and financed by a contract between the Cooperative Research Program of the U.S. Office of Education and Stanford University.


and principles applicable to the fundamental problems of maximising learning in schools.

They note that:

... the quantitative formulation of verifiable laws... whose ultimate aim is establishment of a system of concepts and relations (the so called nomothetic net) in which all specific propositions are deducible from a few general principles is far from being a reality.

On the other hand Ebel states that:

The primary task of professional educators is to improve the process of education ... they will do well to direct their efforts towards applied research designed to yield information immediately useful in the solution of contemporary educational problems. 44

Wallen and Travers view, which is in effect a compromise between the stands of Cronbach and Ebel is that instructional methods should be designed or redesigned on the basis of learning models which have been derived from empirical researches. They claim that there exists a need:

To design a teaching method which makes as much use as possible of a wide range of learning principles so that there may be... some hope of finding a teaching method which is definitely and markedly superior to others which have not been thus systematically designed. 45

Recognising that, for better or worse, the selection of gross instructional procedures is likely to be made on other than logical grounds 46 Wallen and Travers note that:

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45 Wallen and Travers, in Gage, p. 500.

46 Wallen and Travers, in Gage, p. 465 and p. 484.
There is a possibility that many different teaching paradigms might be designed which would make full use of many principles, differences between them being a product of the objectives that each is designed to achieve. 47

As an outcome of the thesis adduced by Wallen and Travers, it is postulated that in terms of the attainment of specific objectives a given instructional method should be capable of improvement if the conditions of learning are modified in directions indicated by the theories derived from prior empirical research. The general principles preferred by Wallen and Travers are by no means exhaustive and are concerned with reinforcement, motivation, practice, individualisation, imitation and activity learning. When aligned with Cronbach's paradigm for research in teaching:

With subject matters of this nature... experience of this type, in this amount, produces this pattern of response, in pupils of this level of development. 48

the proposition of Wallen and Travers suggests the possibility of attempting to improve an instructional method on a genuinely technological level i.e. where the outcomes might be specific and useful but where knowledge obtained from the study feeds back into empirically derived theory.

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47 Wallen and Travers, in Gage, p. 500

III THE PROBLEM IN DETAIL

Reference has already been made to the objectives of the course in the teaching of science. These were described under two headings:

Informative - to provide opportunities for the acquisition of factual knowledge and general principles, and to give practice in the application of general principles.

Inspirational - to motivate the student towards further pertinent reading, and to promote the development of desired attitudes towards appropriate methods of teaching science in primary schools.

It was assumed, on a priori grounds, that guided discussion and/or observational studies which took place in small-group learning situations would help students attain these ends. Although the commitment of lecturers to the teaching method was strong and outcomes were regarded as acceptable, it was by no means clear that the method was being used to its best advantages.

The problem then, confronting the writer was that of attempting to increase the effectiveness of a teaching method (which occupied an accepted place in the system of teaching used in the Science Department of the Teachers' College) through the application to the method of 'Principles of Learning'. Furthermore it was necessary to evolve a research design which would allow the outcome of this experiment to be
measured.

Reference has been made to the "Principles of Learning Applied to Teaching" described by Wallen and Travers. These were accepted by the writer as the clearest statement of such generalisations which he had encountered at the time of designing the research programme and as such were seen to provide a sound theoretical base for the experiment. While not all principles were equally relevant (in terms of the practicability of their implementation) it appeared that it might have been possible to improve the effectiveness of the teaching method by putting into effect Principles 1, 2, and 3. Three principles were discarded in the interim. The convergent nature of the course precluded the application of Principle 4:

Since learners differ in their capacity to make the responses to be acquired learning will be most efficient if it is planned so that each learner embarks on a programme commensurate with his capacity to acquire new responses.

Principle 5:

If a pupil has had training in imitation, then he is capable of learning by observing demonstrations of the skills to be acquired.

was less applicable to the small-group-discussion than to the lecture method. Principle 6:

The learner will learn more efficiently if he makes the responses to be learned than if he learns by observing another make the response or makes some related response.

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49 Wallen and Travers, in Gage, pp. 494-500.
had already been applied through the use of the basic teaching method i.e. through reading-for-meaning followed by small-group and class discussion.

The three principles which were adjudged to be particularly relevant were:

1. Behaviour which represents the achievement or partial achievement of an educational objective should be reinforced.

2. The introduction of cues which arouse motivation toward the achievement of an educational objective will increase the effectiveness with which the objective is achieved.

3. Practice in applying a principle to the solution of problems will increase the probability of transfer of training to new problems which require the use of the same principle for their solution.

Wallen and Travers\(^{50}\) have indicated how the principles might be applied by referring in the case of each to its significance for classroom learning and utilization by different teaching methods. As the teaching method under consideration was one which in its basic form involved students in reading-for-comprehension exercises and discussion in small group

\(^{50}\)Wallen and Travers, in Gage, pp. 494-500.
situations (followed by large group discussion with a lecturer) it appeared that it might be improved in two ways which were both practicable and, in keeping with the selected principles. It was conjectured that the introduction of concrete objects i.e. animals or plants, into the small-group-discussion situation or, the restructuring of the basic comprehension exercises as problems to be solved rather than as passages to be understood should increase opportunities for reinforcement, \(^{51}\) contribute to the arousal of students, \(^{52}\) and present occasions on which students would be able to practice applying principles to problems. \(^{53}\) The problem then became one of assessing whether and to what extent the 'improvements' to the teaching method, when implemented either singly or together effected the selected learning outcomes.

As a related issue and in terms of feedback to the theoretical model some doubt had to be cast upon the universal validity of Principle 2. \(^{54}\) Studies cited by, for example

\(^{51}\) Wallen and Travers, in Gage, pp. 495-497.

\(^{52}\) Wallen and Travers, in Gage, pp. 495-497.

\(^{53}\) Wallen and Travers, in Gage, pp. 497-498.

\(^{54}\) Wallen and Travers, in Gage, p. 495. In fairness to Wallen and Travers, it should be noted that the problem of the "direction of action" is discussed in relation to Principle 2.
Hebb, Marks and Raymond, and Anderson and Gates suggest that cue levels would need to be controlled to reduce contingent interference effects which could lead to the inhibition of specific learnings.

Finally, it was apparent that it would be necessary to examine the contribution made by attempting to improve the teaching method to the 'inspirational' outcomes of the course in the teaching of science. Foss notes that 'bad' teaching in Teachers' Colleges tends to perpetuate itself:

We do not use visual aids enough; we pour strings of dull words at numb rows of passive students telling them to use visual aids and activity methods.

He considers that the reason for this might be that their (the lecturers) teachers may have adopted a similar procedure and that the 'perverse' teaching practices of the colleges resulted from the tendency of lecturers to imitate the teaching methods of their teachers rather than to follow their instructions.


Vessel supports the opinion of Foss when he notes that:

Inasmuch as teachers usually teach the way in which they have been taught it is important that the prospective teachers learn how science should be taught by example rather than by precept. 59

In response to the implications of these assertions the problem, in this case, was that of attempting to relate the improvements to the teaching method derived from the theoretical model afforded by the 'principles' to the developed attitudes of student-teachers towards the subsequent utilization of specified teaching procedures in primary schools.

IV THE PROBLEM STATED IN THE FORM OF FOUR HYPOTHESES TO BE TESTED

Hypothesis 1. Retention of testable factual information and principles derived from the study guides and information acquired from the suggested readings will vary according to the strength (in terms of the 'Principles of Learning') of the variant of the instructional method which had been encountered by classes of students.

Hypothesis 2. Success in applying learned principles to new problems (transfer) should be most marked in the case

of individual students who had been subjected to the problem-solving variant of the teaching method (Principle 3).

Hypothesis 3. The improvements to the teaching method when applied together should not result in further increases in learning outcomes in terms of the retention of testable factual information and principles derived from the study guides and information acquired from the suggested readings.

Hypothesis 4. Students should show a preference for permitting children to manipulate concrete objects during classes if they themselves (the students) had learned about related objects and ideas in the presence of similar concrete objects.
Chapter 4

PROCEDURES ADOPTED IN THE STUDY

I AN OVERVIEW

Design and Statistical Treatment

The design of the experiment resulted from the necessity to prepare a format within which the effectiveness of a basic reading-for-meaning group discussion, teaching method (A) could be compared with variants of the method which had been augmented by comprehension exercises re-cast in the form of problems to be solved (B), supplied concrete objects (C), both comprehension exercises re-cast in problem form and supplied concrete objects (D).

The availability of classes of students and the nature of their scheduled programmes placed severe limitations upon the type of experimental design which could be used in the experiment. In practice eight classes (in two units each of four classes) of students were able to be employed as the experimental population during three eighty-minute teaching sessions; one further class was available for use during a projected pilot study. As only three teaching sessions were offered the implementation of a fully rotational experimental
programme during which each class of students would have been exposed successively to the four variants of the basic teaching method was precluded. Under these circumstances the advantages of a non-rotational system were considered to exceed those of a semi-rotational system on the grounds that the most useful accumulation of data could be obtained through the repeated exposure of comparable groups of students to single variants of the method under consideration.

It was assumed that the application of a t test of the significance of the difference between the means of the scores of the students in various classes would give a reliable indication of the validity or otherwise of the experimental hypotheses but should significant correlations be found to exist between the variants of tested intelligence and science interest/experience and the various test scores then an analysis of variance could be undertaken which would, as a further measure, expose the nature and extent of interaction effects.

The design of the experiment was thus developed in three phases: The Pilot Experiment, The Experimental Programme Proper, Parts I and II.

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The Pilot Study

A class of students which would not otherwise have been involved in the experiment would take part in a preliminary investigation into the adequacy of the methods and materials which it was proposed would be employed during the experiment proper. More particularly a proposed testing programme would be scrutinized and an attempt made to establish the validity of individual test items and of the tests as a whole. A subjective assessment of the feasibility of the projected experiment would be made during the pilot sessions, and, if necessary, appropriate modifications made to the overall plan for the development of the experiment proper.

The Experimental Programme Proper (Part I)

Four of the eight available classes, each of approximately forty Year One (beginning) students would be involved in this section of the experiment, (Part I). Each class would be taught through a six lecture-hour course, i.e. for 240 minutes, over a period of three weeks, through the use of a single variant of the group-discussion method. The classes of students were designated: A, B, C, and D. Topics prescribed as part of the course in science teaching which were to be considered during each of the three teaching sessions were represented by the symbols X, Y, Z. One major topic would be explored during each teaching session.
In Table I the teaching plan is presented in diagrammatic form.

<table>
<thead>
<tr>
<th>TOPICS</th>
<th>COMPREHENSION</th>
<th>COMPREHENSION + CONCRETE OBJECTS</th>
<th>PROBLEM</th>
<th>PROBLEM + CONCRETE OBJECTS</th>
<th>Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>A/E</td>
<td>B/F</td>
<td>C/G</td>
<td>D/H</td>
<td>80</td>
</tr>
<tr>
<td>Y</td>
<td>A/E</td>
<td>B/F</td>
<td>C/G</td>
<td>D/H</td>
<td>80</td>
</tr>
<tr>
<td>Z</td>
<td>A/E</td>
<td>B/F</td>
<td>C/G</td>
<td>D/H</td>
<td>80</td>
</tr>
</tbody>
</table>

The Experimental Programme Proper (Part II)

A further four classes of students (Year Two) designated E, F, G, and H were the subjects of this section of the investigation which was in fact, a repetition of Part I. Students from classes E, F, G, and H were those who were undertaking the course in science teaching in the second rather than the first year of training. These students were in general one year older than those in classes A, B, C, and D.

It was anticipated that additional correlates might become available through the involvement in each of the two parts of the experiment of classes of students of varying age and experience within the Teachers' College. Furthermore,
because Parts I and II of the experiment were to be conducted by two lecturers independently, it was anticipated that this factor might reduce the possibility of contamination of the experimental results through lecturer bias.

A Programme of Testing

A programme of testing was incorporated in the design of the experiment. Data drawn from a questionnaire completed by all students participating in the experiment indicated that the range of prior experience considered to be significant (i.e. participation in fifth and sixth form courses in biology and in advanced courses in biology within the Teachers' College was wide. A nil basal level of knowledge could not be assumed. A pre and post testing programme was evolved and incorporated in the overall design of the experiment. Further tests which would examine evidence for the differential transfer of learned principles to new areas of study and commitment to certain approved methods of teaching were also to be administered.

II THE PILOT STUDY

Reasons for the Pilot Study

It was considered advisable to preface the main study with a pilot experiment which would have a number of functions

1. To enable the experimenter to assess the extent of negative student reaction (if any) to the materials of the
experiment (i.e. to an information seeking questionnaire, the pre and post tests, the test for transfer and the printed study guides) and to the manner in which the tests were administered and the topics taught. An assessment would be made as a result of subjective observations of the students' reactions throughout the teaching and testing programme and afterwards, through informal discussions between experimenter and subjects.

2. Instructional procedures had been selected which, it was assumed, would be sufficiently familiar to the students to preclude the invalidation of any part of the experiment through interference from novelty effects. It was anticipated that such an assumption might be justified or rejected through observations made on a subjective basis. Signs of undue excitement or unusual enthusiasm or involvement might indicate that the experimenter had departed sufficiently from accepted practice to arouse students' interest through the presentation of novel topics or through the use of unusual instructional procedures.

3. The administration of pre and post tests required that the students participating in the experiment be informed that a section of the course was to be subjected to an investigation and their co-operation solicited. An attempt would be made to assess subjectively subsequent increases in or diminution of normal co-operativeness.
4. On ethical grounds it was considered desirable to exclude data drawn from the post tests from the students' course record cards although students would be told that the content material of the courses under investigation would be examined formally at a later date. Given these conditions the danger of test scores becoming little more than that which might be expected from chance was apparent. On the other hand it was surmised that incorporation of the testing programme of the experiment within the official examination programme of the College would have resulted in a reduction of the possibility of discriminating between the variants of the teaching method. The necessity to achieve a stated minimal grade in the tests would have motivated students towards undertaking intensive programmes of personal study. The introduction of such a powerful variable would almost certainly have masked any significant differences in learning which might have resulted from the utilization of variants of the teaching method. Students reaction to this explanation would be noted during the pilot study.

5. Comparisons by students of the two forms of the study guide (comprehension and problem) which would be used to direct the group-discussion sessions would provoke undesirable discussion and interest. In such circumstances novelty effects would tend to reduce the usefulness of the resultant data. It was planned to so organise the teaching sessions that the two
forms of the study guide would be available for comparison (if this occurred) and, at the close of the teaching sessions to establish by discussion whether or not comparisons had been made.

6. An assessment of the power of individual test items would be undertaken using a conventional item power index.

The class selected for the pilot study consisted of students in the first year of training who were regarded as being of more than average ability when compared with the student population of the College as a whole. Selection for the class had been made on the basis of assessments made at secondary schools and as a result of an initial programme of ability testing administered at the College. As there was no intention of comparing the data obtained from this class with that derived from classes participating in the main experiment the somewhat atypical nature of this group was not considered to be disadvantageous. There were 36 students in the class.

Procedures

A questionnaire \(^{61}\) seeking relevant information about each student was distributed two weeks before the commencement of the experiment and collected after one week.

Pre-test \(^{62}\) was administered and at a subsequent

\(^{61}\) Appendix A

\(^{62}\) Appendix B
teaching session, i.e. after one week, Topic X (Adaptive Features of Mammals) was introduced. The teaching session, which was identical to that which had been planned for the main experiment, was of two lecture-hours or, in practice, eighty-minutes duration. Students were requested to study in self-selected discussion groups of five or six individuals. Study Guides\textsuperscript{63} were issued and reading and discussion in groups followed the schedule outlined in the guides. The session closed with a review of the contents of the study guide conducted by the lecturer on a class discussion basis. During this discussion the lecturer followed a pre-arranged teaching plan.\textsuperscript{64} Post-test\textsuperscript{65} was administered one week later and the students were subsequently requested to mark their own scripts under the guidance of the lecturer.

A similar procedure was followed for Topic Y,\textsuperscript{66} (Inter-relationships on the Rocky Sea Shore). Because of an unanticipated change of lecture-hours this class of students was not available for the remainder of the pilot study as had been planned i.e. for the testing of Topic Z,\textsuperscript{67} (Plants on the Sand

\textsuperscript{63} Appendix E
\textsuperscript{64} Appendix G
\textsuperscript{65} Appendix B
\textsuperscript{66} Appendix E
\textsuperscript{67} Appendix B
Dunes) and the Transfer Test. It was considered that should the data gathered from the teaching and testing of Topics X and Y prove to be useful then the outcomes of the pilot experiment, even in its truncated form, could be employed to make some inferences regarding the feasibility of the main experiment.

Development of the Pilot Study

No unusual reactions to the materials of the experiment i.e. to the study guides and tests, were noted during the course of the teaching programme.

The experiment continued with little manifest evidence of undue enthusiasm or curiosity on the part of the students. During a subsequent discussion members of the class claimed that the session had been similar to those to which they had previously become accustomed. On these grounds the possibility of a novelty effect occurring in the experimental programme proper was dismissed.

No increase or decrease in normal co-operativeness was noted.

The normal level of involvement and interest in the study session shown by the students appeared to indicate that

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68 Appendix C
the procedures adopted i.e. of informing them that the subject material of the topics would be examined in future formal examinations but not through the tests administered during the experiment, had been successful in maintaining students' concern for learning about the topics at a moderate level. Although not evident superficially the possibility of some differential contamination at this level cannot be entirely discounted. Some caution in the interpretation of test results thus seemed to be indicated.

During the initial teaching sessions students were instructed to gather in groups. Of the six groups formed, three were issued with Study Guide Form A/B⁶⁹ (Topic X) and the remaining three with Study Guide Form C/D⁷⁰ (Topic X). This procedure was repeated with Topic Y. The membership of the self-selected study groups varied from session to session. It was not intended that the composition of the groups during each teaching session would be identical, nor did this factor appear to be relevant within the context of the experiment.
In subsequent discussions it became clear that students had not suspected that different forms of the study guide had been prepared and issued. In fact some surprise was expressed at this disclosure. On this basis it was assumed that there was little

⁶⁹ Appendix E
⁷⁰ Appendix F
possibility that cross-checking would occur during the main experiment; if comparisons had not been made within a class when the students were engaged in study within a single room it seemed unlikely that comparisons of study guides would be made between members of separate classes outside of teaching sessions.

Items for Tests X and Y had been adopted after extensive consultations with colleagues. Before the commencement of the pilot study lecturers agreed that few further modifications could be made to the test items through the preparation of alternative distractors but it was considered advisable to reinforce subjective opinion regarding the usefulness of individual items with objective data drawn from an analysis. An analysis of the power of individual test (X and Y) items was made by the I.P.I. (Item Power Index) method.\(^7\) Ten items did not discriminate above the basal level described in the I.P.I., but it was considered advisable to continue with their use on the grounds that replacement items could not be formulated within the circumscribed context of the study programmes. Although the level of discrimination required by the I.P.I. test appears to be excessively high\(^8\) it is recognised that


\(^8\) Smawley R.B., "Compact Item Analysis of Classroom Tests", Science Education, 48-5, p. 317
the comparative lack of ability to discriminate demonstrated by some items should be taken into account when data derived from the tests is being interpreted.

Conclusions

With the reservations mentioned above, the writer was satisfied that the teaching procedures, the study guides and the testing programmes examined in the pilot experiment were adequate for use in the experiment proper.

III COMPOSITION OF THE CLASSES USED IN THE EXPERIMENT

Eight classes of students were available over a period of one month for participation in the main experiment. Classes A, B, C, D, were students in their first year of training who were undertaking the course in science teaching. Classes E, F, G, H, were made up of students in their second year of training who were attempting a similar course. The distribution of the measured intellectual capacity of the personnel of classes A, B, C, D, and E, F, G, H, is described in the following table.

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73 Students entering the College who were drafted to classes A, B, C, D, were required to undertake a course in science teaching of 60 hours duration during their first year of training. Students posted to classes E, F, G, H, did not commence this study until the beginning of their second year of training. The courses were identical.
Students in classes E, F, G, H, were approximately one year older than those in classes A, B, C, D, when the aggregated differences between the means of their ages was considered. The majority of students in classes E, F, G, H, had successfully passed or had been accredited with the University Entrance Examination. Few of the students in classes A, B, C, D, had attained an equivalent educational standard at the time of their admission to Teachers’ College. In terms of this measure of achievement classes A, B, C, D, were comprised of less able students. A similar conclusion was reached by comparing the distribution of A.L.A.Q. scores.

The comparability of Classes A, B, C, and D, in terms of measured intellectual capacity was established on the

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Appendix D
following basis: the personnel of the classes were selected on an alphabetical basis. The writer can find no evidence which suggests that there is other than a random distribution of intellectual ability among segments of the population as delimited by the initial letter of the surname. A.L.A.Q. (combined) scores are included in the following figure which indicates that this assumption is justified in that it is supported by objective evidence derived from A.L.A.Q. tests of intellectual ability.

TABLE III

DISTRIBUTION OF SCORES (IN STANINES) OF TEACHERS' COLLEGE ENTRY TESTS (AL A.Q. COMBINED) COMPARING CLASSES ABCD

<table>
<thead>
<tr>
<th>CLASS A</th>
<th>n = 39</th>
<th>CLASS B</th>
<th>n = 33</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 2 1 1 7 8 5 3 2 0</td>
<td>4 4 3 1 0 6 0 6 0 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS C</th>
<th>n = 35</th>
<th>CLASS D</th>
<th>n = 33</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6 7 8 9</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 3 5 3 1 4 4 1 1 2</td>
<td>5 5 4 4 5 4 4 2 0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Furthermore, the personnel of the groups were comparable in terms of age, sex and prior experience of biology (Completion of a fifth form high school course in biology was accepted as a criterion of previous experience in this aspect of science).
Each of the classes A, B, C, and D, was undertaking a similar course in the teaching of science and had, at the time of the experiment, completed approximately one half of the course.

Clearly the composition of the experimental classes A, B, C, and D, was of a sufficient degree of homogeneity to ensure that gross interaction effects at the class level would not obscure the effects of the independent variables.

Students were apportioned to groups E, F, G, and H, in part on an alphabetical basis but also because of their stated intention to pursue supplementary courses of university studies i.e. there were more students undertaking university studies in Education in classes E and F than in classes G and H. It was assumed that there was a likelihood of the occurrence of some interaction between the specialised and developed interests of the subject-orientated classes of students with the information and materials of the science teaching programme. However, it was anticipated that the nature of the sample would provide opportunities for making a variety of subjective observations and that other quantitative data obtained might be related with caution bearing in mind the significance of gross differences in specialised interests among the individuals of the various classes and the interaction effects these would be likely to have with the experimental variables.
Thus it was clear that the comparable classes A, B, C, and D, should form the population for the experiment proper and that correlated evidence obtained from the treatment of classes E, F, G, and H, could be used cautiously in a supportive capacity.

IV ADJUSTING THE METHOD OF TEACHING

The Method in Practice

The method of teaching, i.e. a task-centred group-discussion technique, and the accepted justification for its use in the course in science teaching have already been described and outlined in Chapters 2 and 3. Briefly, it was anticipated that the method employed would result in the acquisition of factual knowledge, (both as a result of learning experiences in the lecture room and through directed reading) the learning of principles, and the development of appropriate attitudes to methods of teaching similar topics to classes of children. It was expected that learned general principles would be able to be re-applied to allied areas as an aid to understanding.

In practice, the group discussion technique involved 'reading-for-information' (described as 'comprehension' in this study) sessions with associated small group and subsequent class discussions. Upon some occasions concrete
objects (i.e. living organisms or physical science apparatus) were made available to the students. Guidance was provided orally, by the teacher or through the text of the guide sheets provided.

To test the major hypotheses of this study the variants of the teaching method were clearly defined.

Comprehension Form:
Study Guides only (A) 76
Comprehension Form:
Study Guides plus concrete objects (B) 77
Problem Solving Form:
Study Guides only (C) 78
Problem Solving Form:
Study Guides plus concrete objects (D) 79

The Topics to be Studied

In accordance with the prescription of the course in science teaching for the period which included the experiment three topics were selected within the context of which an examination of the influence of the teaching method could be made:

Mammals
Their characteristic features
The general notion of adaptive features

76 Appendix E
77 Appendix E
78 Appendix F
79 Appendix F
Seashore Life
Some common organisms found on the rocky seashore
The general notion of inter-relationships between
plants and animal, and animal and animal.

Plant Life on the Sand Dunes
Common plants of the sand dunes
The general notion of succession

The form of the Study Guides

For the purposes of the experiment it was necessary
that the study guides should conform to pre-established
criteria.

1. They should contain only that amount of information
which could reasonably be expected to be assimilated during
the maximum of eighty minutes available for the study of each
topic.

2. The guides should lend themselves to production in
two parallel forms i.e. in 'comprehension' and 'problem'
variants.

3. The alternative forms of the study guides should
resemble each other so closely that the possibility of cross-
checking with concommitant novelty effects would be avoided.

4. The contents of the guides should add something
relevant to students' knowledge (a justifiable pre-requisite
to the granting of permission to carry out the projected
research within the Science Department).
The common features of the six study guides were:

1. Each was printed on both sides of a single sheet of foolscap paper.

2. Each commenced with a set of explicit instructions which detailed the activity for the teaching period and outlined testing arrangements.

3. The introductory sentences took the form of a brief statement which indicated the relationship between the topic under consideration and its place in the curriculum of the primary school.

4. The bulk of each guide was devoted to the exposition of a general notion (adaptive features, inter-relationships, succession) and this included pertinent factual information.

5. In each case some information was presented in pictorial/diagrammatic form.

6. A comment on teaching methods was couched in terms which were not unduly prescriptive e.g. from Study Guide Mammals 81 "Lessons about mammals are best undertaken by presenting children either with pictures of mammals or with real mammals".

7. Each guide contained a set of exercises which was prefaced by the instruction 82 "Please record your answers during

80 Appendices E and F

81 Appendix E

82 Appendix E
the period but discuss these with the members of your study group before noting them". This feature was designed to ensure that the information presented in the guide was reviewed, and to give a directed basis for class discussion.

Each guide concluded with a reading reference. The significant reference, which was entitled "Essential Reading", referred to a textbook which was in the possession of all students participating in the course.

Each of the study guides was prepared in two forms.

The 'Comprehension' Form. It was planned that the factual information and the explanation of general principles contained in this variant of the study guide should be sufficient in itself to enable students to make adequate responses to the questions set in the "Exercises from the Study Guide".

The 'Problem' Form. Some essential information was included, but a section of the guide was devoted to the

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83 Appendix E


85 Further references i.e. to "Additional Reading" were provided. The volumes mentioned were held in reserve in the College library. In fact, only five students availed themselves of the opportunity to read further (as judged by the number of occasions on which these books were issued) throughout the experiment.

86 Appendix E

87 Appendix F
presentation of a set of simple problems which could be solved readily by deductive and logical methods.

**Similarities between the Two Forms.** The superficial similarities between the two forms were preserved. Factual information was included in the 'Problem' form to compensate for the limited pool of knowledge which, it was anticipated, would be available to the participating students.

The extent to which numbers of problems could be included in the 'Problem' form was limited in part by the relatively short time available during each teaching session for group discussion and problem-solving activities but, more pertinently, by the necessity to maintain the similarity of appearance between the two forms.

**The 'Concrete' Objects**

Concrete objects i.e. living animals and plants, were presented during study sessions to classes B and D in the main experiment, and to classes F and H in the subsidiary experiment. Precautions were taken to ensure that it would not be possible for students in classes A, C, E, and G, to become aware of the existence of the concrete materials. Between teaching sessions animals and plants were housed in a preparation room to which students were not permitted access.

**Mammals.** The mammals were presented in cages. These were rotated informally through the working groups. It was
possible to remove the animals from the cages for closer inspection. Species utilized were: house cat, hedgehog, rabbit, guinea pig and white mouse.

Seashore Life. Each working group was furnished with a shallow, enamelled dish containing a quantity of seawater. In each dish living specimens of the following animals were placed: dark topshell, anemone, cushion starfish, half-crab and rockfish.

Plant Life of the Sand Dunes. A reduced cross-section of a sand dune was constructed in a large galvanized tray. Growing plants were used. The tray was set in the centre of the lecture room and could be examined freely by members of the study groups. Specimens of plants featured in the reconstruction of the sand dune area were also made available for examination within the discussion groups.

Procedures Adopted During Class Sessions

Two adjacent lecture periods each of a maximum of forty minutes duration were available for the teaching of each of the three topics. In practice between seventy and eighty minutes of this time was utilized for active study and discussion.

Two lecturers were required to direct the course of studies. The experimenter conducted the teaching programme with classes A, B, C, D, and an associate directed the studies of classes E, F, G, and H. Teaching procedures were standard-
ized in order that effects resulting from variations in the approach of the two lecturers should be reduced to a minimum.

Factors in the standardizing process were the experimental design which imposed a clearly definable form upon the teaching sessions, the identical study guides which were made use of by both lecturers and the preliminary discussions which took place between the lecturers about both the intent of the experiment and the content of the lessons.

The lecturers agreed to adhere to a common "lesson plan" for each topic. Each plan included a detailed statement of the procedures to be adopted during the lesson and a precise summary of those aspects of the lesson which would be examined in the testing programme and to which it was essential that all students should have been exposed; the associate lecturer observed at teaching sessions during the pilot study.

Each teaching session was followed by a discussion between the writer and his associate in order that subjective observations might be assessed and recorded.

General Programme for a Teaching Session

Organization and Introduction to Topic. (Ten minutes)
The students were requested to gather in groups of six. The arrangement of the lecture room furniture facilitated the form-

Appendix G
ation of groups. Each student was issued with a copy of the appropriate form of the study guide.

**Study Period** (Thirty to Forty Minutes) During this period students read the study guide. Those issued with Form A/B wrote answers to comprehension type questions after discussion within their group. Students using Form C/D attempted to solve set problems and recorded their solutions in a similar way. In addition, students in Classes B and D examined appropriate animals or plants.

**Class Discussion and Summary** (Up to Thirty Minutes)
The lecturer conducted a class discussion session during which he reviewed comprehension or problem questions and in the case of classes using study guide Form C/D corrected proffered solutions in those instances where this was necessary. In this context the main purpose of the discussion was to equate the amount and type of information presented to each class and to ensure in particular that students using Form C/D did not leave the lecture room having recorded erroneous information. The matter of teaching methods applicable to the primary school classroom was not discussed. For the purposes of the experiment, discussion of emergent issues was curtailed on those occasions when the teacher considered that the overlong examination of otherwise relevant diversions was jeopardizing the equation of the amount and type of testable information presented to each class. Attention was drawn to the suggestions
for further reading which were included in the study guide and to a note about the time and duration of a forthcoming testing period.

**Summary**

The organisation and presentation of materials was arranged to enhance the effects of the selected method variables while at the same time efforts were made to reduce the possibility of the occurrence of novelty and other extraneous effects. However, it is conceded that in spite of the precautions taken, the possibility that the lecturers varying interests and aptitudes, relative to the elements of the teaching methods under examination, may have been reflected in the post-test scores, could not be entirely disregarded.

V THE PROGRAMME OF TESTING

**The Pre-tests**

Significant variation in previous exposure to formal learning situations in biology existed between individual students in the samples selected for the study to negate the possibility of postulating a common basal level of knowledge and understanding.

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89 Appendix B
Thus a pre-test was designed to assist in the establishment of a basal level of knowledge and understanding for each of the topic areas to be explored. The decision to proceed with the construction of the tests was made when it became apparent that available standardized tests bore insufficient relationship to the subject material of the current course to warrant their use in the experiment.

The demands of the experimental situation made it essential that for each of the topics to be investigated a basal level be established (for each student) with regard to specific factual information included in the study guide, the general principles to be considered, and information contained within the further reading which students would be asked to undertake.

The Post-tests

The post-test was identical with the pre-test thus allowing for direct assessment of increments of factual knowledge and understanding to be made. It was recognised that difficulties could arise through the employment of a programme of testing organised this way. Identified problems are discussed in the following paragraphs.

A knowledge of pre-test scores could influence post-

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90 Appendix B
test scores. For this reason students were not informed of their pre-test scores.

Students could be annoyed and frustrated by the re-application of pre-tests and post-tests. This factor was examined by referring to the reactions of the pilot class after the administration of the first and second post-tests. Negative reactions were not expressed. Indeed, the majority of students did not recognize that the pre and post test items were similar in each case although some students reported that they recalled some test items and considered that others were "vaguely familiar".

The pre-test itself could be of teaching value in that it might draw the attention of students to the subject matter of the topic to be considered. There is no evidence to suggest that the occurrence of this phenomenon would have differentially affected the outcomes of learning by the various classes although interaction effects between this and other subject variables e.g. previous science experience and interest, cannot be discounted.91

Use of Multiple Choice Tests

The variety of forms of multiple choice and other objective-type tests which were in constant use in the Teachers' 

College precluded the possibility of the contamination of the results of the testing programme through novelty effects in this instance. In order to increase the strength of the programme of testing and to facilitate the scoring process a multiple choice-type test with five options for each item was selected. Four distractors were provided in each case plus a "don't know" category.

**Number of Items in the Tests**

The conditions under which the experiment was conducted imposed limits upon the number of test items which could be used.

**Time**. Thirty minutes of testing time only were made available for each teaching session (thus allowing fifteen minutes each for pre and post tests).

**The extent of testable information**. A strictly limited quantity of testable information was presented in the study guides and ancillary reading. It was, in fact, a difficult exercise to amass thirty items with significant test value in each topic area.

Test items were allotted within each topic area as follows:

- Knowledge of factual information (from the study guide) 10 items.
- Knowledge of principles (from the study guide) 10 items.
- Knowledge of factual information (from the required reading) 10 items.
Use of Test Scores

Scores could be examined within each sub-section of each of the three tests, or by aggregating test scores from each of the three topic areas. Individual performance could thus be assessed further on the basis of a ninety item multiple choice test. A sub-analysis would be made on the basis of a thirty item cross-topic aggregation of the items in each of the three categories: facts (30), principles (30), reading (30), (see Table IV).

<table>
<thead>
<tr>
<th>Knowledge of Factual Information from the Study Guide.</th>
<th>Items For Analysis Separately</th>
<th>Total Items For Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of Principles from the Study Guide</td>
<td><strong>TOPIC X</strong> 10 10 10</td>
<td>30</td>
</tr>
<tr>
<td>Knowledge of Factual Information from the Required Reading</td>
<td>10 10 10</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>30 30 30</td>
<td>90</td>
</tr>
</tbody>
</table>

Randomization of Test Items

The assembled items for each test were randomized by using a random number table to order items from each of the three
sections of the test. These were designated Q1, Q2, Q3, etc. The process was repeated until all thirty items were numbered.

Administering the Tests of Factual Knowledge and Understanding

Each pre and post test was prefaced by a set of instructions which emphasized the penalty for guessing. A completed example of the type of item used in the test was then presented. Students completed the example with the assistance of the lecturer before proceeding with the test. The pre-test was administered one week before the relevant teaching period, the post-test one week after the teaching period. The pattern of distribution of the teaching and testing periods was determined by the fixed timetable of lectures.

Scoring the Post-tests

Post-tests were scored by the students at the conclusion of each testing period. In this way the post-tests were utilized as teaching devices and to this extent their inclusion in the course was justified. It was recognized that interaction between this procedure, the variant of the teaching method employed and the programme of testing for transfer could occur. The scoring of the post-tests was checked by the researcher. There was no evidence of alterations having been made to test responses. It was considered that the non-assessable nature of

\[92\text{Appendix B}\]
the programme (that is, in relation to the students' general assessment by the College) would have reduced the motivation for cheating to a low level. It was noted that in three instances where students misinterpreted the stated purposes of the tests evidence of cheating was discovered. To obtain total scores students were requested to add plus and minus scores of individual items. In view of the multiplicity of choices of responses available for each item in the tests no correction was made for guesses in the preparation of scores for processing. Thus minus scores were not considered and raw data was compounded from the records of unmodified correct responses.

Testing for Transfer

One objective of the course in science teaching was:

...... "to give practice in the application of general principles....". In order to test the differential attainment of this objective a test\(^9^3\) was devised which was administered one month after the final post-test for short term recall. The transfer test contained thirty items which were to be answered in fifteen minutes. Ten items relate each of the three motions of adaptation, interdependence, and succession (as described in Study Guides A, B, and C respectively) to the ecosystem of the

\(^9^3\)Appendix C
Avon River/Heathcote River Estuary (Christchurch). The thirty test items were assembled in random order. Sufficient information was printed on the test paper to permit students to attempt to apply the previously learned principles.

In the case of the test for transfer a pre-test was not administered. On the basis of the writer's personal knowledge of studies undertaken in secondary schools in the area it seemed unlikely that a significant number of students, if any, would have investigated the area of the estuary in relation to the three general notions to be examined.

The 'Method' Section of the Post-test

An attempt was to be made to assess the effects of the presence or absence of concrete objects during the teaching sessions upon the stated opinions of the students regarding the importance of the presence or absence of concrete objects when primary school children were learning about similar plants and animals.

Students were asked to note which three of twelve described features of a classroom lesson they regarded as contributing most significantly to learning in the particular setting of a specific science lesson. The choice was forced i.e. all the described features could be regarded as being

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94 Appendix B
significant to a greater or lesser degree in the teaching situation. It was reasoned that those students who had been markedly motivated by the presence of concrete materials might tend to include the option "Living mammals (seashore animals, sand dune plants) present", within their first three choices more frequently than students who had studied in the presence of diagrammatic material only.

The discussion of the significance or otherwise of the presence or absence of concrete objects in the primary classroom was avoided during the period of class discussion.

This section of the experiment was regarded as most tentative as a greater or lesser degree of interference was anticipated from the influence of the approach of the total course in science teaching in which there was a strong positive stress upon the significance of all educational experiences involving objects and events.

It was proposed to score the test responses by ascribing a loading of three units for each instance in which the "Living mammals present" appeared as the first choice within the three choices permitted, two units for second place and one for third.

Students were offered the opportunity to make a written comment on the method section of the test if they desired. It was anticipated that in this way subjective comments relating to the nature of the students' motivation could be gathered.
Additional Correlates

Information which it was anticipated, would be used in establishing essential correlates was obtained from students before the commencement of the testing and teaching programme. This information included: sex; age (years, months, at the time of the commencement of the experiment); total marks obtained in the School Certificate Examination; scores on the ALAQ testing programme administered in the Teachers' College; place where childhood spent i.e. country, small town, city; level attained in studies of biology in secondary school. A simple rating scale was devised which ranked students 0-10 on science interest and experience. The questionnaire from which the ratings and other information were derived examined students' secondary school experiences in science and mathematics, their preference for science studies at secondary school and at Teachers' College, their science hobbies and television viewing interests.

\[95\] Appendix A
\[96\] Appendix A
Chapter 5

THE DEVELOPMENT OF THE STUDY

I INTRODUCTION

In general the procedures devised for use in the pilot study proved to be effective when they were used in the experiment proper. However, attempts to test the validity of Hypothesis 4:

Students would show a preference for permitting children to manipulate concrete objects during classes if they themselves (the students) had learned about related objects and ideas in the presence of similar concrete objects.

were discontinued when it became evident that the devised testing procedure\(^{97}\) was insufficiently sensitive to detect changes in stated commitment to method and, in addition, that the period of time over which the experiment was being conducted would be of inadequate duration to allow valid conclusions being drawn from the accumulated data. Furthermore, evidence drawn from students' subjective comments on teaching methods (for children) indicated that they were responding to the overall approach of the Teachers' College (in relation to approved teaching methods in schools) rather than to commitments which

\(^{97}\)Appendix B
may have arisen during the teaching session of the current research programme. This source of massive and possibly differential contamination could not be disregarded. References to the hypothesis however, have been retained throughout the thesis in order that its relationship to the whole study might be demonstrated.

II SUBJECTIVE OBSERVATION

General Reaction of Students to the Teaching Programme

Students on the whole responded satisfactorily to the contents of the teaching programme. The belief, based on experience derived from the pilot study, that the various forms of the study guides would not be compared proved to be well-founded. At the close of the experiment some students reported that they had been disappointed in not having been permitted to examine living creatures when other students had presumably been given this opportunity. Few students were in this category; most appeared to have been unaware of the treatments which had been accorded other classes.

Overt Reactions to the Variants of the Teaching Method

Both the writer's colleague and the writer noted that the least enthusiasm for relevant discussion was engendered in classes A and B i.e. those which had been supplied with the comprehension form of the study guide only. Most students in
these classes co-operated as usual during the teaching sessions but took part less vigorously in discussions and appeared (on the basis of subjective estimates by the lecturers) to ask fewer questions during subsequent full class discussion sessions. It may not be entirely coincidental that the only overt negative reactions to the experiment as a whole (not uncommon amongst students at tertiary level) came from a group of students in class E.

Students supplied with the comprehension form of the study guides plus living animals or plants and those using the problem solving form of the guide showed increased interest, took part in more animated discussions and asked more questions during the full class sessions. More intense interest and involvement was demonstrated by students who were able to examine animals and plants in conjunction with the problem solving forms of the study guides. It was the impression of both lecturers that the presence of plants (Topic 2) did less to arouse interest than living animals.

There was no evident change or diminution of interest in the topics presented during the course of the experiment.

**Reaction of Students to the Programme of Testing**

Some adverse reactions to the programme of testing were voiced by individual students, more particularly those in class E. When the experiment had been completed students
responded to the query: "Did you find the testing onerous?" by commenting that they thought there had been "too much testing". The reaction on the whole however, was both vague and weak indicating that resistance to the programme of testing had not been extensive.

Approaches of the Two Lecturers

Both the writer's colleague and the writer attempted to ensure that their teaching procedures were strictly comparable. The teaching schedules\textsuperscript{98} were adhered to rigourously. In discussion prior to the commencement of the experiment, they had explored what would have seemed to be the advantages and disadvantages of the variants of the method from the lecturers' points of view. In adopting this procedure it had been hoped that both lecturers would have been able to maintain, overtly, a neutral and objective stand throughout the experiment insofar as this was possible. In spite of the widely differing views of the lecturers on matters of educational theory and practice in general, the comparability of the scores of the two groups of classes taught tends to indicate that they had sustained this position successfully. Nevertheless, the possibility of contamination of the experimental data from this source cannot be entirely disregarded.

\textsuperscript{98}Appendix G
III ANALYSIS OF THE DATA

Introduction

In attempting to isolate a constant or constants which would enable the data to be analysed with the aid of more powerful statistical tools (i.e. analysis of variance) the writer had selected both the ALAQ\textsuperscript{99} scores of students and their ratings on a science interest/experience scale\textsuperscript{100} for closer examination. With reference to ALAQ scores, it was assumed that this measure of general intelligence might be found to be positively and significantly related to the student's tested ability to learn factual information and general principles. If this, in fact, did not prove to be the case\textsuperscript{101} then it was conjectured that ratings on a science interest/experience scale might provide an alternative constant. The scale contained a strong attitudinal component which it was anticipated, might have correlated more closely with performance in the science studies than tested results of general mental ability.

\textsuperscript{99} Appendix D
\textsuperscript{100} Appendix D
\textsuperscript{101} Observations of the relationship between tested mental ability and performance in examinations in general within the Teachers' College suggested that this relationship was not high (personal communications from Adams E., Principal Lecturer in Mathematics, Christchurch Teachers' College).
Preliminary Correlations

Two classes were selected at random from classes ABCD for the preliminary tests of correlation. These were classes A and B. The correlations calculated, using the Pearson Product Moment method were:

1. ALAQ (raw scores) with total pre-test scores, total gain scores, science interest/experience ratings.

2. Science interest/experience ratings with total pre-test scores, total gain scores, ALAQ (raw scores).

The outcomes of the calculations are summarized in Tables V and VI.

TABLE V

CORRELATIONS OF ALAQ RAW SCORES
(PEARSON PRODUCT MOMENT METHOD)

<table>
<thead>
<tr>
<th>CLASS</th>
<th>TOTAL PRE-TEST SCORES</th>
<th>TOTAL GAIN SCORES</th>
<th>SCIENCE INTEREST/EXPERIENCE RATINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n=35)</td>
<td>.14</td>
<td>.31</td>
<td>.29</td>
</tr>
<tr>
<td>B (n=32)</td>
<td>.21</td>
<td>.24</td>
<td>.09</td>
</tr>
</tbody>
</table>
TABLE VI

CORRELATIONS OF SCIENCE INTEREST/EXPERIENCE RATINGS
(PEARSON PRODUCT MOMENT METHOD)

<table>
<thead>
<tr>
<th>CLASS</th>
<th>TOTAL PRE-TEST SCORES</th>
<th>TOTAL GAIN SCORES</th>
<th>ALA QA SCORES</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>.24</td>
<td>.20</td>
<td>.29</td>
</tr>
<tr>
<td>(n=35)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>.11</td>
<td>.07</td>
<td>.09</td>
</tr>
<tr>
<td>(n=32)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Outcomes of the Correlation Procedures

The correlations between students' ALAQ scores, pre and post-test scores and ratings in the science interest/experience scale for the selected classes as presented in Table V were positive but slight. Similarly, the correlation between ratings for previous science interest/experience and pre and post-test scores was low (Table VI). It appeared unlikely that any significant information would be gained by utilizing pre-test scores as a covariant as these had shown only insignificant correlations with the other major variables. The effect of the other unexamined variables e.g. the students' speed of reading, level of independence and general orientation towards the professional task could not be disregarded but in practice it seemed likely that the motivational climate of each learning situation was likely to be the factor which would correlate most significantly with learning outcomes.
The writer concluded that the effect of the independent variables could be adequately examined by utilizing the t test of the significance of differences between the mean scores of the various tests of the otherwise comparable classes. It was recognized that this statistical technique would not aid in the exposure of subtle interaction processes but would offer a coarse but reliable method of examining the effect of the independent variables. This decision was in keeping with the writer's reservations concerning the effects of differential contamination from the various sources mentioned above and his reluctance to draw more from the data than was warranted by its reliability.

Calculations of the t Test of Significance of the Difference Between Related Means

The t tests: t tests of the significance of differences between comparable means for classes ABCD were applied to:

1. Total gain scores
2. Total facts/gain scores
3. Total principles/gain scores
4. Total reading/gain scores
5. Transfer test scores
6. Gain scores Topic X
7. Gain scores Topic Y
8. Gain scores Topic Z
For classes EFGH, t tests were applied to:

9. Total gain scores
10. Gain scores Topic X
11. Gain scores Topic Y
12. Gain scores Topic Z

The results of the t tests are presented in the tables which form the bulk of this section of the chapter.

Where differences between the means are significant at the .05 level of confidence or greater the appropriate figures have been entered in the right-hand column in each table.

In each case df has been calculated as $\sqrt{N(1)+N(2)}-2$.

### TABLE VII

**t TEST 1 TOTAL GAIN SCORES CLASSES ABCD**

<table>
<thead>
<tr>
<th>CLASSES AND TREATMENTS</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>35</td>
<td>32</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>$\bar{x}$</td>
<td>17.837</td>
<td>20.562</td>
<td>18.333</td>
<td>14.484</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>6.347</td>
<td>8.373</td>
<td>4.819</td>
<td>6.382</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>t TEST</th>
<th>LEVEL OF CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>1.498</td>
</tr>
<tr>
<td>AC</td>
<td>0.336</td>
</tr>
<tr>
<td>AD</td>
<td>2.184</td>
</tr>
<tr>
<td>BC</td>
<td>1.273</td>
</tr>
<tr>
<td>BD</td>
<td>3.298</td>
</tr>
<tr>
<td>CD</td>
<td>2.680</td>
</tr>
</tbody>
</table>
### TABLE VIII

**t Test 2 Total Facts/Gain Scores Classes ABCD**

<table>
<thead>
<tr>
<th>Classes and Treatments</th>
<th>t Test</th>
<th>Level of Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>35</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.429</td>
<td>3.744</td>
<td>6.400</td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.087</td>
<td>3.965</td>
<td>3.820</td>
</tr>
</tbody>
</table>

### TABLE IX

**t Test 3 Total Principles/Gain Scores Classes ABCD**

<table>
<thead>
<tr>
<th>Classes and Treatments</th>
<th>t Test</th>
<th>Level of Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>35</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.343</td>
<td>8.875</td>
<td>8.900</td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.505</td>
<td>4.682</td>
<td>3.429</td>
</tr>
</tbody>
</table>

### TABLE X

**t Test 4 Total Reading/Gain Scores Classes ABCD**

<table>
<thead>
<tr>
<th>Classes and Treatments</th>
<th>t Test</th>
<th>Level of Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>35</td>
<td>32</td>
<td>30</td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.600</td>
<td>4.156</td>
<td>3.467</td>
</tr>
<tr>
<td>s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.871</td>
<td>3.606</td>
<td>3.658</td>
</tr>
</tbody>
</table>
### TABLE XI

**t Test 5** Transfer Scores Classes ABCD

<table>
<thead>
<tr>
<th>Classes and Treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>( t ) Test</th>
<th>Level of Confidence</th>
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</thead>
<tbody>
<tr>
<td>( n )</td>
<td>35</td>
<td>32</td>
<td>30</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>13.285</td>
<td>13.218</td>
<td>13.866</td>
<td>12.030</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( s )</td>
<td>3.836</td>
<td>3.585</td>
<td>3.879</td>
<td>4.393</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE XII

**t Test 6** Gain Scores: Topic X Classes ABCD

<table>
<thead>
<tr>
<th>Classes and Treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>( t ) Test</th>
<th>Level of Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n )</td>
<td>39</td>
<td>33</td>
<td>36</td>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>4.359</td>
<td>5.939</td>
<td>5.361</td>
<td>4.805</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( s )</td>
<td>3.166</td>
<td>3.625</td>
<td>2.699</td>
<td>3.134</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE XIII

**t Test 7** Gain Scores: Topic Y Classes ABCD

<table>
<thead>
<tr>
<th>Classes and Treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>( t ) Test</th>
<th>Level of Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>( n )</td>
<td>38</td>
<td>34</td>
<td>34</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \bar{x} )</td>
<td>6.342</td>
<td>6.824</td>
<td>5.853</td>
<td>3.649</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( s )</td>
<td>3.263</td>
<td>4.294</td>
<td>2.830</td>
<td>2.988</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE XIV

**t TEST 8 GAIN SCORES: TOPIC Z CLASSES ABCD**

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>t TEST</th>
<th>LEVEL OF CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>36</td>
<td>33</td>
<td>33</td>
<td>38</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>x̄</strong></td>
<td>6.444</td>
<td>7.030</td>
<td>6.393</td>
<td>6.026</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>s</strong></td>
<td>3.483</td>
<td>3.904</td>
<td>3.229</td>
<td>3.876</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE XV

**t TEST 9 TOTAL GAIN SCORES CLASSES EFGH**

<table>
<thead>
<tr>
<th></th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>t TEST</th>
<th>LEVEL OF CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>25</td>
<td>31</td>
<td>25</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>x̄</strong></td>
<td>15.600</td>
<td>20.226</td>
<td>22.840</td>
<td>19.852</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>s</strong></td>
<td>6.190</td>
<td>7.205</td>
<td>9.102</td>
<td>6.926</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE XVI

**t TEST 10 GAIN SCORES: TOPIC X CLASSES EFGH**

<table>
<thead>
<tr>
<th></th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>t TEST</th>
<th>LEVEL OF CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>n</strong></td>
<td>30</td>
<td>35</td>
<td>32</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>x̄</strong></td>
<td>4.967</td>
<td>7.600</td>
<td>9.625</td>
<td>6.333</td>
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<td></td>
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<tr>
<td><strong>s</strong></td>
<td>3.146</td>
<td>4.086</td>
<td>4.021</td>
<td>3.259</td>
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</tr>
</tbody>
</table>
**TABLE XVII**

**t TEST 11 GAIN SCORES: TOPIC Y CLASSES EFGH**

<table>
<thead>
<tr>
<th>CLASSES AND TREATMENTS</th>
<th>t TEST</th>
<th>LEVEL OF CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E FH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>23 35</td>
<td>27 31</td>
</tr>
<tr>
<td>x</td>
<td>6.640</td>
<td>7.068 7.148 7.193</td>
</tr>
<tr>
<td>s</td>
<td>3.160</td>
<td>3.850 4.080 3.847</td>
</tr>
</tbody>
</table>

**TABLE XVIII**

**t TEST 12 GAIN SCORES: TOPIC Z CLASSES EFGH**

<table>
<thead>
<tr>
<th>CLASSES AND TREATMENTS</th>
<th>t TEST</th>
<th>LEVEL OF CONFIDENCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E FH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G H</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>26 33</td>
<td>31 36</td>
</tr>
<tr>
<td>x</td>
<td>4.231</td>
<td>4.546 6.259 6.111</td>
</tr>
<tr>
<td>s</td>
<td>3.456</td>
<td>3.105 4.056 3.230</td>
</tr>
</tbody>
</table>

**Examination of the t Test Scores for Classes ABCD**

**Total Gain Scores (Table VII):** The mean scores of the comprehension, (A) comprehension plus concrete objects (B) and problem (C) Treatments/Classes were superior (at the .025, .0005 and .05 levels of confidence respectively) to those of

\[102\text{Henceforth described simply as Classes.}\]
the problem plus concrete objects (D) class. The difference between the mean of classes A and B (17.857; 20.562) were marked though not significant.

**Total Facts Gain Scores (Table VIII):** Only the mean gain scores of class B (Comprehension plus concrete objects) were significantly greater than those of class D (Problem plus concrete objects) at the .01 level of confidence.

**Total Principles Gain Scores (Table IX):** The mean scores of classes B and C were superior to the scores of class D at the .025 and .01 level of confidence respectively. The mean score of class C was significantly greater than that of class A at a .05 level of confidence.

**Total Reading Gain Scores (Table X):** The differences between the mean gain scores in this area were not statistically significant.

**Transfer Test Scores (Table XI):** The mean gain scores of class C were superior to those of class D at the .05 level of confidence.

**Gain Scores: Topic X (Table XII):** For Topic X (Mammals) the mean gain scores of class B were superior to those of class A at the .05 level of confidence.

**Gain Scores: Topic Y (Table XIII):** The mean gain scores of classes A, B, C, were significantly superior to those of class D at the .0005, .0005, and .005 levels of confidence respectively for this topic (Seashore Animals).
Gain Scores Topic Z (Table XIV): There were no significant differences between the mean gain scores of the classes for this topic (Plant Life of Sand Dunes).

Examination of the t Test Scores for Classes EFGH

Total Gain Scores (Table XV): The mean total gain scores of classes F (comprehension plus concrete objects) and G (problem) were superior at the .01 and .005 levels of confidence respectively to those of class E (comprehension). The mean gain scores of class H (problem plus concrete objects) were superior to that of class E at the .025 level of confidence. The mean gain scores of class G were superior to those of class H at a level approaching but not reaching the .05 level of confidence.

Gain Scores Topic X (Table XVI): For this topic (Mammals) the mean gain scores of classes F and G were superior to the scores of class E at the .005 and .005 level of confidence. The mean score of class G was superior to that of class H at the .0005 level of confidence, the scores of class G were superior to those of class F at the .025 level of confidence.

Gain Scores Topic Y (Table XVII): There were no significant differences between the mean test scores of the classes for this topic (Seashore Animals).

Gain Scores Topic Z (Table XVIII): For this topic (Plant Life of Sand Dunes) the mean gain scores of classes H
and G were superior to those of class F at the .025 and .05 level of confidence respectively. The mean gain score of class E was also inferior to that of class H and G at the .025 level of confidence.

IV DISCUSSION ON THE EXPERIMENTAL HYPOTHESES

Because of the writer's previously expressed concern regarding the weak discriminating power of some test items used in the experiment and the possibility that interaction between the lecturer's unconscious bias, the independent and dependent variables could have occurred, and because of the relative coarseness of the statistical techniques employed, the level of acceptance or rejection of the experimental hypotheses was set at the .01 level of confidence.

The experimental Hypothesis 1:

The retention of testable factual information and principles derived from the study guides and information acquired from the suggested readings will vary according to the "strength" (in terms of the Principles of Learning) of the variant of the instructional method which had been encountered by classes of students.

was supported but not sufficiently strongly by the data gathered from Part 1 or the experiment. Total gain scores indicated that the addition of concrete objects (B) to the comprehension learning situation (A) was associated with increased total gain scores but not at a statistically significant level (i.e. at the .01 level of confidence). Hypothesis 3:
The improvements to the teaching method when applied together would not result in further increases in learning outcomes in terms of the retention of actual testable information and principles derived from the study guides and information acquired from the suggested readings. 

was clearly supported by the data as both comprehension plus concrete (E) and, problem Classes (C) scored significantly higher (0.001 level of confidence) than the problem plus concrete object Class (D).

With reference to the learning of facts alone Hypothesis 1 was not supported. The scores of the comprehension plus concrete objects Class (B) were superior (at the .01 level of confidence) to those of the problem plus concrete objects Class (D) thus supporting Hypothesis 3.

Hypothesis 1 was not supported at the required level of acceptability by the analysis of the principles/gain test scores although it must be noted that the scores of the problem Class (C) would have been regarded as superior to those of the comprehension Class (A) if the .05 level of confidence had been acceptable. Hypothesis 3 was supported in that the scores of the problem plus concrete objects Class (D) were clearly inferior to those of the problem (C) Class (.01 level of confidence). At the .02 level, scores of the comprehension plus concrete objects Class (B) were also higher than those of the problem plus concrete objects Class (D).

Neither hypothesis was supported by the analysis of the total reading gain scores. Indeed the generally low attainment
in this aspect of the test would appear to indicate that the students involved in the experiment were not prepared to undertake additional reading when the only effective motivation was that supplied by the prospect of an examination at a remote later date.

Hypothesis 2:

Success in applying learned principles to new problems (transfer) would be most marked in the case of individual students who had been subjected to the problem-solving variant of the teaching method (Principle 3) was not supported by the analysis of the transfer test scores. Problem Class (C) scores were superior to the problem and concrete objects Class (D) scores but at the .05 level did not reach the critical level which would have supported acceptance of Hypothesis 3.

When the test scores were analysed on a topic basis the derivation of the earlier differences in mean scores between the Classes/Treatments was revealed. No significant differences at the critical level of acceptance were recorded for Topic X (Mammals) although comprehension plus concrete objects Class (B) scores were superior to comprehension Class (A) scores at the .05 level of confidence. For Topic Y (Seashore Animals) the superiority of scores from comprehension (A), comprehension plus concrete objects (B), and problem Classes (C) to the problem plus concrete objects Class (D) scores was marked at 0.0005, 0.0005, and 0.005 levels of confidence respectively.
Hypothesis 3 is thus strongly supported.

For Topic Z (Plant Life on Sand Dunes) there were no significant differences between the scores of the experimental classes.

Hypothesis 1 is strongly supported by the results of the analysis of the total gain scores of Classes EFGH. Scores of comprehension plus concrete objects (F) and problem (G) Classes are superior to those of the comprehension Class (E) at the .01 and .005 level of confidence respectively.

Further support is given to Hypothesis 1 through the examination of the scores derived from Topic X (Mammals). Here both comprehension plus concrete objects Class (F) scores and problem Class (G) scores are superior to comprehension Class (E) scores.

Hypothesis 3 is supported by the high scores of the problem Class (G) relative to the problem plus concrete objects Class (H) (.0005 level of confidence).

No significant differences between test scores were found to exist for Topic Y (Seashore Animals) and Topic Z (Plants of the Sand Dunes), although it must be noted that for Topic Z the superiority of the scores of both the problem (G) and problem plus concrete objects (H) Classes relative to the comprehension (E) Class was approaching significance at a 0.025 level of confidence.
On the whole the evidence derived from the study indicates that Hypothesis 1:

The retention of testable factual information and principles derived from the study guides and information acquired from the suggested readings will vary according to the "strength" (in terms of the Principles of Learning) of the variant of the instructional method which had been encountered by classes of students.

is not tenable in the stated form, at least at the level of acceptability set by the writer. Certainly the evidence derived from the test scores of Class E could not be used to substantiate the claim that this variant of the teaching method was markedly inferior to others, as it was in Class E that some students demonstrated resistance to participation in the experiment. However, it may have been that this resistance which did not manifest itself until after the completion of more than half of the experimental programme may have been, in fact, an overt reaction to the relative drabness of the comprehension variant of the method. Nevertheless, a general tendency for students who had been exposed to either the comprehension plus concrete objects or problem variants of the method to score more highly on the post-tests is clearly evident even if the
degree of acceptability of the evidence did not reach the critical level.

Hypothesis 2:

Success in applying learned principles to new problems (transfer) should be most marked in the case of individual students who had been subjected to the problem-solving variant of the teaching method (Principle 3). was unsupported at the required level of confidence although there were indications that the effects predicted in Hypothesis 3:

The improvements to the teaching method when applied together would not result in further increases in learning outcomes in terms of the retention of factual testable information and principles derived from the study guides and information acquired from suggested readings.

were interacting with students' capacity to use previously learned principles in new problem areas as evidenced by the lower score in the transfer tests of the problem plus concrete objects Classes (.05 level of confidence).

Hypothesis 3 was strongly supported by the analysis of the data for Part 1 of the experiment. It appeared that the increased attention of students in the problem plus concrete objects Class had been divided between two sets of demanding arousal cues (problem/concrete objects) and that this had resulted in less effective learning in terms of the stated cognitive goals of the course in science teaching. It is probably significant that the differences between the test scores of these classes of relatively immature students were
most marked to the disadvantage of the problem plus concrete objects Class in the case of Topic Y (Seashore Animals). Here the inherent interest of the living and unusual animals proved to be a powerful distractor, more so than for instance, sand dune plants. It is probably equally significant than in Part 2 of the study which involved more mature students the experimental results strongly support Hypothesis 3 only when the data derived from Topic X (the first studied) is examined. It is likely that after the initial teaching session these more sophisticated students adjusted to the presence of living plants and animals (in terms of their experience with study techniques) in the lecture room and by selecting cues from the study guides were able to attain scores comparable to those of students from other classes.

It might be reasonably inferred from the outcomes of the experiment that 'principles of learning' should not be applied to particular study situations in an arbitrary fashion. Although in most cases some gains in cognitive learning outcomes were made by students in classes taught by 'improved' variants of the teaching method excessive and arbitrary applications of the practices derived from the 'principles of learning' resulted in a marked diminution in cognitive learning outcomes for younger, less experienced students compared to students who had studied in the Teachers' College for an additional year.
Indeed, the outcomes of the experiment give strong support to Cronbach who, as previously noted, had proposed that with reference to research into teaching methods:

... we search for limited generalisations of the following form:

With subject matter of this nature, inductive experience of this type, in this amount, produces this pattern of responses, in pupils at this level of development. 103

The results of this experiment indicate that Cronbach's five categories might be preceded by a sixth i.e. "with these objectives in mind". Certainly within the limitations of the subject dealt with in the experiment it would appear that optimum conditions of learning for classes of students at a particular level of development could be defined and described in terms of specific cognitive outcomes as, for instance, those described in the outline of the course in science teaching.
Chapter 7

RECOMMENDATIONS FOR FURTHER STUDY

The most disappointing aspect (to the writer) of the study was the failure of the section of the experiment programme which had sought to assess the attitudinal outcomes of the teaching programmes of the experiment as a whole in terms of the relationships between the variants of the teaching methods used and the development of attitudes to teaching science in the schools in specified ways. The whole matter of the relationships between the models provided by secondary school teachers and Teachers' College lecturers and methods of teaching used in the primary schools could well bear long-term scrutiny. While it is clear that the cognitive outcomes of learning can be related to learning experiences of varying "strengths" (and it is likely that this relationship would become clearer if the studies were conducted over a longer period, for example, a semester or half academic year) it is equally true that less stress is being placed both in the primary schools and in the Teachers' Colleges on the cognitive
outcomes of learning alone. The greatest need in the Teachers' Colleges appears to be for studies of a long-term nature to be made which will relate variants of accepted teaching methods to the development of specified inquiry and expressive skills, attitudes to inquiry and expression generally and to the growth of commitment in the short and long term to certain methods of teaching children of primary school age. Furthermore, as the development of these non-cognitive goals is measured the type and extent of their interaction with the residual cognitive goals of modern educational practice should be estimated and described.

A SELECTED BIBLIOGRAPHY


Phi Delta Kappan. (Phi Delta Kappan, Professional Fraternity for Men in Education). Eighth Street, and Union Avenue, Bloomington, Indiana.


Science Education. Council of Elementary Science, International University of Tampa, Tampa, Florida.


APPENDIX A

THE QUESTIONNAIRE

Age: ........ Years........ Months

GROUP: ........................................

METHOD STUDY

INFORMATION: Please note that information supplied on this form and on others during the study will be regarded as confidential. I would be grateful if you could supply complete answers to as many questions as possible. Where you are asked to express preferences as e.g. for one subject against another, please remember that there is no absolutely right answer, only one that is right for you.

1. Note Science subjects studied during each year at high school (e.g. General Science, Physics, Biology, Nutrition, Chemistry, Agriculture, Human Biology, Horticulture etc.)

   Form 3........................................
   Form 4........................................
   Form 5........................................
   Form 6A........................................
   University....................................

2. (a) Had it been possible within the organisation of your school would you have preferred to have studied more Science subjects at School Certificate or University Entrance level? Encircle: YES/NO

   (b) If your answer to 2. (a) was "Yes" name any such preferred subjects in order of preference:

   S.C. 1.............. 2.............. 3..............
   U.E. 1.............. 2.............. 3..............

3. Indicate highest level reached in mathematical study (exam not necessarily passed). Encircle only highest level:

   Form 2, Core Form 3/4, Form 5, Form 6, Form 6A, University Stage...

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4. If you are completing or have completed a Teachers' College credit in Nature Study/Science please encircle below:
   Nature Study (A), Nature Study (B),
   Physical Science (A), Teaching Science (B),

5. During the remainder of your stay at College do you intend to take a further Nature Study/Science credit, or if you have not taken such a credit to date do you intend to in the future? Please indicate (encircle) which credit(s) below:
   Nature Study (A), Nature Study (B),
   Physical Science (A), Teaching Science (B).

6. If you could study only three subjects (other than Education/P.E.T.) while you were at College select the three you would prefer from the list supplied and set them out in order of preference. Music, History, Phys.Ed., Art and Craft, Nature Study, Physical Science, Geography, English, Mathematics.
   1. .................................................................
   2. .................................................................
   3. .................................................................

7. Write the name of any subject that you would particularly like to study at University, W.E.A. classes, Adult Education, or other adult classes after you had graduated as a teacher.
   .................................................................

8. What is your favourite hobby (other than a sport) i.e. one in which you actively participate(d)?
   Now.................................................................
   At Age 12.............................................................

9. List your three favourite television programmes in order of preference. (Be honest).
   1. .................................................................
   2. .................................................................
   3. .................................................................

10. Where did you spend most of your childhood? Encircle:
    City    Small Town    Country/Farm
APPENDIX B

THE PRE AND POST TESTS

SCIENCE DEPARTMENT

Surname:..........................

Christian Names:...................

Group:............................

This test is designed to evaluate your knowledge in a particular area of science study. There is a time limit of fifteen minutes so you will have to work quickly. DO NOT GUESS. Marks will be deducted for incorrect answers. When not reasonably certain of an answer use the option "don't know".

For each question encircle the letter beside the most correct answer as in this example. Please answer all questions.

EXAMPLE:

Most fish have:

a) one set of paired fins,
b) two sets of paired fins,
c) three sets of paired fins,
d) four sets of paired fins,
e) don't know.

NOW BEGIN:

1. One native New Zealand mammal is the:

a) Maori dog,
b) long-eared bat,
c) brown rat,
d) oppossum,
e) don't know.

2. A cat has some missing teeth. These are:

a) incisors (front),
b) canines (eye),
c) pre-molars (mid-back, cheek teeth),
d) molars (back-cheek teeth),
e) don't know.
3. "Toothless are small canine teeth found in horses". This statement is:
   a) true for some young horses, but not all,
   b) true for all young horses,
   c) true for all old horses,
   d) true for some old horses, but not all,
   e) don't know.

4. The term "mammal" is derived from the name of:
   a) a particular gland,
   b) a section of the skeleton,
   c) a characteristic feature of the skull,
   d) a section of the musculature,
   e) don't know.

5. The possession of retractile claws is a characteristic feature of:
   a) hunting dogs,
   b) domestic cats,
   c) all rabbits,
   d) the weasel family,
   e) don't know.

6. The outer coat of the wild sheep protects the animal against:
   a) loss of body heat,
   b) rain and snow,
   c) predators,
   d) infection,
   e) don't know.

7. "The eyes of mammals are an adaptive feature". This statement is:
   a) always true,
   b) frequently true,
   c) rarely true,
   d) never true,
   e) don't know.

8. An adaptation or adaptive feature of a mammal is:
   a) a feature of a mammal which relates to the care of its young,
   b) a feature of a mammal which indicates its ability to adapt to changing circumstances,
   c) a feature of any individual mammal which makes it distinguishable from others.
   d) a feature of a mammal which fits it to the place in which it lives,
   e) don't know.
9. When studying the biology of mammals a "place" is regarded as:
   a) a physical place,
   b) a biological place,
   c) both a physical and a biological place,
   d) none of these things,
   e) don't know.

10. A most essential element in the development of adaptive features in mammals is:
    a) a low speed of change of adaptive features,
    b) the age of the organism in question,
    c) a slow reaction to the environment,
    d) very long periods of time,
    e) don't know.

11. The horse's foreleg from knee to hoof corresponds to which of the following parts of the human body:
    a) arm from elbow to finger nail,
    b) arm from elbow to wrist,
    c) finger from wrist to finger nail,
    d) finger from upper joint of finger to lower joint,
    e) don't know.

12. The young of mammals are unique because they are:
    a) warm blooded,
    b) relatively weak at birth,
    c) fed milk by the mother,
    d) in the process of developing an insulating covering,
    e) don't know.

13. Sharp edged molars assist:
    a) rats to gnaw wood,
    b) cats to cope with flesh,
    c) hares to nibble grass,
    d) deer to cope with woody vegetation,
    e) don't know.

14. The eyes of hunted mammals are known to:
    a) focus extremely accurately,
    b) discriminate finely between colours,
    c) receive visual stimuli in a wide range of light intensities,
    d) have a wide arc of vision,
    e) don't know.
15. On which of the following observed occurrences is the principle of the natural selection of mammals based:  
   a) survival of those mammals which have been artificially bred,  
   b) survival of the majority,  
   c) survival of the most developed,  
   d) survival of the fittest,  
   e) don't know.

16. A cat walks on its:  
   a) feet,  
   b) toes,  
   c) heels,  
   d) claws,  
   e) don't know.

17. "An outcome of adjustment through evolution to environmental factors". When applied to mammals this statement is a definition of:  
   a) a mutation,  
   b) "survival of the majority",  
   c) an adaptive feature,  
   d) beneficial development,  
   e) don't know.

18. The teeth of a hedgehog are:  
   a) numerous and sharp,  
   b) few and sharp,  
   c) numerous and flat,  
   d) few and flat,  
   e) don't know.

19. The "odd man out" in this list of dogs and relatives is:  
   a) the fox,  
   b) the wolf,  
   c) the jackal,  
   d) the wild dog,  
   e) don't know.

20. Adaptive features in mammals are fixed more or less permanently by:  
   a) natural selection of features,  
   b) persistent attempts to use the feature,  
   c) discarding unused features,  
   d) consciously selecting desired features,  
   e) don't know.

21. In hunting mammals the eyes are placed:  
   a) towards the middle region of the side of the head,  
   b) towards the upper surface of the head,  
   c) towards the front of the head,  
   d) towards the lower surface of the head,  
   e) don't know.
22. The hedgehog is classified with:
   a) carnivorous animals,
   b) insectivorous animals,
   c) omnivorous animals,
   d) granivorous animals,
   e) don't know.

23. Canine teeth are used for:
   a) tearing food,
   b) grinding food,
   c) crushing bones,
   d) sheering vegetation,
   e) don't know.

24. The operation of intelligence which is more extensively developed in mammals than in other organisms results in:
   a) more economic behaviour,
   b) better integrated behaviour,
   c) less destructive behaviour,
   d) more flexible behaviour,
   e) don't know.

25. A mutation in mammals is:
   a) a change in genetic material in which chromosomes are not involved,
   b) any change, whether for good or bad, in genetic material,
   c) a reorganisation for the good in an organism's genetic make-up,
   d) a development for the worse in an organism's genetic make-up,
   e) don't know.

26. In most dogs the senses are arranged in order of importance in the following way:
   a) hearing, sight, smell,
   b) hearing, smell, sight,
   c) smell, hearing, sight,
   d) smell, sight, hearing,
   e) don't know.

27. Variety (i.e. variation) in mammals results from:
   a) an ordered plan for variation,
   b) individual adjustment to environment,
   c) flexibility of growth patterns,
   d) mutation in germ cells,
   e) don't know.

28. A further cause of variation in mammals is:
   a) asexual reproduction,
   b) sexual reproduction,
   c) multiple reproduction,
   d) seasonal reproduction,
   e) don't know.
29. The number of incisor teeth possessed by hares and rabbits is:
   a) two,
   b) four,
   c) six,
   d) eight,
   e) don't know.

30. Which one of the following features is unique to mammals?
   a) skin cells secreting horny material,
   b) insulating coverings developed in the skin,
   c) skin glands that secrete sweat,
   d) skin secretions that assist in preventing infection,
   e) don't know.

**METHOD**

(Note different requirements for this section of the test).

A mammal lesson may have certain features. Some features which may be present are listed below. Select the three which you consider to be the most significant and list in order of importance. (Write in full in the spaces provided)

good pictures of mammals;
group structure;
children well motivated;
mammal films;
good discipline;
live mammals present;
cyclostyled drawings of mammals;
oral presentation by the teacher;
stimulating blackboard work;
central theme;
ample books about mammals;
exercises to aid learning.

1. ........................................
2. ........................................
3. ........................................

Comment on the method section (if desired).

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This test is designed to evaluate your knowledge in a particular area of science study. There is a time limit of fifteen minutes so you will have to work quickly. DO NOT GUESS. Marks will be deducted for incorrect answers. When not reasonably certain of an answer use the option "don't know". Marks will not be deducted when this answer is used.

For each question encircle the letter beside the most correct answer as in this example. Please answer all questions.

EXAMPLE:
The term "mammal" is derived from the name of:

   a) a particular gland,              
   b) a section of the skeleton,      
   c) a characteristic feature of the skull, 
   d) a section of the musculature,    
   e) don't know.

NOW BEGIN:

1. A topshell is:

   a) a bivalve,                           
   b) a seashell which is firmly fixed to the rocks near the high tide mark, 
   c) a sea snail,                        
   d) a shellfish with a long pointed shell, 
   e) don't know.

2. An elephant fish egg capsule would most likely be found:

   a) at high tide level,                
   b) at upper mid-tide level,           
   c) at lower mid-tide level,           
   d) at low tide level,                 
   e) don't know.

3. The study of inter-relationship in the sea is basically a study of:

   a) the transfer of hereditary,         
   b) characteristics,                   
   c) the transfer of energy,            
   d) the transfer of oxygen,            
   e) the transfer of cells as in reproduction, 
   f) don't know.
4. "Desiccation" means:  
a) having been left by the retreating tide,  
b) drying out,  
c) cut by wave action,  
d) adjusting to extremes of temperature,  
e) don't know.

5. Which one of the following animals is an echinoderm (spiny skinned animal)?  
a) crayfish,  
b) cake urchin,  
c) shore crab,  
d) marine isopod,  
e) don't know.

6. Life in the sea is dependent upon:  
a) sunlight,  
b) the effects of ocean currents,  
c) plankton,  
d) the richness of the seashore habitat,  
e) don't know.

7. The possession of stinging tentacles is a characteristic feature of:  
a) octopuses,  
b) anemones,  
c) starfish,  
d) some true fish,  
e) don't know.

8. The lip of the shell of a carnivorous univalve is:  
a) plain,  
b) scalloped,  
c) indented,  
d) sharp,  
e) don't know.

9. Which of the following features have sea anemones and jellyfish in common?  
a) flowerlike appearance,  
b) holdfasts,  
c) extrudable stomach,  
d) hollow body,  
e) don't know.

10. Seashore animals compete for:  
a) oxygen,  
b) a foothold,  
c) access to light,  
d) supplies of essential minerals,  
e) don't know.

11. A "Blenny" is:  
a) a kind of eel,  
b) a true fish,  
c) a sea squirt,  
d) a particular jellyfish,  
e) don't know.
<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Which of these relationships is commonest on the rocky shore?</td>
<td>a) predator/prey, b) parasite/host, c) traveller/carrier, d) herbivore/plant, e) don't know.</td>
</tr>
<tr>
<td>13. Limpets are most mobile:</td>
<td>a) at high tide, b) at low tide, c) during neap tides, d) in areas subject to marked tidal flow, e) don't know.</td>
</tr>
<tr>
<td>14. Mussels are attached to rocks:</td>
<td>a) by suction, b) by threads, c) by a foot, d) by gripping teeth-like structures, e) don't know.</td>
</tr>
<tr>
<td>15. Some seashore animals are able to resist the destructive action of waves. These animals possess adaptive features which particularly fit them to:</td>
<td>a) the terrestrial environment, b) the biological environment, c) the physical environment, d) an impermanent environment, e) don't know.</td>
</tr>
<tr>
<td>16. All &quot;rockfish&quot; have characteristically:</td>
<td>a) rounded ends to their fin spines, b) finger-like paired fins, c) short, stubby tail fins, d) a large area of fin, e) don't know.</td>
</tr>
<tr>
<td>17. The pea-crab is a degenerate animal which lives inside:</td>
<td>a) the gills of fish, b) sea squirts, c) mussel shells, d) masses of decaying seaweed, e) don't know.</td>
</tr>
<tr>
<td>18. Which of the following is a &quot;low energy&quot; compound?</td>
<td>a) sugar, b) carbon dioxide, c) carbohydrate, d) protein, e) don't know.</td>
</tr>
</tbody>
</table>
19. The barnacle is most closely related to:
   a) crabs,
   b) mussels,
   c) tubeworms,
   d) sea squirts,
   e) don't know.

20. The valves of mussels are drawn together by:
   a) the action of ligaments,
   b) external water pressure,
   c) adductor muscles,
   d) a leathery girdle,
   e) don't know.

21. "Synthesis" means:
   a) taking apart,
   b) building up from parts,
   c) extracting the essential elements from,
   d) utilizing light energy,
   e) don't know.

22. "Plankton" is found:
   a) in the open water,
   b) attached to the rocky shore,
   c) in clumps in estuaries,
   d) on the walls of rock pools,
   e) don't know.

23. The term "decapod" used when describing crustaceans refers to:
   a) numbers of swimming appendages,
   b) numbers of legs,
   c) numbers of teeth,
   d) numbers of sensory bristles,
   e) don't know.

24. The significance of plants in the pattern of inter-relationships on the seashore is that they:
   a) provide essential cover from predators,
   b) produce large amounts of excess oxygen,
   c) fix the energy of sunlight,
   d) absorb excess carbon dioxide,
   e) don't know.

25. The home of the tube-worm is:
   a) a sandy tube,
   b) a rocky tube,
   c) a limy tube,
   d) a tube fashioned from the broken shells of other sea animals,
   e) don't know.
26. The number of valves possessed by chitons is:
   a) four,
   b) six,
   c) eight,
   d) ten,
   e) don't know.

27. There is a marked patterning in the distribution of animals and plants on the rocky shore. This patterning is known as:
   a) banding,
   b) biological patterning,
   c) zonation,
   d) stratification,
   e) don't know.

28. "Tube feet" are a characteristic feature of:
   a) paddleworms,
   b) cushion starfish,
   c) sea-lice,
   d) tubeworms,
   e) don't know.

29. Scutus, the large black sea slug is a:
   a) mollusc,
   b) coelenterate,
   c) crustacean,
   d) echinoderm,
   e) don't know.

30. "A group of animals and plants living together in an area as a result of their dependence on particular resources of energy, nutrients and space" is a definition of:
   a) a population,
   b) a society,
   c) an aggregation,
   d) a community,
   e) don't know.

METHOD

(Note different requirements for this section of the test).

A lesson about seashore life may have certain features. Some features which may be present are listed below. Select the three which you consider to be the most significant and list in order of importance. (Write in full in the spaces provided.

   good pictures of seashore life;
   good structure;
   children well motivated;
films about seashore life;
good discipline;
live seashore plants and animals present;
cyclostyled drawings of seashore life;
oral presentation by the teacher;
stimulating blackboard work;
central theme;
ample books about seashore life;
exercises to aid learning.

1. ........................................
2. ........................................
3. ........................................

Comment on the method section (if desired).

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SCIENCE DEPARTMENT

Surname:..............................

Christian Names:........................

Group:.................................

This test is designed to evaluate your knowledge in a particular area of science study. There is a time limit of fifteen minutes so you will have to work quickly. DO NOT GUESS. Marks will be deducted for incorrect answers. When not reasonably certain of an answer use the option "don't know". Marks will not be deducted when this answer is used.

For each question encircle the letter beside the most correct answer as in this example. Please answer all questions.

EXAMPLE:
A topshell is:
   a) a bivalve,
   b) a seashell which is firmly fixed to the rocks near the high tide mark,
   c) a sea snail,
   d) a shellfish with a long pointed tail,
   e) don't know.
1. Temperatures are extremely variable in the sandhills because sand conducts heat: a) not at all, b) quickly, c) poorly, d) unevenly, e) don't know.

2. On the Canterbury East Coast the prevailing wind blows: a) from the north down the beach, b) from the south up the beach, c) from the sea to the land, d) from the land to the sea, e) don't know.

3. Salt spray is not always a problem in the dunes as the residues are: a) absorbed by sand binding plants, b) scattered by wind, c) washed out by rain, d) chemically changed by the sand, e) don't know.

4. The first plants which appear in difficult areas are known as: a) migrants, b) pioneers, c) exploiters, d) settlers, e) don't know.

5. If you sat for long enough high on a Canterbury sandy beach you would finally find yourself: a) submerged in several feet of water, b) buried in sand, c) in farmland, d) in the midst of the mountains, e) don't know.

6. The sand dune nearest the sea is known as the: a) back-dune, b) mid-dune, c) sea-dune, d) fore-dune, e) don't know.

7. "Spinifex" is a: a) dune grass, b) cactus-like, creeping succulent plant, c) tree with hairy seeds, d) introduced sand-binding shrub, e) don't know.
8. One factor which makes plant succession possible is:
   a) the rapid growth rate of plants
   b) the transfer of seeds by various agencies,
   c) man's intervention in the process,
   d) exceptionally good weather,
   e) don't know.

9. "Haresfoot trefoil" is a:
   a) monocotyledon,
   b) legume,
   c) biennial,
   d) tuberous rooted plant,
   e) don't know.

10. The process of plant succession occurs:
    a) in fully established areas of vegetation,
    b) in areas of vegetation which have not yet become stable,
    c) in areas of vegetation strictly controlled by man,
    d) in uncontrolled forest areas,
    e) don't know.

11. The term "xerophytic" means:
    a) adapted to grow in sand,
    b) adapted to grow where spray is present,
    c) adapted to grow where water is scarce,
    d) adapted to grow where water is extraordinarily plentiful,
    e) don't know.

12. Strong winds cause uneven growth of shrubs by retarding bud development on the:
    a) lower portions of stems and shoots,
    b) windward side of the stem,
    c) leeward side of the stem,
    d) whole growing section of the stem,
    e) don't know.

13. A plant growing in any environment:
    a) helps modify that environment,
    b) is affected by, but does not affect that environment,
    c) is not affected by and does not modify that environment,
    d) is only modified by other plants growing in the same environment,
    e) don't know.
14. In the hottest months in the dunes moisture is normally found: 
   a) just below the surface, 
   b) a few inches below the surface, 
   c) eighteen inches below the surface, 
   d) only at a depth of several feet below the surface, 
   e) don't know. 

15. The "salt meadow" is situated: 
   a) just above the edge of the sea, 
   b) between the back and fore dunes, 
   c) amongst either the back or fore dunes, 
   d) between high and low tide marks, 
   e) don't know. 

16. Areas of "climax" vegetation are always: 
   a) completely stable, 
   b) almost completely stable, 
   c) quite unstable, 
   d) completely unstable, 
   e) don't know. 

17. "Seligeria", a plant, grows: 
   a) as a tall erect bush, 
   b) over other plants in a scrambling fashion, 
   c) flat to the ground, 
   d) as a short branching bush, 
   e) don't know. 

18. Thickened water-storing leaves are a characteristic feature of: 
   a) shore convolvolus, 
   b) bladder kelp, 
   c) shore grass, 
   d) haresfoot trefoil, 
   e) don't know. 

19. Plant succession in many areas (including the sandy shore) may be observed as a progression in: 
   a) shape, 
   b) space, 
   c) size, 
   d) height, 
   e) don't know. 

20. Admirably suited to conditions behind the dunes are introduced: 
   a) oak trees, 
   b) Douglas firs, 
   c) pinus species, 
   d) fruit producing trees, 
   e) don't know.
21. In the summer months the dunes are mainly populated by:
   a) seedling plants,
   b) plants not more than a foot high,
   c) dead and decaying plants,
   d) adult plants,
   e) don't know.

22. "Catsear", an introduced weed, grows freely:
   a) at the upper edge of the beach,
   b) in the back dunes,
   c) in the salt meadow,
   d) in the fore dunes,
   e) don't know.

23. "Plant succession" refers to:
   a) plants giving way to herbivores,
   b) successive generations of a species of plant growing in a given area,
   c) a variety of plant species appearing in sequence in a given area,
   d) the successive growth and decay of plants from season to season,
   e) don't know.

24. Generally sand retains surface water poorly because the sand particles are:
   a) too big,
   b) too small,
   c) too round,
   d) too uneven in size,
   e) don't know.

25. "Seabocket" is commonly found:
   a) in the back dunes,
   b) just above high tide mark,
   c) in the salt meadow,
   d) just below high tide mark,
   e) don't know.

26. The term "halophytic" when applied to plants means:
   a) adapted to grow where salt is present,
   b) adapted to grow where light intensity is extremely high,
   c) adapted to grow where winds are constant,
   d) adapted to grow without water,
   e) don't know.
27. Nitrate producing bacteria are largely absent from sand dunes because of a lack of: a) water in sufficient quantities, b) rotted vegetation or humus, c) atmospheric nitrogen, d) suitable particles to adhere to, e) don't know.

28. The leaves of "Native Spinach" are: a) thin in cross section, b) thickened, c) elongated, d) much shortened, e) don't know.

29. In dry conditions lupin leaves may be observed to: a) fold and droop, b) fold, then fall from the plant, c) d) fold and stand erect, e) don't know.

30. "Hawksbeard", which is occasionally found in moist hollows in the dunes is: a) a rosette plant, b) a climbing plant, c) a mat plant, d) a scrambling plant, e) don't know.

METHOD

(Note different requirements for this section of the test).

A lesson about plant life in the sand dunes may have certain features. Some features which may be present are listed below. Select the three which you consider to be the most significant and list in order of importance. (Write in full in the spaces provided).

good pictures of sand dune plant life;
group structure;
children well motivated;
films about sand dune plant life;
good discipline;
living sand dune plants present;
cyclostyled drawings of sand dune plants;
oral presentation by the teacher;
stimulating blackboard work;
central theme;
ample books about sand dune plants;
exercises to aid learning.

1. ............................................

2. ............................................

3. ............................................

Comment on the method section (if desired).

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APPENDIX C

THE TRANSFER TEST

SCIENCE DEPARTMENT

Surname: ........................................

Christian Names: .............................

Group: .........................................

This test is designed to evaluate the effectiveness of our teaching in certain general areas of biological study. We would be grateful if you would read the following notes carefully. Then continue with the test according to the instructions.

1. INFORMATION:

Where streams of fresh water meet the sea as in a river estuary, living things are generally abundant. In the estuary of the Avon and Heathcote rivers salt water laden with plankton pours over the mud flats at high tide. Some animals in the area obtain supplies of food by filtering out living organisms from the tide, others burrow in the mud where they consume the decaying remains of other creatures. Some pursue larger animals in the open water.

A conspicuous green plant, sea lettuce, flourishes throughout the estuary. Although food is plentiful living conditions are not always easy as large areas of mud flat are exposed at low tide. In addition, the salinity (saltiness) of the water varies a great deal from place to place and from time to time. In spite of this, many crabs, anemones, sea-worms, shellfish, true fish and birds seem to find a good living in the estuary. Silt from both river and sea is slowly filling the estuary. Most silt is deposited around the edges. In the semi-dry land and dry land areas at the edge of the estuary terrestrial plants struggle to survive. Those special land plants which have penetrated as far as high tide mark are often submerged at high spring tides and in addition are lashed by easterly winds which blow almost constantly over the estuary.

2. TEST:

Using the background information set out above and drawing
on your own knowledge, please complete the test set out below. There is a time limit of fifteen minutes so you will have to work quickly. For each question encircle the letter beside the most correct answer. DO NOT GUESS. Marks will be deducted for incorrect answers. When not reasonably certain of an answer use the option "don't know. Marks will not be deducted when this answer is used. Please answer all questions.

EXAMPLE:
On the Canterbury East Coast the prevailing wind blows:
  a) from the north down the beach,
  b) from the south up the beach,
  c) from the sea to the land,
  d) from the land to the sea,
  e) don't know.

NOW BEGIN:

1. The group of animals and plants which live together in the estuary and which depend on particular resources of energy, nutrients and space are known as:
   a) a population,
   b) a community,
   c) a society,
   d) an aggregation,
   e) don't know.

2. Not all members of each species of estuary-dwelling animal are exactly alike. One cause of variation from individual to individual results from:
   a) an ordered plan for variety in Nature,
   b) mutations or changes in the germ cells,
   c) a general trend towards individuality in structure,
   d) the possession of adaptive features,
   e) don't know.

3. The rate of variation of bodily characteristics is increased significantly in many estuarine organisms because they utilize the mechanism of:
   a) asexual reproduction (e.g. algae)
   b) sexual reproduction (e.g. fish)
   c) multiple budding (e.g. anemones)
   d) reproducing at regular seasonal intervals (e.g. most marine organisms),
   e) don't know.
4. Land plant succession a) the climate is particularly good in this area, b) the seeds of plants are readily transferred from one place to another, c) man assists the process, d) the plants in question grow very quickly, e) don't know.

5. "Climax" vegetational a) permanent, areas near the estuary b) almost permanent, c) are most likely to be: d) absolutely impermanent, e) don't know.

6. During photosynthesis a) built up from simple parts, b) in sea lettuce certain c) compounds utilized as d) broken down into simple constituents, e) don't know.

7. Certain changes in a parent estuarine a) a development for the worse in animal e.g. a crab, b) a genetic reorganisation for the good of the organism, c) may lead to signs of d) any change, whether for good or mutation in its offspring. These changes e) in genetic material, result from: f) a genetic change in which chromosomes are not involved, e) don't know.

8. Land plant succession a) height, b) in the estuarine area c) may be observed as a d) progression in: e) don't know.

9. The complex tidal a) strata, system of the estuary, b) zones, c) with markedly different conditions obtaining from place to place, will result in d) aggregations, e) don't know. animals becoming distributed predominantly in:
10. Land plants growing near the estuary:
   a) are modified by, but do not modify, the immediate environment.
   b) are not altered by, and do not themselves alter the immediate environment.
   c) tend to alter portions of the immediate physical environment.
   d) may be structurally modified only by the effect of the other plants growing in the same environment.
   e) don't know.

11. The fixing of a proportion of the energy of sunlight available in the estuary is carried out by:
   a) crabs and allied species.
   b) sea anemones.
   c) sea lettuce.
   d) small drifting members of the animal plankton.
   e) don't know.

12. The characteristic adaptive features of estuarine animals develop:
   a) by various mechanisms over extremely long periods of time.
   b) through the slow reaction of individual animals to the physical environment.
   c) because the offspring of estuarine animals exhibit adaptive features which are a reaction to the environment in which the parents have lived.
   d) as a response to temporary changes in the estuary e.g. changes in salinity.
   e) don't know.

13. The term "plant succession" when used in connection with events involving land plants in the estuarine region refers to:
   a) the successive growth and decay of plants seasonally.
   b) varieties of plant species appearing in sequence in the area.
   c) successive generations of a plant species growing in the area.
   d) plants being succeeded by herbivorous animals.
   e) don't know.
14. Only the "fittest" animals have survived in the estuary. The term "fittest" here is related to the idea of:
   a) artificial selection,
   b) natural selection,
   c) selection of those individuals with the most complex organs,
   d) selection in terms of muscular strength alone,
   e) don't know.

15. If you were to drive a concrete stake into the mud and silt at high tide mark in the estuary and exclude all man made changes eventually the stake would be:
   a) permanently swamped by the waters of the estuary,
   b) permanently buried in sand,
   c) permanently partly or completely buried in soil and vegetation,
   d) permanently surrounded by solid rock,
   e) don't know.

16. In the estuary the predator/prey relationship is likely to be:
   a) non-existent,
   b) relatively uncommon,
   c) fairly common,
   d) very common,
   e) don't know.

17. In the estuary land plant succession is most likely to take place:
   a) well back from the waters edge in established vegetation areas,
   b) in the unstable area near the edge of the tide,
   c) only in those areas where some control has been established by man,
   d) only in those areas where sand (in contrast to mud and silt) is present,
   e) don't know.

18. The adaptive features of estuarine animals are fixed more or less permanently by:
   a) the repeated attempts of the animal to use the feature,
   b) the tendency for unused features to decay and disappear,
   c) the conscious selection of desired features,
   d) natural selection of features,
   e) don't know.
19. Carbon dioxide, which is dissolved in the waters of the estuary, is:
   a) a high energy compound,  
   b) a compound which inhibits the energy fixing process,  
   c) a compound with relatively low energy content,  
   d) a compound whose energy is directly available to animals,  
   e) don't know.

20. Some land plants found near the edge of the edge of the estuary are "xerophytes". This means that they are adapted to:
   a) grow in mud and silt,  
   b) grow where driven spray is present,  
   c) grow in drying winds,  
   d) grow where large amounts of water are present,  
   e) don't know.

21. Estuarine animals compete for:
   a) space in which to live,  
   b) oxygen,  
   c) supplies of essential minerals,  
   d) access to light,  
   e) don't know.

22. The various adaptive features of shellfish living in the estuary:
   a) are concerned with the care of young shellfish,  
   b) make one individual shellfish distinguishable from another,  
   c) fit the shellfish to the place in which they live,  
   d) are developed by individual shellfish in response to the demands of the environment,  
   e) don't know.

23. The term "place" when used in connection with animals living in the estuary means:
   a) simply a location,  
   b) a physical location,  
   c) a biological location,  
   d) both a physical and biological location,  
   e) don't know.

24. Those land plants which push out into the silt at the edges of the estuary are known as:
   a) exploiters,  
   b) migrants,  
   c) settlers,  
   d) pioneers,  
   e) don't know.
25. "An outcome of adjustment through evolution to environmental factors". When applied to estuarine animals this statement refers to:

a) a mutation,
b) the survival of the most complete
   c) an adaptive feature,
d) a feature of the physical
   e) don't know.

environment,

26. "The legs of crabs which are found in the estuary are adaptive features". This statement is:

a) accurate when applied to a limited number of crabs,
b) accurate when applied to all crabs in the estuary,
c) not accurate at all with reference to the adaptive feature described,
d) accurate when applied to the majority of crabs in the estuary but not necessarily to all,
e) don't know.

27. Most relationships between living things in the local estuary are concerned with:

a) the need to reproduce,
b) the struggle to obtain sufficient oxygen,
c) the obtaining of energy,
d) competition for light,
e) don't know.

28. Halophytic land plants thrive near the edge of the estuary because they are adapted to living in conditions which are:

a) windy,
b) wet,
c) exposed to strong sunlight,
d) salty,
e) don't know.

29. In the estuary most animals are ultimately dependent for their food supply upon:

a) sunlight falling upon the ocean in general,
b) oceanic plankton,
c) movement of larger fish into the estuary at high tide,
d) large plants growing in the open sea,
e) don't know.

30. A whole series of adaptations brought about by the influence of the physical environment on estuarine animals is a consequence of:

a) the tidal nature of the area,
b) the small size of most estuarine creatures,
c) the presence of sea lettuce in large quantities,
d) a large crab population,
e) don't know.
APPENDIX D

PERSONAL DATA AND TEST RAW SCORES
### TABLE XIX

**PERSONAL DATA AND TEST RAW SCORES FOR CLASS A**

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### TABLE XXVI

**PERSONAL DATA AND TEST RAW SCORES FOR CLASS H**

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APPENDIX E

THE STUDY GUIDES FORM AB: TOPICS X, Y, Z.

SCIENCE DEPARTMENT

STUDY GUIDE

First read the following notes. Then discuss your answers to the questions set with the rest of the members of your study group. When you agree that you have discovered the correct answers to the questions note these on a separate sheet. Retain these printed notes and your own answer sheet for study purposes. You will be tested on your knowledge of this material within the next two weeks. Please note that you must study the specified reading in your own time.

MAMMALS

1. From the earliest years mammals are a source of interest and delight to children. From associations with domestic mammals and with the emphasis given to mammals in picture books for the very young, children soon learn to identify various species of mammals and at an early age begin to know something of their main characteristics. Children can continue their exploration of the world of nature through the study of mammals because topics for study are readily accessible and because, with a little preparation, they may be dealt with in a classroom situation.

2. Underlying this study of mammals is the concept of adaptation to environment. An adaptation is a feature of a living organism which particularly fits it to the place (in both the physical and the biological sense) in which it lives. Adaptations have developed for the following reasons:

No two animals are exactly alike. Variety or variation in living things is the result of mutations (changes) of the genetic material of the reproductive cells and, perhaps more significantly, follows from the infinite number of genetic combinations which are the outcome of sexual reproduction. By various mechanisms, not all of which are fully understood (including the idea of the "survival of
the fittest or natural selection") and over periods of millions of years some favourable variations and combinations of variations emerge as adaptive features that allow their possessors to survive and to continue to compete for a place in the world. Eyes, teeth, ears, two pairs of jointed limbs, and "claws" are examples of complex adaptive features found in mammals.

3. Mammals are vertebrate (backboned), air breathing animals but have three noticeable adaptive features which distinguish them from other classes of animals viz. (a) hair, and skin glands secreting water, (b) milk for the feeding of the young, and (c) higher intelligence.

Hair enables the body heat to be conserved; skin glands secrete water which evaporates, thus cooling the body. Under the control of internal mechanisms the balance between heating and cooling results in an even internal temperature which enables mammals to survive and function in extreme air temperatures. (b) and (c) are inter-related in that the possession of higher intelligence and greater flexibility of behaviour, although of great competitive value in the world, implies a long period of training or "childhood". The young mammal begins to explore the world while still in an early stage of development and is supplied with milk from the mother's glands (mammar) during a part of this period.

4. Some special adaptive features of mammals divide the class into two broad groups, i.e. hunters and hunted. This is, for young children, a more refined idea of classification than that of "mammal/not mammal". Study the features of the two broad groups. The main distinguishing features have been underlined.

<table>
<thead>
<tr>
<th>HUNTED</th>
<th>MOUSE</th>
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<tbody>
<tr>
<td>RABBIT</td>
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<tr>
<td>Large sensitive ears detect predators.</td>
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<tr>
<td>Eyes on side of head give all round vision.</td>
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<td>White tail flags danger.</td>
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<td>Legs thump - warn others.</td>
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<tr>
<td>Large hind limbs for quick take-off and getaway.</td>
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<tr>
<td>Generally herbivores with chisel and grinding teeth to cope with vegetation.</td>
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**HUNTERS**

**DOG**

- Sensitive ears to detect prey.
- Eyes toward front of head for more accurate vision.
- Running pads for pursuit.
- Runs down prey in packs.
- Pointed canine (eye) teeth for tearing & cutting prey. Sharp-edged molars (cheek teeth).
- Excellent sense of smell for tracking.

**CAT**

- Long tail aids balance in springing.

**EXERCISES FROM THE STUDY GUIDE**

PLEASE RECORD YOUR ANSWERS DURING THIS PERIOD, BUT DISCUSS THEM WITH THE MEMBERS OF YOUR STUDY GROUP BEFORE NOTING THEM.

1. List two reasons why mammals make a convenient study topic.
2. Give two reasons for children's interest in mammals.
3. What is the concept which underlies this study of mammals?

The hedgehog, an insectivorous mammal, is both hunter and hunted. Its nocturnal habits help it to catch its insect prey and also, with the aid of its sharp "prickles" to escape from those animals which prey on it.

**METHOD**

Lessons about mammals are best undertaken by presenting children with either pictures of mammals or real mammals. Suitable questions which you devise should direct the child's attention to important features. The contrasting of hunted and hunting mammals aids understanding and helps the child develop the beginnings of an idea of a simple classification system.
4. What is an adaptive feature or adaptation? Note five examples in mammals.

5. What are the two known mechanisms which lead to variety or variation in mammals?

6. Name the three adaptive features most characteristic of mammals.

7. What are the characteristic adaptive features of each of the two broad groups of mammals mentioned as being useful in a child's classificatory system?

8. How are mammal lessons best undertaken? How could a child be helped to develop the beginnings of a simple classificatory system?

ESSENTIAL READING

"Nature Study - A Handbook for Teachers" by D. Beggs
Pages 237-257.

Additional References:

"A Book of Common Beasts" by Sandars. (on reserve in library)

SCIENCE DEPARTMENT

A/B TWO

STUDY GUIDE

First read the following notes. Then discuss your answers to the questions set with the rest of the members of your study group. When you agree that you have discovered the correct answers to the questions note these down on a separate sheet of paper. Retain these printed notes and your own answer sheets for study purposes. You will be tested on your knowledge of this material within the next two weeks. Please note that you must study the specified reading in your own time.

SEASHORE LIFE

1. The sea is a place of wonder and delight for most people during childhood. For many it remains so throughout life. When children discover the abundant life of the tidal rock
pools they are invariably fascinated by it. With suitable guidance children may find not only interest in seashore animals but also by studying them gain some understanding of the organisation of nature. The world of seashore animals and plants is one in which the organisation of living things into communities may be seen rather more plainly than in more diffuse terrestrial (land) environments. In a community of plants and animals (e.g. the community of the rocky shore) relationships exist between the individual members which share a common need for energy, and space. Underlying this study of seashore animals is the concept of inter-relationship. All animal life has a dependent relationship with plant life in that plants supply the necessary sources of energy (foods) which enable animals to survive. Plants utilize the energy of sunlight to combine low-energy compounds (viz. water and carbon dioxide) into high energy compounds, in particular, sugars. The energy thus locked within sugars is released when the sugars are broken down into water and carbon dioxide. This energy is utilized by the plant in the synthesis (building up) of complex proteins from which the living material of its cells, the protoplasm, is formed. When animals eat plants they are able to make use of the entrapped energy which is locked in both the sugars and proteins of the plant.

Relationships between animals and/or plants may be at several levels.

1. Animal/Plant:

   Herbivorous animals e.g. topshells (a sea snail) and scutus (sometimes called a sea slug) browse on the fine growths of algae (weed) covering the rocks in intertidal areas. Most sea animals however, depend on the growth of uni-cellular (single celled) plants which drift in the ocean at large in enormous numbers and are eaten by very small animals, which are in turn eaten by larger animals and so on up the chain. The drifting, usually minute life of the sea, is called plankton.
2. **Predator/Prey:**

Carnivorous animals take their high energy foods directly from other animals (which of course have already taken their energy supply from plants). This is the commonest form of inter-relationship on the seashore.

(a) **The Cushion Starfish** with its sucking tube feet wraps itself around a mussel, exerting a gentle but firm pressure which after a time the mussel is unable to resist. The two sections of the mussel shell are forced apart and the starfish digests the mussel.

(b) **Crabs** crush smaller animals with their strong pincers, then with delicate hand-like processes set beneath their jaws they transfer the pieces to their mouths.

(c) **Anemones** trap small animal members of the plankton with stinging tentacles.

(d) **Fish** (water dwelling animals with two sets of paired fins, gills for breathing, and a skeleton, including a backbone, made of true bone). The blenny and rockfish, common fish of rock pools and the rocky seashore towards low tide level, are active predators. Their food includes crabs and other small, marine creatures which are captured in strong, widely opening jaws.

3. **Symbiosis:**

This means "living together" - for the advantage of one or more partners (of different species) concerned. One species of crab carries animals and plants on its back. As they grow they afford the crab some protection by assisting to camouflage it. A common "rider" is the anemone (a tubular animal with stinging tentacles). The anemone is carried about by the crab to new sources of food. Normally an anemone can move only very slowly from one place to another.
4. **Relationship with the Physical Environment:**

Many seashore animals show rather clearly how their bodily structures have developed as a response to a demanding physical environment. Seashore animals need both to be able to resist the pounding of waves and counter the possibility of desiccation (drying out) between tides. Some escape from these dangers by remaining in rock pools or in deep crevices between tides and during storms. Others which live on open rock faces have various features which enable them to survive.

**Limpets** (belong to the family of molluscs) attach themselves with a broad sucking foot - remain immobile when high and dry. Smooth streamlined shell offers little resistance to waves.

**Barnacles** (related to crabs - crustaceans) are cemented to rocks. Retreat inside shells and shut valves at top at low tide.

**Tubeworms** live in long calcareous (limy) shells cemented to rocks. Retreat inside at low tide.

Some animals such as topshells (a kind of sea snail) tend to retreat with the tide thus ensuring that their browsing on marine algae might continue undisturbed.

**Zonation:**

Seashore animals are often distributed in marked horizontal zones across rock faces. Tougher animals tend to live near high tide mark (e.g. periwinkles and limpets). Here they avoid the predators of the sea but are of course exposed to those of the land (e.g. gulls). Each species of animal, from high tide on the rocky shore to low tide level, lives in the zone to which its adaptive features particularly fit. Note also that in each zone there is competition between animals for a foothold on the rocky substratum. If an animal dies it is quickly replaced by others. Space is a premium on the rocky shore.
METHOD:
Seashore animals and plants are best studied in group situations using a variety of questions which will direct the children's attention to important features. Group activity should be followed by class discussion sessions.

EXERCISES FROM THE STUDY GUIDE:
1. Give one reason why it is useful for children to study seashore life.
2. What is a "community" (in the biological sense of the word)?
3. What is the underlying concept in this study of the seashore?
4. How does the energy of sunlight find its way through to e.g. fish?
5. Give two examples of animal/plant relationships on the rocky shore.
6. Give four examples of the predator/prey relationships showing how each predator catches its prey.
7. Aside from animal/plant and animal/animal relationships what other type of relationship is significant on the rocky seashore?
8. How are lessons on seashore life best undertaken?

ESSENTIAL READING:
"Handbook of Nature Study" by D. Beggs.
Pages 184-186 (the marine aquarium), and
Pages 196-203 (Seashore Animals)

Additional Reading:
"The Rock Pool" - A Primary School Bulletin (on reserve in library)
First read the following notes. Then discuss your answers to the questions set with the rest of the members of your study group. When you agree that you have discovered the correct answers to the questions note these down on a separate sheet of paper. Retain these notes and your own answer sheets for study purposes. You will be tested on your knowledge of this material within the next two weeks. Please note that you must study the specified reading in your own time.

PLANT LIFE ON THE SAND DUNES

1. Early in life children are confronted with the idea of change. Animals and plants are seen to change with growth and age, the seasons change, they themselves change. Later comes the realization that the earth, too, changes in external appearance over long periods of time: mountains rise and are subsequently eroded, plains are inundated by the sea, lakes are filled with silt, a forest is swamped by desert sands. Although a detailed understanding of the nature or course of such long term changes is not within the capacity of children of primary school age, eleven and twelve year olds may learn about some change processes which may be particularly clearly illustrated. One of these processes is that of "plant succession".

2. Underlying this study is the concept of ecological succession (the changes in composition of an animal and/or plant community which has not yet reached stability). Plant succession may be seen in action e.g. at the edges of a tidal mud flat, on a shingle fan, in a city section cleared and then neglected, in a pond. The process depends on these factors:—
   (a) a change in the physical environment e.g. a landslide, a fire, sand blown on shore by the wind.
   (b) the transfer of seeds by the wind, birds and other agencies.
   (c) that some plants are better adapted to difficult environments, than are others.
   (d) that once a plant has been able to establish itself in a particular environment it will alter that environment either during its life (by e.g. providing shade and shelter from wind) or after its death (by e.g. forming humus) so that other less rugged plants will then be able to gain a foothold and survive.
3. The sand dune area has been chosen to demonstrate the broad principles of succession partly because of its convenience but more particularly because it shows spatially what may in other areas be seen only over long periods of time. In a lake the succession of plant life which will eventually lead to the filling of the lake may be seen only over a period of many years. On the sandy shore the succession of plants which will eventually result in the creation of stable tussock or scrub land may be seen as a progression in space from the tide line back through the dunes to the countryside beyond.

4. Physical factors (on a beach such as Kairakei or Spencer Park): Sand is deposited on the beach. Through wave and wind action it is driven inshore to form the fore-dunes. This is a continuous process in time i.e. the beach is extending further and further out to sea. A strong drying wind, laden with salt spray and sand blows almost constantly from the East. Sand surface temperatures become very high in summer.

5. Cross Section of the Dunes:

6. The Succession: Just above high tide mark the first pioneering plants grow.

   (a) These plants which are tolerant of salty conditions include shore convolvulus (with thickened water storing leaves) and searocket. Other plants are simply not tough enough to survive in this area.

   ![Shore Convolvulus](image)

   (b) The fore-dunes are colonised by marram grass which has rolled leaves to reduce transpiration. As sand piles up around the plants new shoots are produced to prevent smothering.

   ![Marram Grass](image)
(c) Sand blown from the top of the fore-dune piles up some distance behind in the back-dunes. In between is a relatively sheltered but salty area, the salt meadow. Here a number of xerophytic (drought resistant) plants survive. Most are also halophytic (able to grow in salty conditions. A thin layer of soil has been built up from decomposed plant tissue (humus). Conditions here are still rigorous but not as severe as on the wind swept dunes. Some typical inhabitants of the area:

- Salsola (thickened leaves)
- Creeping Sellicia (grows flat to the ground)
- Baresfoot

(d) In the moist hollows in the sheltered back-dunes less hardy plants grow, die and make humus:

- Catsear
- Lupin

(e) Introduced pine trees are able to grow in and behind this area. Without man's interference a climax vegetation would develop which would be similar to that of the surrounding countryside. The climax vegetation (e.g. low tussock grass land) is a "permanent" phase which is only disturbed by general climatic or geological changes.

If we were to sit at the base of the dunes - eventually we would find ourselves behind the dunes in the salt meadow then amongst the back-dunes and finally in the midst of the bush (or whatever the climax vegetation happened to be).

METHOD:

Lessons about succession in the sand dune area are best taken by confronting the children with the key features of the plants and physical nature of the area (by the use of suitable questions). Through discussion of findings a general understanding of the concept of succession in time
as well as in space may begin to emerge.

EXERCISES FROM THE STUDY GUIDE:

1. What broad aspects of physical/biological change would you hope to open up to children of eleven/twelve years of age?

2. What is the concept underlying this study?

3. What are the four factors which effect the process of succession?

4. Give two reasons for the choice of the sand dunes as a study area.

5. What are the physical factors obtaining on local shores?

6. What are the five successional areas of the seashore? Describe the characteristics of plants found in each area.

7. How are lessons about the sand dunes best undertaken with children?

ESSENTIAL READING:

"Places to Explore" (Nature Study Bulletin, Supp. No. 5) - The Sandy Shore, Pages 68-78.

Additional Reading:

"Basic Ecology" - Buchsbaum, (on reserve in the library)
APPENDIX F

THE STUDY GUIDES FORM CD: TOPICS X, Y, Z.

SCIENCE DEPARTMENT

STUDY GUIDE

First read the following notes. Then discuss your answers to the questions set with the rest of the members of your study group. When you agree that you have discovered the correct answers to the questions note these on a separate sheet. Retain these printed notes and your own answer sheet for study purposes. You will be tested on your knowledge of this material within the next two weeks. Please note that you must study the specified reading in your own time.

MAMMALS

1. From the earliest years mammals are a source of interest and delight to children. From associations with domestic mammals and with the emphasis given to mammals in picture books for the very young, children soon learn to identify various species of mammals, and at an early age begin to know something of their main characteristics. Children can continue their exploration of the world of nature through the study of mammals because topics for study are readily accessible and because, with a little preparation, they may be dealt with in a convenient classroom situation.

2. Underlying this study of mammals is the concept of adaptation to environment. An adaptation is a feature of a living organism which particularly fits it to the place (in both the physical and the biological sense) in which it lives. Adaptations have developed for the following reasons:

No two animals are exactly alike. Variety or variation in living things is the result of mutations (changes) of the genetic material of the reproductive cells, and perhaps more significantly, follows from the infinite number of genetic combinations which are the outcomes of sexual reproduction. By various mechanisms, not all of which
are fully understood, (including the idea of "the survival of the fittest or natural selection") and over periods of millions of years some favourable variations and combinations of variations emerge as adaptive features that allow their possessors to survive and to continue to compete for a place in the world.

3. Mammals are distinguished from other classes of animals by the possession of several adaptive features which make them, as a group, unique. Select three features from the list below which apply only to mammals (and not to birds, reptiles, amphibians, etc.). Note why each selected adaptation confers some advantage on mammals.

- Multi-toed; sense of smell; higher intelligence and flexibility of behaviour; two pairs of jointed limbs; hair, coupled with skin glands secreting water; teeth in conjunction with powerful jaws; young born alive; young fed on milk by the mother from glands - mammae; highly developed vision; air breathing; vertebrate (backboned); sense of hearing (ears); possession of "claws".

4. Pictured below are four mammals with some of the features described. A simple classificatory system for young children can be devised by dividing common mammals into two broad groups. Two of the pictured animals belong to one group, two to another. Decide on a name for each of the two groups and, from the various features described, select and note the distinguishing adaptive features of each group.

**RABBIT**

A herbivore with chisel teeth to cut and grind vegetation. Eyes on side of head to give all round vision.

Large sensitive ears detect predators.

Large hind limbs for quick take-off and getaway. White tail flags danger. Legs thump to warn others.
CAT
Eyes toward front of head - accurate binocular vision. Sensitive ears detect prey.
Pointed canine (eye) teeth for tearing and cutting prey. Sharp edged molars (cheek teeth).
Long tail aids balance in springing.
Retractile claws for grasping with pads to cushion landing.

DOG
Eyes toward front of head for more accurate vision. Sensitive ears detect prey. Excellent sense of smell for tracking.
Pointed canine teeth for tearing and cutting prey.
Running pads for pursuit. Runs down prey in packs.

MOUSE
Large sensitive ears detect predators.
Eyes on side of head give all round vision.
Large hind limbs for quick take-off and getaway.

The hedgehog is an insectivorous (insect eating) mammal. How does it fit into your classificatory system?

METHOD
Devise a sound method of teaching children about mammals. How could you assist them to understand a simple classificatory system?
EXERCISES FROM THE STUDY GUIDE

PLEASE RECORD YOUR ANSWERS DURING THIS PERIOD, BUT DISCUSS THESE WITH THE MEMBERS OF YOUR STUDY GROUP BEFORE NOTING THEM.

1. List two reasons why mammals make a convenient study topic.
2. Give two reasons for children's interest in mammals.
3. What is the concept which underlies this study of mammals?
4. What is an adaptive feature or adaptation? Note five examples in mammals.
5. What are the two known mechanisms which lead to variety or variation in mammals?
6. Name the three adaptive features most characteristic of mammals.
7. What are the characteristic adaptive features of each of the two broad groups of mammals mentioned as being useful in a child's classificatory system?
8. How are mammal lessons best undertaken? How could a child be helped to develop the beginnings of an idea of a simple classificatory system?

ESSENTIAL READING

"Nature Study - A Handbook for Teachers" by D. Beggs
Pages 237-257.

Additional References:

"A Book of Common Beasts" by Sandars (on reserve in library)

SCIENCE DEPARTMENT

STUDY GUIDE

First read the following notes. Then discuss your answers to the questions set with the rest of the members of your study group. When you agree that you have discovered the correct answers to the questions note these on a separate sheet. Retain these printed notes and your own answer sheets for study purposes. You will be tested on your knowledge of this material within the next two weeks. Please note that you must study the specified reading in your own time.
SEASHORE LIFE

1. The sea is a place of wonder and delight for most people during childhood. For many it remains so throughout life. When children discover the abundant life of the tidal rock pools they are invariably fascinated by it. With suitable guidance children may find not only interest in seashore animals but also by studying them gain some understanding of the organisation of nature. In a community of plants and animals (e.g. the community of the rocky seashore) relationships exist between the individual members which share a common need for energy, mineral resources and space.

What advantages has the study of the rocky seashore over that of a terrestrial (land) environment?

Underlying this study of seashore animals is the concept of inter-relationship. All animal life has a dependent relationship with plant life in that plants supply the necessary sources of energy (foods) which enable animals to survive. Plants utilize the energy of sunlight to combine low-energy compounds (viz. water and carbon dioxide) into high energy compounds, in particular, sugars. The energy thus locked within sugars is released when the sugars are broken down into water and carbon dioxide. This energy is utilized by the plant in the synthesis (building up) of complex proteins from which the living material of its cells, the protoplasm, is formed. When animals eat plants they are able to make use of the entrapped energy which is locked in both the sugars and proteins of the plant.

Relationships between animals and/or plants may be at several levels.

1. Animal/Plant:

Pictured below are two common herbivores (plant eating animals) of the seashore. How significant do you think their position is in the chain of life in the sea?

Bearing in mind what you have read in the paragraph above decide what must be the source of energy which is utilized by the immense fish populations of the ocean.

Topshell (a sea snail) Scutus (sometimes called a sea slug)
2. **Predator/Prey:**

How do predators derive energy for growth and activity?

Pictured below are a number of common animals found on the rocky seashore. From an examination of the animals decide how each goes about dealing with its prey.

- **Cushion Starfish**
  - with tube feet

- **Rookfish**
  - (rounded ends to fin spines)

- **Anemone**

- **Crab**

The "Blenny" is another common fish of similar habit (not pictured)

In what ways may fish be distinguished from other seashore animals?

3. **Symbiosis:**

This term means "living together". Pictured here is a crab with an anemone " rider". Would this partnership be of benefit to either or both of the pair?

4. **Relationship with the Physical Environment**

- **Tubeworms** - live in long calcareous (limy) shells cemented to rocks.

- **Limpets** (belong to the family of molluscs). Attach themselves with a broad sucking foot. Smooth streamlined shell

- **Barnacles** (related to crabs - crustaceans) retreat inside shells. Valves may be shut.
The animals shown above possess various adaptive features which fit them for the seashore environment. What are the particular factors of the physical environment which animals have to contend with on the rocky shore?

**ZONATION:**

Seashore animals tend to be distributed in horizontal zones across the rock faces e.g. periwinkles, limpets and barnacles, mussels.

How do you account for this phenomenon?

What is one significant thing that seashore animals would compete for, other than food?

**METHOD:**

Devise a suitable method for teaching children about seashore life.

**EXERCISES FROM THE STUDY GUIDE:**

1. Give one reason why it is useful for children to study seashore life.

2. What is a "community" (in the biological sense of the word)?

3. What is the underlying concept in this study of the seashore?

4. How does the energy of sunlight find its way through to e.g. fish?

5. Give two examples of animal/plant relationships on the rocky shore.

6. Give four examples of the predator/prey relationships showing how each predator captures its prey.

7. Aside from animal/plant and animal/animal relationships what other type of relationship is significant on the rocky shore?

8. How are lessons on seashore life best undertaken?
ESSENTIAL READING:
"Handbook of Nature Study" by D. Beggs, Pages 184-186, (the Maine Aquarium), and Pages 198-203 (Seashore Animals)

Additional Reading:
"The Rock Pool" - A Primary School Bulletin (on reserve in library)

SCIENCE DEPARTMENT

STUDY GUIDE
First read the following notes. Then discuss your answers to the questions set with the rest of the members of your study group. When you agree that you have discovered the correct answers to the questions note these down on a separate sheet of paper. Retain these notes and your own answer sheets for study purposes. You will be tested on your knowledge of this material within the next two weeks. Please note that you must study the specified reading in your own time.

PLANT LIFE ON THE SAND DUNES

1. Early in life children are confronted with the idea of change. Animals and plants are seen to change with growth and age, the seasons change, they themselves change. Later comes the realization that the earth, too, changes in external appearance over long periods of time: mountains rise and are subsequently eroded, plains are inundated by the sea, lakes are filled with silt, a forest is swamped by desert sands. Although a detailed understanding of the nature or course of such long term changes in not within the capacity of children of primary school age, eleven and twelve year olds may learn about some change processes which may be particularly clearly illustrated. One of these processes is that of "plant succession".

2. Underlying this study is the concept of ecological succession (the changes in composition of animal and/or plant community which has not yet reached stability). Plant succession may be seen in action e.g. at the edges of a tidal mud flat, on a shingle fan, in a city section cleared and then neglected, in a pond. The process depends on these factors:—
(a) A change in the physical environment e.g. a landslide, a fire, sand blown on shore by the wind.
(b) The transfer of seeds by the wind, birds and other agencies.
(c) That some plants are better adapted to difficult environments, than are others.
(d) That once a plant has been able to establish itself in a particular environment it will alter that environment either during its life (e.g. by providing shade and shelter from wind) or after its death (e.g. by forming humus) so that other less rugged plants will then be able to gain a foothold and survive.

3. The sand dune area has been chosen to demonstrate the broad principles of succession partly because of its convenience but more particularly because it shows spatially what may in other areas be seen only over long periods of time. Problem: In this context what is meant by "shows spatially"?

4. Physical factors (on a beach such as Kairakei or Spencer Park); Sand is being deposited on the beach by the sea. This is a physical factor in the local environment. What other physical factors are present which affect (a) the landscape, and (b) the vegetation?

5. Cross Section of the Dunes:

6. The Succession
(a) Just above high tide mark the first pioneering plants grow. These plants include shore convolvulus (with thickened water storing leaves) and searocket. To what particular features of the physical environment would these plants show marked adaptations?

Shore Convulvulus
(b) The fore dunes are colonized by marram grass which has rolled leaves to reduce transpiration. By examining the diagram can you explain how this grass copes with moving, smothering sand?

(c) Behind the fore dunes is a relatively sheltered but salty area, the salt meadow. Here a number of xerophytic (drought resistant) plants survive. Most are also halophytic (able to grow in salty areas). Conditions here are still rigorous but not as severe as on the wind swept dunes. Some typical inhabitants of the area:

Native Spinach (thickened leaves) Creeping Seligeria Haresfoot Trefoil (grows flat to the ground) (a legume utilizing atmospheric nitrogen)

How do you account for the presence of a thin layer of soil in this area?

(d) Behind the salt meadow is a line of back dunes. Can you explain how they came to be formed? (see diagram of 5 above). In the moist hollows in the sheltered back dunes less hardy plants grow, die, and make humus.

(e) Introduced pine trees are able to grow in and behind this area. Without man's interference a climax vegetation would develop which would be similar to that of the surrounding countryside. The climax vegetation (e.g. low tussock grassland) is a "permanent" phase. Could you describe two ways in which this "permanency" could be disturbed?
What is the meaning of this diagram?

METHOD:

How in your opinion should lessons about the sand dune area be organized?

EXERCISES FROM THE STUDY GUIDE:

1. What broad aspects of physical/biological change would you hope to open up to children of eleven/twelve years of age?

2. What is the concept underlying this study?

3. What are the four factors which effect the process of succession?

4. Give two reasons for the choice of the sand dunes as a study area?

5. What are the physical factors obtaining on local sandy shores?

6. What are the five successional areas of the seashore? Describe the characteristic plants found in each area?

7. How are lessons about the sand dune area best undertaken with children?

ESSENTIAL READING:

"Places to Explore" (Nature Study Bulletin, Supp.No.5) - The Sandy Shore, Pages. 68-78.

Additional Reading:

"Basic Ecology" - Bucksbaum (on reserve in library)
APPENDIX G

A SAMPLE TEACHING GUIDE FOR LECTURERS

Mammals
(Procedure for the class-discussion session)

Q.1. State two reasons why mammals make a convenient school study topic?
A.1. a) topics for study are readily accessible
b) with a little preparation may be dealt with in a classroom situation.

Q.2. Give two reasons for children's interest in mammals
A.2. a) from emphasis in picture books for the very young,
b) from associations with domestic animals (mammals).

Q.3. What is the concept which underlies this study of mammals?
A.3. The concept of adaptation (define briefly)

Q.4. What is an adaptive feature? Note five examples in mammals.
A.4. Define briefly; note examples: eyes, teeth, ears, jointed limbs, claws, hair, milk, etc.

Q.5. What are the two known mechanisms which lead to variety in mammals?
A.5. a) mutation (define)
b) sexual reproduction (define)
Q.6. Name three adaptive features most characteristic of mammals.

A.6. a) Hair, and skin glands secreting water,
    b) Milk to feed the young,
    c) Higher intelligence.
    Note advantages of each

Q.7. What are the characteristic adaptive features of each of the two broad groups of mammals mentioned as being useful in a child's classificatory system?

A.7. a) Hunted mammals. Large sensitive ears detect predators; eyes on side of head for all round vision; generally herbivores with chisel and grinding teeth; large hind limbs for quick take-off and getaway.
    b) Hunting mammals. Sensitive ears to detect prey; eyes towards front of head for more accurate vision; pointed canine (eye) teeth for tearing and cutting prey; sharp edged molars.

DEAL BRIEFLY WITH ADDITIONAL QUESTIONS.