THE UNIVERSITY OF MANITOBA

AN EXPERIMENTAL INVESTIGATION OF TWO METHODS OF TEACHING GENERAL SCIENCE IN JUNIOR HIGH SCHOOL

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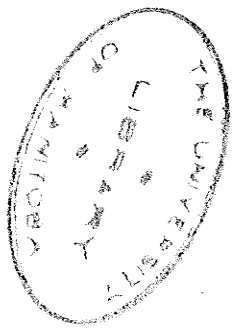

AN EXPERIMENTAL INVESTIGATION OF TWO METHODS OF TEACHING GENERAL SCIENCE IN JUNIOR HIGH SCHOOL

J.C. MARTIN

This investigation was undertaken to find out if there were any significant difference in the effectiveness of the lecture demonstration and developmental discussion as methods of teaching general science using the unit plan. In the lecture demonstration the teacher provided the basic information but in the developmental discussion the teacher secured the information from the pupils.

The study was carried out using Grade 7 pupils who were taught under regular school conditions. The subject matter was divided into four units: 1. Parts of a Plant and Uses, 2. Seed Scattering, 3. Insects, 4. Foods. The same teacher taught all classes using the same teaching aids in each class. The same tests were given to all pupils.

Two groups of pupils equated in pairs were selected as the experimental subjects. There were 26 pupils in each group, 14 girls and 12 boys. The groups were equated on the bases of their scores on a standardized intelligence test and the four unit tests before they were taught the units' subject matter. The unit tests had been validated previously, and each was composed of thirty items. The statistical results secured from the two groups were:

	I.Q.	Unit Tests
Mean - Group A	100.54	20.04
Mean - Group B	100.42	20.00
Variability - F	1.06	1.06
Correlation	.99	.92

In Unit I Group A was taught by developmental discussion and Group B by lecture demonstration. The methods were rotated in successive units. The repetition of the unit test at the end of the unit served to measure the effectiveness of the two methods of teaching by using the difference in means. The groups were also compared on their scores on a school district examination composed of objective and essay type questions and a standardized science test.

The significance of a difference in means for small samples was used to measure the effectiveness of the teaching methods. The means of the final unit scores were:

Unit	Group A	Group B
1	18.76	19.85
2	20.27	19.50
3	23.25	21.96
4	15.85	16.27

The significance of the difference in means using the increase in score for each pupil was also determined.

Correlations were secured by using the scores from the various tests for each group separately. All possible combinations were done and the correlations varied from a low of .31 to a high of .71. The correlations of the scores for Group A compared to Group B were: I.Q. .99, Final unit tests .68, School district examination .65, Standardized science test .30. The correlation coefficient required for significance for 26 cases at the 5 per cent level is .388 and at the 1 per cent level is .496.

The main conclusions derived were:

1. No significant difference at the 1 per cent level as shown in the achievement test results was found in the effect-

iveness of the lecture demonstration and developmental discussion as means of teaching facts and their applications as taught.

2. No tendency was found for either method to consistently excel the other.

3. The unit tests indicated a more valid and reliable means of ranking the students in general science.

The writer influenced by his findings and experiences in the investigation feels that a combination of the two methods would seem to be more effective for teaching general science. The easier portions can be taught using the developmental discussion and the more difficult by means of the lecture demonstration.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation to former and present members of the Faculty of Education, University of Manitoba, who have helped in the completion of this study. To Dr. G. Maccia thanks are due for aid in its design. Thanks are given to Dr. H. Stein for guidance in the statistical and testing portions and help kindly given in the interval between Dr. Maccia's leaving and Professor Whitinger's coming. The writer is very grateful to Professor B. Whitinger for his generous advice and guidance in the completion of the study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Purpose of the Study

This study was undertaken to compare the lecture demonstration and developmental discussion as methods of teaching factual knowledge and its applications as taught in general science. It is the writer's belief that these are the methods commonly used in junior high schools as they are presently equipped for the teaching of science and where the teacher is free to devote a whole period to a class. The writer wished to test the hypothesis that there is no significant difference in the effectiveness of these methods.

It was decided to measure the effectiveness of the methods in terms of pupil gain in knowledge using two groups of pupils equated in pairs. These groups were to be taught four successive units of grade seven general science by the two methods used in rotation. The study was carried out under the regular school conditions; a prescribed text book, sectioned classes comparable in size, and class periods at various times of the day. The classes were required to study a specified amount of subject matter for school district examinations at the end of the first term. In the local situation the investigator preferred to have the pupils unaware of any experimental factor.

The decision to carry out the investigation under normal classroom conditions was strongly influenced by the reading of articles by some of the leaders in educational theory and practice. F.D. Curtis in his Second Digest of Investigations in the Teaching of Science in giving his criticisms on studies of methods of teaching science said, "5. Delimiting Too Rigorously the Teaching Methods under Investigation - In several studies this is done to such an extent that these methods are utterly different from any used in ordinary classroom situations."[1] David P. Ausubel in "The Nature of Educational Research" divided research into three kinds: (a) basic science research in general laws of physical, biological, psychological, and sociological phenomenology as an end in itself, but the findings may be applied to practical problems in education; (b) extrapolated research in the basic sciences which is oriented toward the solution of practical or applied problems; (c) research at an applied level. Speaking of the advantages of research at the applied level he said, "When research is performed in relation to the actual problems of education, at the level of complexity in which they exist, that is, in situ (under the conditions in which they are to be found in practice), the problems of relevance and extrapolation do not arise."[2] Dr. Ausubel later in his article listed the four types of learning problems he considered indigenous to educational research and one of them was, "discovery of appro-

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[1] F.D. Curtis, Second Digest of Investigations in the Teaching of Science, p.5. Philadelphia: P. Blakiston's Son and Co., 1931.

[2] D.P. Ausubel, "The Nature of Educational Research," Educational Theory, III (October, 1953), 318.

priate and maximally efficient practices and ways of organizing and presenting learning materials, of deliberately motivating and directing learning toward specified goals."[1] This study was planned to measure the comparative effectiveness under local conditions of the lecture demonstration and developmental discussion as methods of presenting the subject matter of the units. Explanations of their place in the history of the methods of science teaching and the meaning of these terms as used in the investigation will now be given.

Definitions of Terms

The unit plan, lecture demonstration, and developmental discussion are comparatively late developments in the teaching of science. Elliott R. Downing lists the methods of teaching science in order of their development:

> 1. Lecture 2. Question and answer 3. Book 4. Text assignment, recitation 5. Object 6. Picture 7. Observation 8. Experiment 9. Demonstration 10. Individual laboratory 11. Problem method 12. Heuristic 13. Developmental 14. Project 15. Contract 16. Unit supervised study 17. Historic[2]

These methods can be grouped as some are later modifications and developments of an earlier technique.

In the lecture the teacher imparts knowledge to the learner. In the question and answer method the teacher tries to elicit such information as the student has already acquired from his experiences and to help the pupil organize the knowledge to serve as a basis for understanding. In the book

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[1] Ibid., p. 319.

[2] E. R. Downing, An Introduction to the Teaching of Science, p. 126. Chicago: The University of Chicago Press, 1934.

method a larger number of pupils have access to the teacher's knowledge as contained in the teacher-written text book. The text book assignment followed by recitation means that the pupil learns what is in the book letter perfect, often with little understanding of the subject matter.

Rebellion against blind acceptance of the knowledge written in the books of famous ancient scholars led to development of a new group of methods of learning science. The object method as developed by Pestalozzi was the first of these. The student with the object as stimulus recorded details of what he saw, felt, and heard. Pictures were a modified form of object study, since objects were not always available. Observation of objects and pictures which at first was of a casual nature gave way to purposeful observation to acquire facts as a basis for thought processes used in the solution of problem situations.

The development of the experimental method marked a new phase. The experiment was set up by the student to get Nature to furnish evidence which would help solve a problem. The school took over the task of performing the required experiments through demonstrations performed by the teacher. This is exemplified in the German schools. Some educators felt that the students would learn more if they did the experiments themselves. This was the beginning of the laboratory method. As many students performed the experiments mechanically with no idea of their relation to the text discussion and no understanding of what the experiment signified many well correlated forms of text books and laboratory work books were developed. The laboratory method has been very success-

fully developed in the American school system.

Science teaching subsequently went through a period of different combinations of methods. The problem method was the first of these. Some science problem within the capacities of the students was suggested, preferably by the pupils themselves or by the teacher. Means of finding a solution to the problem were discussed, and appropriate action taken through reading of references, experiments, and any other available means. The resulting knowledge constituted a body of learning. The heuristic method was a matter of the students' discovering for themselves scientific facts which were already known about some phase of science. The developmental method was based on learning about some scientific topic also. It involved a pooling of class effort. In the discussion the individual class members first contributed what they already knew about the topic. Further discussion aided in organizing what had to be learned. Methods of finding out this extra knowledge were discussed, and appropriate class action taken.

The last four methods of science teaching seem to be methods of organizing the work. In the project method a student or group of students undertakes to make something. The effort involved in making the object and operating it results in learning. The contract method is a means of taking care of individual differences. The assignment on the section of work taught is generally divided into three parts. All students are expected to do a minimum of the first part. The better students according to their ability are also expected to do the second part or the second and third parts. These often require extra individual study. The grade received by

the pupil is determined by the quality and quantity of the total assignment done. In the unit of supervised study the unit is a related section of the year's work. The students are introduced to the unit altogether but progress at various speeds in attaining acceptable mastery of the subject matter of the unit. The historic method organizes the subject matter around the lives of famous scientists, and what each discovered, and how he discovered it is learned. This is followed by a study of modern technological advances where applicable. Since the unit plan in grouping the subject matter was the one used in the study a brief explanation of its main principles is given.

The unit plan is associated with H.C. Morrison's name, although earlier educators had developed similar forms. Downing in speaking of the unit says,

> Teaching units, perhaps better designated "learning allotments", should be relatively short and definitely circumscribed. They should be assignments of study materials organized (1) to give such an understanding of and familiarity with a principle or group of closely related principles of science, together with so much practice in their application to problematic situations, that their use will be insured when the need arises in a pupil's life; (2) to give conscious skill in the use of one or two of the elements or safeguards of scientific thinking, (3) to establish in the pupil one of the important emotionalized standards.[1]

Morrison's organization of the unit plan is:

1. Exploration to find out what the pupils already know about the unit.

2. Presentation to give a view of the whole unit.

3. Assimilation to secure mastery of the principles, develop scientific thinking, and emotionalized standards.

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[1] Ibid., p.102.

4. Organization to have the pupil review and organize the subject matter of the unit.

5. Recitation in which the pupil shows he has acquired mastery of the unit's subject matter.

The five steps were carefully planned and followed in each unit. The assimilation periods should occupy about three quarters of the time of the unit. This is the time for individual and group study of the subject matter by the pupils aided by the teacher and this is the time when the teacher uses the lecture demonstration or developmental discussion method according to plan in helping the students.

The lecture demonstration as used in the study was a matter of the teacher providing the basic facts of the subject matter accompanied by the use of objects, specimens, pictures, charts, experiments, and films wherever possible. One modern group of authorities speaking of the present day use of the lecture method in schools says,

> In the use of the lecture method the teacher develops a topic in science more or less from a logical organization. It is now very common, when this method is used, to supplement the lecture with demonstrations and visual aids. It is also a common practice today to have pupils participate in the lecture either by giving part of it or by doing experiments and demonstrations from the demonstration table.[1]

The same authorities' opinion of the demonstration can be quoted,

> As a device for developing understanding in the pupil for facts, concepts, and principles this method has proven to be very effective. Employed in conjunction with the lecture it may very well become a most efficient method for covering a given section of content in a limited time. It has the advantage of being easily adapted to a logical

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[1] E.D. Heiss, E.S. Obourn, and C.W. Hoffman, Modern Science Teaching, p. 115. New York: The Mac Millan Co., 1950.

development of content when the teacher so desires.[1]

These quotations express the use of the lecture demonstration in attempting to carry out the practice and philosophy of the unit plan.

The developmental discussion as practised by the investigator was the reverse of the lecture demonstration. The investigator tried to get the facts from the pupils and only supplemented their information where necessary. Hunter's name is associated with the developmental discussion technique as it is generally practised. Hunter in discussing the use of the developmental discussion says,

> Utilize the first part of the period for demonstration and classroom activity in which the problems to be studied are developed in round table discussion, or begin laboratory work with group demonstration or individual work. By using the basal text as a basis, a socialized recitation may be developed in which discussion is kept closely to the problem in hand.[2]

Further to the use of the text Hunter says,

> In the supervised study period the teacher can read from the text and then get group discussion centred on the paragraph that has just been read. Out of the discussion the important concepts will appear and these can be used by the individuals of the group in making outline summaries for their notebooks or workbooks.[3]

The investigator based his developmental discussion technique fairly closely on these suggestions of Hunter's.

Science teachers are not always in agreement as to the name which should be given to a particular method used in teaching a science topic. After these brief explanations of

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[1] Ibid., p. 116.

[2] G.W. Hunter, Science Teaching, p. 165. New York: American Book Co., 1934.

[3] Ibid., pp. 335-6.

the main principles of the unit plan, lecture demonstration, and developmental discussion as used in the investigation; the writer wishes to refer to important earlier studies of the effectiveness of teaching science by the use of different techniques and the conclusions reached by the various investigators.

CHAPTER II

REVIEW OF THE LITERATURE

The literature available on investigations of different methods of teaching science was rather limited, particularly as to recent investigations. The Investigations in the Teaching of Science by F.D. Curtis consisting of three different texts covering different periods of time provided much interesting information on investigations which Curtis considered major ones of the three periods. For investigations covering the period 1940 to the present the Journal of Educational Research, Volume XLIII, January 1950, No. 5 and Science Education, Volume 39, March 1955, provided information. The investigations reported in the period from 1940 on are mostly at the high school and college level. Only those studies are mentioned which the investigator considered were in some way similar to his own problem.

In reading the literature on previous studies of the effectiveness of different methods of teaching science the writer was interested to find that in many cases the classes were comparatively small - approximately twenty pupils per class. The teacher was free to choose his own subject matter, was not required to cover a certain amount of subject matter in a given time, and secured expressions of the class's

opinion as to which method they preferred.

The first important study of the effectiveness of different teaching methods in science was made by J.E. Mayman in 1912. He wished to determine which one of the four methods book, lecture, experiment, and experiment notebook (combination method) was best from the point of view of efficiency, economy, interest, permanency. His pupils consisted of 500 boys in Grades 7 and 8, average age 13 - 8, in classes which he assumed to have the same average I.Q. His subject matter was physics. Each lesson was taught to each experimental class of the same grade by a different method from that used with the other classes of the same grade, and the methods were rotated. In the book method the boys were given a mimeographed sheet containing the lesson material which they studied for themselves. In the lecture method the teacher gave the substance of the lesson accompanied by gestures and blackboard drawings. In the experimental method the same material was given by demonstration supplemented by questions and suggestions, and the boys drew their own conclusions. In the experimental notebook method the boys were allowed to make notes, but this method was later dropped. Essay type questions testing memory and power were given at the end of each lesson. Quoting from Curtis on Mayman's conclusions:

> 1. On the basis of efficiency as measured by percental attainment, by lasting impression on the minds of elementary school pupils, by persistence in memory, by encouragement of independent thought and self reliance, and by popularity among the pupils the three methods rank experiment method, lecture method, book method.
> 2. On the basis of minimal time consumption in the actual teaching of the lessons, of arousing and holding interest and attention, and of the minimal expenditure of mental and physical energy, they rank as follows -

lecture method, experimental method, book method.[1]

In 1916 G.W. Hunter made a study of the developmental (the experimental method applied orally in the classroom), lecture, and text book methods. His pupils were three classes of respectively 30, 35, and 25 boys of median age 15. His subject matter was health. The three methods were used the same day, a different method for each class, and the methods were rotated. In the developmental method the problem was discussed by the teacher and pupils. In the lecture method the teacher gave the lecture accompanied by experiments, but allowed no questions. In the text book method the pupils studied the text book and were not allowed to ask questions nor were they asked any. A test was given at the end of each lesson. To quote from Curtis on Hunter's findings: "For immediate retention and for development of power the developmental method stands first, the lecture method stands second, and the text book third."[2]

Martin L. Robertson in 1930 undertook to compare the effectiveness of a guidance outline method and the developmental-discussion method. He used 60 pupils in Grade 5 who were equated into groups by the use of a standardized reading test and their scores on preliminary subject matter tests. His subject was seasonal changes in nature. For teaching by the guidance outline method the pupils were given an outline and mimeographed text for each lesson. The pupils studied the text and the teacher gave individual help. The pupils made a

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[1] F.D. Curtis, Investigations in the Teaching of Science, p. 32. Philadelphia: P. Blakiston's Son and Co., 1926.

[2] Ibid., p. 58.

brief topical outline individually at the end of the lesson. In the developmental-discussion method the teacher drew the facts from the children's experience by questioning and added facts as necessary. The conclusions were developed by the class and written on the board. The tests were of the short answer type for each unit. Robertson concluded, "In so far as the results of this investigation may be conclusive, it seems reasonable to conclude that this 'developmental - discussion method' has some slight advantage over this 'study - guide' method', both with respect to immediate recall and retention, though the results are not statistically significant."[1]

Forsyth used two groups of eighth grade pupils one of forty pupils with superior marks, and the other of twenty-five who had poor achievement records. The teaching methods used were rotated five times. The first method was a definite assignment, followed by recitation, discussion, and test; the second, a lesson-guidance method using the Morrison unit plan. At the end of each rotation a factual information test was given. For the superior students the unit plan was found to be significantly better; but for the poor students the conventional plan of assignment, recitation, discussion was better.

Olson and Kambly studied three groups of ninth grade students using the Morrison plan with the following ramifications; one group worked together, the second group worked separately receiving aid from the teacher who went from pupil to pupil, and the third group worked separately being aided by

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[1]F.D. Curtis, Second Digest of Investigations in the Teaching of Science, p. 61. Philadelphia: P. Blakiston's Son and Co., 1931.

the teacher when requested. While the third group learned the least, and the second group learned the most, there was no statistically significant difference.

Bond utilized the social implications approach to the study of a unit on genetics. The groups were from the science department of Western Washington College of Education. Facts and principles were taught when necessary to illuminate personal social problems of immediate interest to the class, and the development method featured in the experimental group. The control group featured the traditional lecture method with facts and principles of genetics presented, and social implications introduced as applications of the principles studied. Evaluative instruments used were the American Council Psychological Examination, a selections of facts test, an application of principles test, both consisting of selections of items from the Cooperative College Zoological Test; Interpretation of Data test, scientific test, superstitions test, and a test of opinions regarding different nationalities. The latter tests were constructed for use in the experiment. Equivalent forms of each test were given before the following instruction. The intelligence quotient and initial standing on the evaluation test were used for matching purposes. It was found that the experimental group did as well as the control group on the information test as a whole. The experimental group surpassed the control group in all other abilities measured, i.e., the so-called concomitant learnings.

Barnard did a study comparing the relative effectiveness of the lecture demonstration and the problem solving method. He used students taking a survey course in biological

sciences at New York University. The lecture demonstration group was given an orientation lecture covering scientific method and scientific attitudes, and subsequent lectures were of the conventional type. The problem group was taught by the developmental method with active student participation in setting up problems and planning solutions. Reports, assigned readings, instructor and assistants, and content materials were identical. Evaluating instruments included tests measuring recall of specific information, understanding of generalizations, abilities in problem solving, and scientific attitudes. Equivalent forms of the tests were administered before and after. The control and experimental groups were equated by comparing students on the basis of average standard scores on the pre-test and a psychological test. In the tests measuring recall of information the lecture demonstration group was more successful. In the tests measuring understanding of generalizations there was a slight but not significant difference in favor of the problem solving method. In tests requiring problem solving and scientific attitudes the experimental group was superior.

Studies have dealt with such topics in science teaching as the use of a prepared work book or pupil written notes, the uses of drawings, pupil drawn or mimeographed, inked or not inked; and the use of films, their advantages, when they should be used, and which type is best. In this study these aids were used in teaching by both methods according to the equipment which was available.

CHAPTER III

METHODS USED IN GROUPS TESTED

General Method of Approach

Before describing the procedure of the investigation something should be said of its background. The school was situated on the outskirts of the city of Winnipeg.

The science room was equipped with fixed desks, a demonstration table, cold water, a science cupboard with the essential chemicals and glassware, and a minimum of reference books. The collection of objects and specimens depended largely on the ingenuity of successive teachers and pupils.

The fathers of the students were mostly mechanical tradesmen, office workers, or small business men. The experiment was carried out with pupils in Grade 7 in the period 7.1 - 7.5. There were three classes totalling 99 pupils, 55 girls and 44 boys with an average age of 12 - 3 when the experiment was started. The pupils were taught by the same teacher. They had five periods per week of thirty-five minutes each.

The basic text for the pupils was Science Indoors and Out: Book I by Hensley, Patterson, and Armstrong. The curriculum required the study of chapters 1 - 6, 11, 2 of 12 - 14, 7 - 9 in the first term, preferably in that order. The school district examination required the study of chapters 1 - 6 and

an option of 11 - 14 or 7 - 9. The required work was divided into four units:

1. Parts of a Plant and Uses.	Chapters 1 - 4	3 weeks
2. Seed Scattering	Chapters 5 - 6	2 weeks
3. Insects	Chapters 12, 11, 14	4 weeks
4. Foods	Chapters 7, 8, 9	3 weeks

In order to secure two equated groups for measuring the effect of the two methods of teaching the pupils were equated by pairs on the bases of their scores on The Dominion Tests, Group Test of Learning Capacity; Intermediate - Grades 7,8,9 (Omnibus Edition - 1950) Form A, a copy of which is Appendix A; and their total scores on the four unit tests given as preliminary tests, copies of which are in Appendix B. The Dominion test consisted of seventy-five items including arithmetic, opposites, analogies, number sequence, classification, reasoning, and spatial relations. The time allowed was thirty minutes. The unit tests each consisted of thirty items of the recall type on the subject matter of the unit. The items had all been checked for validity from the scores secured by pupils of previous years. The time allowed was fifteen minutes. The two groups were called Group A and Group B.

Group A was taught Units 1 and 3 by developmental discussion and Units 2 and 4 by lecture demonstration. Group B was taught in the reverse order. The repetition of the unit test at the end of the teaching of the unit served to determine the effectiveness of the method of teaching used. The increase in knowledge for each pupil on the unit was also used as a check on the effectiveness of the two methods of teaching.

After the units had been taught and tested, a week was spent on review work before the school district examination. This examination was made by a committee of teachers who were teaching the subject. The form of the examination as to the proportions of short answer and essay type questions and the questions asked depended mainly on the committee's decision. After the Christmas vacation these papers were given back to the pupils and discussed with them. The school district examination comprises Appendix C. The pupils then wrote Dvorak's General Science Form S - 2 which is Appendix D. This consisted of sixty multiple choice questions graded as to difficulty into three groups of twenty questions each. The scores were so computed that a score of eighty is the median score for Grade 9 pupils just completing a year's course in general science.

The scores secured by the pupils in Groups A and B on the intelligence test, the total unit final tests, the school district examination, and the general science standardized test were then used for the computation of correlations within each group and group versus group.

In order to complete the investigation the final scores and papers for each unit of all the ninety-nine pupils in Grade 7 were used to re-check the validity and to determine the reliability of the unit tests.

The Unit Plan

The five phases and purposes of each in the unit plan have been mentioned. Hunter, in writing on the use of the unit plan in science teaching said, "The chief desirable

results which come from the unitary arrangement in science are the fact that the social and civic aspects of daily life are emphasized through a study of science problems that are real to the student."[1] An explanation of how each phase of the unit plan was used in the investigation follows.

Exploration, as conceived by Morrison, was economical of time because there was no need to teach what the pupils knew. It oriented both teacher and pupils as to what needed to be learned. It served as motivation by relating the new learning to present knowledge. Morrison suggested that exploration could be done by means of a class discussion or a short test. The unit tests of thirty items were used for exploration purposes, being given in four successive periods of the first week of school. Shorter tests might have been better but for the purpose of equating the groups these were used. The tests showed wide variation as to the knowledge possessed by the pupils and concentration of knowledge in certain sections of the work among different groups of the pupils.

Presentation was giving the major facts about the unit and relating them as much as possible to the pupils' knowledge. The presentation was given by the teacher and might take the form of a lecture, a film, or any other suitable form. In the study the teacher used a lecture to give the presentation. Reference was made to the Table of Contents, required chapters, and Index in the text book. Pictures on the bulletin board and reference books kept on the window sill were brought to the

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[1]Hunter, op. cit., p. 199.

pupils' attention. These were changed in successive units.

Assimilation of the subject matter of the unit was the main part of the unit organization. This involved the use of objects, pictures, films, experiments, reading the text, extensive reading, and doing assignments required by the guide sheet. Writing on the purpose of the subject matter unit W.H. Burton said,

> A subject matter unit is a series of educative experiences centering on subject matter materials which are arranged around a central core found within the subject matter itself and which are to be studied by pupils for the purpose of acquiring learning outcomes derivable from experiences with the subject matter. This core may be a generalization, a topic, or a theme.[1]

The teacher, with the help of the various aids, used the lecture demonstration or developmental discussion according to plan aiming by means of the inductive process to attain generalizations.

Organization involved the forming of a review outline of the unit with the essential supporting elements. One method was to have outlines prepared by the individual pupils on the unit as a whole or on sub-topics. Several were given in class followed by class discussion. The remainder were handed in to the teacher for checking. A second method was a general class review with development of an outline at the blackboard. The latter method was used by the instructor.

Recitation, as first conceived, was to have members of the class prepare a presentation on some part of the unit. Recitations on different parts of the unit were to be given in

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[1]W.H. Burton, Learning and Instruction, pp. 219 - 20. Forty-ninth Year Book of the National Society for the Study of Education, Part I. Chicago: The University of Chicago Press, 1950.

class and the remainder handed in to the teacher. A successful presentation meant mastery and understanding of the unit had been obtained. The repetition of the unit test at the end of the unit was used as the recitation in the investigation.

The unit plan as originally conceived involved re-teaching of those sub-topics not understood to pupils who had not done well on the recitation until an acceptable standard of mastery had been reached. Due to the exigency of having to teach a number of units for the school district examination this was not done. Also the size of the classes did not permit a large amount of individual work. The investigator adopted the philosophy of Westaway, "In any average science class, be satisfied with 25% of α's, 50% of β's, and 25% of γ's; but do not stick labels on the γ's for all the world to recognize them."[1] Otherwise the unit plan was followed through all its stages.

The Lecture Demonstration

It has already been stated that in the lecture demonstration as used in the assimilation periods of the unit study emphasis was placed on the teacher's providing the basic facts. The lecture demonstration was a combination of two earlier methods of teaching science. The lecture came to be regarded as being difficult for school pupils to follow so it has been supplemented by the use of demonstrations. Since our sight conditions so much of our learning the pupils have a visual image as well as an auditory image.

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[1] F.W. Westaway, Science Teaching, p. 39. London: Blackie and Son, 1929.

The lesson was preceded by a brief five minute oral quiz of the main facts of previous lessons in the unit. Brownell and Wade voiced their approval of the use of the question and answer method thus, "It is to be kept in mind, however, that whatever adaptations are made in high school science courses, there must ever be retained a large measure of the instructional effort involved in using the question and answer method."[1.]

The lecture using an inductive approach was given by the teacher. This was accompanied by the showing of objects, specimens, pictures, charts, and experiments. The three stages of science learning; wonder, utility, and systematizing were each used by the teacher in teaching the lesson. Bacon according to Westaway believed in the accumulation of facts to be sifted and organized noting similarities and differences. Westaway quoted directly from Huxley's writings in approval of this method. Huxley said, "It appeared to me to be plainly dictated by common sense that the teacher who wishes to lead his pupils to form a clear mental picture of the order which pervades the multiform and endlessly shifting phenomena of nature; should commence with the familiar facts of the scholar's daily experience; and that; from the firm ground of such experience; he should lead the beginner, step by step, to remoter objects and to the less readily comprehensible relations of things."[2.] The lesson was concluded with a summary linking together the main facts taught for purposes of generalization.

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[1]H. Brownell and F. Wade, The Teaching of Science, p.8. New York: The Century Co., 1925.

[2]Westaway, op. cit., p. 33.

Sometimes the lesson was followed by the reading of selected portions of the text. The pupils took turns at coming to the front of the class to read. A record was kept so that in successive periods all would read. G.W. Hunter said of the text book,

> A basal text book if used as a supplement to laboratory and demonstration is almost indispensable. It is important to have something to hold young people to and a text book assignment properly made will give the pupil a feeling of responsibility for the next day's class meeting.[1]

Sometimes the pupils were referred directly to the text book and the assignment.

Simple guide sheets were used. Sometimes the guide sheet consisted of sentences with the meaningful words left out. Sometimes it was in the form of completion sentences. At other times notes were to be copied from the blackboard. An increasing amount of writing explanatory sentences was given in later units. The aim was to have the pupils produce fairly neat and accurate notes using good English. Westaway emphasized the importance of the teacher's doing his part in improving the pupil's English when he said, "The business of a science teacher or of any other teacher is to teach English as well as his special subject."[2] Westaway further to his comments on the importance of English and satisfactory notes remarked,

> Note-taking is an art that must be taught. Small boys cannot be expected to make notes until they have been taught how to do it. In the very early stages, notes may be dictated, for pattern purposes; and lessons may occasionally be given on the way in which notes should be made.[3]

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[1]Hunter, op. cit., pp. 162 - 3.

[2]Westaway, op. cit., p. 113.

[3]Ibid., p. 113.

While the students were copying and doing the assignment the particular objects and experimental results were shown to the pupils in more detail, generally in groups of four at their seats.

The remainder of the period was used by the teacher in helping individual pupils and checking the pupils' previous assignments at their desks. The work of the weaker pupils was examined each period and the work of the other pupils at regular intervals, as time was available.

The Developmental Discussion

The developmental discussion as used in the teaching of the sub-topics of the unit required that the students provided most of the basic information. The teacher acted as the discussion leader, and the pupils were active participants in the discussion. Frank said, "In a class in General Science the discussion should be dominated entirely by the teacher who should keep the class alert and actively thinking by skilfully putting questions and suggestions."[1]

Opinions vary as to when pupils should read about the topic. To quote Brownell and Wade, "Teaching experience warrants the use of text matter as an effective means of exerting pressure upon pupils for that sustained effort which is involved in the forced mental activities of school days."[2] The instructor preferred to have the reading done first in class, except for experiments, since the better students are generally

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[1] J.O. Frank, How to Teach General Science, p. 114. Philadelphia: P. Blakiston's Son and Co., 1926.

[2] H. Brownell and F. Wade, op. cit., p. 115.

better readers, more industrious, more likely to read ahead in the text book, and to have read more on the topic in their miscellaneous reading. The teacher had previously selected the parts read. As in the lecture demonstration procedure the pupils took turns in reading aloud to the class. At the end of some paragraphs different students were questioned to find out whether they understood the central thought of the paragraph. The reading provided all the students with some basic information for use in the discussion.

The discussion followed the reading. The teacher aimed to get active participation from all pupils, to keep the discussion going, to fill in details, and to keep it within the bounds of the topic. As in all use of the question and answer method, it was insisted upon that the pupils raise their hands if they thought they knew the answer, and those not doing so were frequently asked. A conscious effort was made to get the more retiring students to answer, to ask the slower students questions it was hoped they could answer, and not to let certain students dominate the discussion. The students were free to ask questions that pertained to the discussion, and an effort was made to get some one else in the class to provide the answer. The teacher showed the objects etc. from the front of the class during the discussion at the appropriate times. This was in agreement with Hunter's idea who stated, "Potentially discussion groups should have access to all types of observational material during the discussion and should use this material in a way that will aid them in helping to solve the problematical situations that must natur-

ally arise out of the discussion."[1] Without making direct references to the guide sheet the teacher tried to centre the discussion of the questions contained in it and closed the discussion with a brief summary contributed by the pupils.

Where experiments were done, the discussion was an integral part of the lesson. Speaking of the use of experiments Hunter remarked, "Our conclusion must be that demonstration work certainly needs to be given more emphasis and that in place of long periods of 'busy work' on the part of the students the time may be much more profitably spent in a combination period in which demostration, discussion, and individual work are interwoven."[2] Westaway also centred the lesson about the demonstration with the important proviso of order. He said,

> But in a school the lecture room is a place for teaching and the demonstration table is the teacher's laboratory bench. The teacher works experiments, often because the experiments are beyond the pupils' skill; the lesson consists of questions and answers all the time - directed questions; and in case of emergency leading questions; and answers which are used for cross-examination and for further questions. The teacher does not work experiments primarily to verify; but to present new facts; and such facts thus presented at first hand are made the basis of the whole lesson. It is true that the pupils are not using their hands, but it is this freedom that enables them to give all their attention to the teacher; their attention is not divided by their having to engage in difficulties of manipulation. (It is, of course, assumed that the teacher is able to compel sustained attention.)[3]

At first the teacher wrote the experiment on the blackboard as it was performed, and later when the pupils knew more about the form for writing an experiment, individual pupils were called upon to write the experiment on the blackboard as the class decided what should be written. The summary followed,

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[1] Hunter, op. cit., p. 178. [2] Ibid., p. 176.

[3] Westaway, op. cit., p. 16.

the teacher getting the pupils to generalize as much as possible.

The same guide sheet as used in the lecture demonstration was used by the instructor. The objects and experimental results were shown to the pupils at their seats as they worked. The teacher used the remainder of the period to go around amongst the pupils to give individual help and to look at their previous assignments.

CHAPTER IV

SELECTION OF THE SAMPLE

Validity and Reliability

The tests used in equating the two groups and in measurement of the comparative effectiveness of the lecture demonstration and developmental discussion methods of teaching the units to the groups must have acceptable validity and reliability standards. Validity and reliability in a test are considered essential if reasonably accurate judgments are to be made as to what the pupils already knew before they were taught, or learned through being taught.

A valid test examines the subject matter which the pupils were taught. The validity of a test refers to the identity of the property being measured. Some definitions of validity by competent authorities are, "The validity of a test is an expression of the degrees to which the test measures the knowledges, skills, abilities, and qualities which it is designed and supposed to measure."[1] "Validity refers to the care taken to incorporate in a test or examination those elements or items which are of prime importance, and to the pain taken to eliminate the non-essential."[2]

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[1] Brueckner and Melby, Diagnostic and Remedial Teaching, p. 81. Boston: Houghton, Mifflin Co., 1931.

[2] G.M. Ruch, The Objective or New-type Examination, p. 28. New York: Scott, Foresman and Co., 1929.

The use of a table of specifications which lists the topics and sub-topics on which one wishes to test and the percentage of the test to be allowed to each, is a prime means of securing validity. The validity of a test is increased by extensive sampling and by arranging the items in order of increasing difficulty. A test is usually validated by the judgment of competent persons or by the use of statistical measures. A valid test is also considered to be reliable.

Reliability is the second main criterion of a good examination. Brueckner and Melby's definition of reliability is, "The reliability of a test refers to the extent to which it consistently and accurately measures the elements which it does measure."[1] The coefficient of reliability of a test for a given group may be defined in one way as the coefficient of correlation between the scores made by that group on two equivalent forms of the test successively administered under the same conditions. The index of reliability which may be secured from the coefficient of reliability theoretically represents the upper limit of the coefficient of validity for a test.

The same conditions which help secure test validity also help secure test reliability: testing on items selected from the total curriculum according to some plan, extensive sampling, items arranged in order of increasing difficulty, and objectivity in marking. Often two equivalent forms of a test are not available; and in such cases the coefficient of correlation to obtain the reliability is secured by giving the

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[1]Brueckner and Melby, op. cit., p. 82.

test twice to the same group, or correlating the marks secured on each half of the test for the same pupils - the split-half technique.

Objective Tests

Objective tests have certain advantages in securing validity and reliability. Extensive sampling is possible because the students can answer the questions in a short time. The student is also limited as to how he can answer if the questions are carefully composed because there is no opportunity for misinterpretation. The answers can be quickly checked because they are so short. Finally objectivity of marking, in that the answer is right or wrong, is a great advantage.

Objective questions are of two classes. In the recognition class two or more answers are given to the question, and the student is required to indicate the correct answer. The recognition class includes true - false, multiple choice, and matching types. In the recall class the pupil provides the answer. The recall class includes the completion and direct question types.

The Dominion Test and Dvorak's General Science Scale used in the investigation are of the multiple choice type. The unit tests are composed of recall items. In addition practice was given in the other types of objective questions in the week preceding the school district examination.

The Group Test of Learning Capacity

Previous reference has been made to the Dominion Group Test of Learning Capacity, Intermediate Grades 7,8,9; (Omnibus

Edition - 1950), Form A, used for determining the intelligence quotient as to its type of objective questions, contents, number of items, and time limits. Some explanation is desirable as to why its validity and reliability, as given by the authors, also made it suitable.

The test is a revised edition of the Intermediate Test (Original Edition, 1934). The items selected were chosen as a result of an experimental testing programme carried out on several hundred Ontario school pupils. The results from 3,300 pupils were used in the final validation of the test. The revised norms were secured from giving the test to approximately 2500 pupils mainly in Grades 7,8, and 9 in Ontario urban and rural schools. Of the table giving the relation of number of questions correct to mental age the authors say, "Table 1, giving these revised norms, was constructed to make the resulting intelligence quotients conform to the following criteria: (1) the average for the total group should, because of selection, be slightly above 100; (2) the standard deviation should be approximately 16, (3) the distribution of I.Q.'s should be close to normal."[1] The comparable forms estimates of the reliability of the test are based on a sample of Grades 7,8, and 9 scores of urban pupils in Ontario to whom both Forms A and B were administered. For 196 pupils in Grade 7 the reliability coefficient of the I.Q. is .930 with a P.E. of individual I.Q. of 2.90. Item analysis based on representative

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[1] "The Dominion Tests, Group Test of Learning Capacity, Intermediate - Grades 7,8,9; (Omnibus Edition - 1950), Forms A and B, Manual of Directions and Keys, Revised Edition Spring, 1952; (With corrections, 1954)," p. 5. Toronto: Department of Educational Research, Ontario College of Education, 1950 (mimeographed).

samples of the total group (Grades 7,8,9) to obtain information concerning the internal consistency of the test shows for 200 pupils an internal consistency estimate of reliability of .934. These reliability coefficients are considered satisfactory for a group intelligence test.

The Unit Tests

The unit tests were to be used with the Dominion Test in equating the groups and by themselves for measuring the results of the teaching. The tests as used were a selection of items from larger unit tests validated in previous years. In preparing the original unit tests, note was taken of what authorities said can be measured in science, "Measurable Outcomes of Science

Facts

Relationships

Problem solving

Attitudes and Interests."[1]

The first three are well within the scope of a simple objective achievement test. The direct question type was used in composing the unit tests. This form was preferred as it gave training for an examination of a combined objective and essay type. The advantages of the direct recall type are:

1. Guessing is almost negligible.
2. The responses are similar to those called for in daily work.
3. Scoring is almost entirely objective and fairly rapid.
4. The reliability is high.

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[1] H.A. Greene, A.N. Jorgenson, and J.R. Gerberich, Measurement and Evaluation in the Secondary School, p. 414. New York: Longmans, Green and Co., 1943.

To secure valid and reliable unit tests, the tests were originally composed of fifty items each. A table of specifications was used in each case. The questions were carefully phrased so that the answers would be mostly one word; and at the time the questions were composed, acceptable answers were noted. The original tests on Units 1 and 2 were validated on the results of having given the tests to 108 pupils. The original tests on Units 3 and 4 were validated on 68 pupils' results.

Validation was carried out by using upper and lower thirds. In this method all the papers were arranged in rank order. The papers were then divided as closely as possible into three even groups. Papers with the same mark must be put into the same group. The two groups of papers with the highest and lowest marks must have the same number of papers. The papers from the upper and lower thirds were re-examined. A tabulation was made of the pupils in each group having each question correct. Any question which a larger number of pupils in the upper group got correct was a good question, and was kept in the test. Any question which a larger number of the lower group got correct was a poor question, through negative discrimination, and was left out of the validated test. Similarly any question which all passed or failed had no discriminating power and was omitted. The non-valid items were left out and also some of the ones with lower validity. The original unit tests through validation and adjustment were now each composed of forty valid items and were suitable for administrative purposes. The index of discrimination for each of the forty valid items on each test was determined by taking the per cent of the upper third having the question correct less the

per cent of the lower third having the question correct.

TABLE 1

ORIGINAL INDEX OF DISCRIMINATION IN PER CENT

Question	Plants	Seeds & Fruits	Insects	Foods
1	18	10	9	46
2	5	14	9	36
3	9	38	27	41
4	44	35	5	46
5	21	28	14	5
6	52	38	18	59
7	24	35	46	41
8	56	21	5	50
9	36	45	59	55
10	44	42	41	64
11	36	42	50	14
12	52	38	9	36
13	52	51	68	59
14	24	51	41	68
15	21	21	59	46
16	52	17	55	46
17	40	21	50	46
18	52	14	64	59
19	40	32	5	41
20	15	42	18	55
21	33	35	23	50
22	40	38	5	64
23	40	32	55	5
24	47	3	41	55
25	36	14	32	14
26	52	32	32	41
27	47	21	46	32
28	36	17	41	46
29	33	48	36	36
30	30	14	23	5

For use in this investigation the unit tests were reduced to thirty items because that number could conveniently be placed on a stencil. A table of specifications was used, and reference made to the previously obtained index of discrimination for each item in selecting the questions. The original index of discrimination for each item selected for the unit tests is given in Table 1. The questions were not arranged in order of increasing difficulty. Leaving the questions in the order in which the subject matter was taught made it easier for the teacher to observe those sub-topics which the majority of the pupils did not understand as well. The tests were mimeographed and were ready for use in the testing program.

Equating the Groups

For the purpose of equating the groups the Dominion Test and the four unit tests were given to the Grade 7 pupils at the beginning of the school term. The directions in the manual were followed in giving the Dominion Test. The pupils were given preliminary training on how to answer questions of the type used in the unit tests before they were given the first test as a preliminary test. They were told to do the questions they knew first and then to try the others. They were given fifteen minutes to do the test. In administering the unit tests the papers were passed out printed side down. The pupils all turned the papers over at the same time, wrote their names at the top, and started. The time at which they had to stop was placed on the blackboard. They were also told when it was three minutes before the end of the time. The pupils put their pens down at the end of the time, and one pupil in each row

collected the papers immediately.

The I.Q. and preliminary unit test scores were used to determine the mean, standard deviation, and standard error of the mean using the formulas given below.

$$\text{Mean} = \text{A.R.} \pm i \frac{\Sigma fd}{N}$$

$$\text{S.D.} = i \sqrt{\frac{\Sigma fd^2}{N} - \left(\frac{\Sigma fd}{N}\right)^2}$$

$$\text{S.E. of Mean} = \frac{\text{S.D.}}{\sqrt{N - 1}}$$

The pupils' scores and statistical results are given in Table 2.

In equating the two groups pupils with excessively high or low scores were omitted since these should be re-tested. Pairs were selected whose difference in I.Q. was no more than 3. The P.E. of the Dominion Test for the individual I.Q. is given as 2.9. The authorities on Dominion Tests say, "I.Q.'s obtained from a group test of this nature can never be regarded as more than a rough indication, correct to within five or ten points."[1] At the same time the pairs selected were to have a difference in total preliminary test score of four or less. This was done because the tests were given in four different periods. The two groups were not finally selected until the end of the experiment. Any pair where one pupil consistently scored much higher than the other because of very irregular attendance was discarded. The suitable pupil was matched with

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[1]The Dominion Tests, op. cit., p. 7.

another student or left out if there were no suitable replacement. The two groups as finally selected each contained 26 pupils, each made up of 14 girls and 12 boys. The pairs were not always the same sex.

The I.Q. and unit scores of Groups A and B were subjected to further statistical analysis. The mean, standard deviation, and standard error of the mean were determined as before. Correlations were done using the rank-order method. These were converted to r by reference to Table XX.[1] The standard error of r was determined. The significance of a difference in means for small samples was determined by finding t. The variability of the two groups was also determined for small samples by finding "F". The necessary formulae follow.

$$\rho = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

$$\text{S.E. of } r = \frac{1-r^2}{\sqrt{n}}$$

$$t = \frac{M_O - M_H}{\sqrt{\frac{\sum d^2}{n(n-1)}}}$$

$$F = \frac{\sigma_1^2}{\sigma_2^2} = \frac{\sum d_1^2}{n_1 - 1} \div \frac{\sum d_2^2}{n_2 - 1}$$

The scores and results of the statistical analysis are given in Table 3.

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[1] H.E. Garret, Statistics in Psychology and Education, p. 192. New York: Longman's Green and Co., 1935.

TABLE 2

SCORES ON I.Q. AND PRELIMINARY TESTS

Pupil	I.Q.	P.T.	Pupil	I.Q.	P.T.	Pupil	I.Q.	P.T.
C.S.	146	41	W.T.	108	11	J.L.	90	33
V.F.	131	25	E.L.	107	22	A.H.	90	21
L.K.	129	27	L.C.	106	22	K.M.	90	20
E.Z.	129	27	F.B.	106	22	W.P.	90	16
B.L.	129	23	L.K.	106	16	J.M.	90	15
M.M.	128	30	J.C.	105	18	P.K.	90	14
D.H.	128	18	D.P.	104	23	V.B.	90	13
J.D.	127	20	J.R.	103	16	M.D.	90	11
J.F.	126	30	M.T.	103	13	L.J.	90	10
R.D.	124	49	B.P.	102	20	B.A.	89	19
C.B.	123	40	B.M.	101	28	J.H.	89	15
D.D.	123	34	L.M.	101	12	S.R.	88	25
M.P.	123	28	D.B.	100	20	F.S.	87	19
P.K.	123	15	N.L.	100	17	J.C.	86	30
B.T.	122	25	M.P.	100	15	E.S.	85	15
M.T.	122	24	C.S.	99	17	G.M.	85	14
T.B.	122	13	B.B.	98	25	P.M.	85	13
J.W.	121	23	B.B.	98	20	G.W.	85	12
B.B.	120	34	S.F.	98	19	G.G.	85	8
J.M.	119	27	L.S.	98	19	P.B.	85	6
D.B.	118	26	M.S.	97	19	P.M.	83	27
R.T.	117	29	S.W.	96	23	J.W.	82	18
V.G.	117	22	M.B.	96	14	G.C.	82	13
S.K.	117	20	N.B.	95	26	J.K.	80	19
R.B.	116	16	D.L.	93	15	M.H.	79	20
J.J.	116	14	S.H.	93	6	V.G.	79	20
I.D.	115	16	R.S.	92	32	D.R.	79	17
G.M.	113	17	D.T.	92	19	G.S.	77	15
G.C.	111	26	D.S.	92	15	E.K.	73	30
D.B.	108	34	V.G.	92	14	R.N.	72	21
R.S.	108	30	B.S.	91	27	A.M.	68	14
J.M.	108	20	B.A.	91	23	J.P.	65	18
K.H.	108	15	P.K.	91	10	E.J.	65	15

Intelligence Quotient	
Mean	100.85
S.D.	17.10
S.E. of Mean	1.73

Preliminary Tests	
Mean	20.51
S.D.	7.65
S.E. of Mean	.77

TABLE 3

SCORES ON I.Q. AND PRELIMINARY TESTS

Group A			Group B		
Pupil	I.Q.	P.T.	Pupil	I.Q.	P.T.
M.M.	128	30	L.K.	129	27
J.D.	127	20	D.H.	128	18
B.T.	122	25	M.T.	122	24
J.W.	121	23	D.B.	118	26
V.G.	117	22	S.K.	117	20
G.C.	111	26	R.S.	108	30
J.M.	108	20	E.L.	107	22
W.T.	108	11	K.H.	108	15
L.K.	106	16	J.C.	105	18
D.P.	104	23	T.B.	106	22
J.R.	103	16	M.P.	100	15
B.M.	101	28	B.B.	98	25
D.B.	100	20	B.P.	102	20
B.B.	98	20	S.W.	96	23
S.F.	98	19	M.S.	97	19
V.G.	92	14	D.S.	92	15
B.A.	91	23	B.S.	91	27
J.L.	90	33	R.S.	92	32
W.P.	90	16	P.K.	90	14
J.M.	90	15	V.B.	90	13
B.A.	89	19	J.H.	89	15
J.C.	86	30	P.M.	83	27
E.S.	85	15	F.S.	87	19
P.B.	85	6	G.G.	85	8
J.W.	82	18	G.M.	85	14
G.C.	82	13	G.W.	85	12

	Group A		Group B	
	I.Q.	Tests	I.Q.	Tests
Mean	100.54	20.04	100.42	20.
S.D.	13.65	6.18	13.23	5.99
S.E. of Mean	2.73	1.24	2.65	1.20

Intelligence Quotient $r = .99$ S.E. $r = .004$ $t = .418$ $F = 1.06$

Preliminary Tests $r = .92$ S.E. $r = .02$ $t = .078$ $F = 1.06$

The equality of Groups A and B used in the investigation was checked in three ways:

1. The significance of a difference in the means of related measures, the t test. Reference to Table 3 - Table of t[1] which gives for obtained values of t the minimum values of the significance ratio at various levels shows for 26 cases using 1 degree of freedom t exceeds the value .418 in 68 per cent of all samples of this size and exceeds .127 in 90 per cent. The two values of t obtained are .418 and .078. This would indicate that the null hypothesis might be accepted and that the two groups may be considered to be equivalent.

2. The significance of a difference in variability for small samples; the "F" test. Table 4 - Table for F[2] shows for 26 cases using 1 degree of freedom an F of 2.61 will be exceeded 1 per cent of the time. The two values of F obtained are 1.06. This shows the two groups are equally variable as far as intelligence and preliminary knowledge of the science subject matter are concerned.

3. The coefficient of correlation. Table 13[3] shows the value of the correlation coefficient for 26 cases required for significance at the 1 per cent level is .496. The correlations secured are .99 and .92. These show the two groups correlate significantly.

The three checks using statistical results secured from the scores of the two groups showed there was no significant difference in the two groups equated in pairs in intelli-

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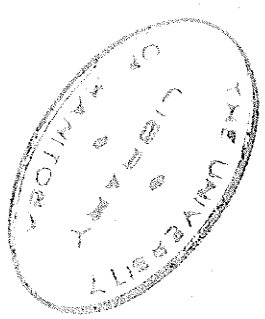
[1] E.F. Lindquist, Statistical Analysis in Educational Research, p. 53. Boston: Houghton Mifflin Co., 1940.

[2] Ibid., p. 62.

[3] Ibid., p. 212.

gence quotient or preliminary knowledge of the science units at the beginning of the investigation.

The marks secured by Groups A and B at the end of the teaching of each unit by the lecture demonstration or developmental discussion should show the effects of the teaching by the selected method. The author now wishes to elaborate on what and how the pupils were taught, before they were re-tested. The results secured from the unit tests were to be used for correlation with the intelligence quotient, school district examination mark, and Dvorak's General Science Scale; and further checking of the validity and reliability of the unit tests.



CHAPTER V

THE APPLICATION OF THE TECHNIQUES

The Content of the Four Units

The unit plans followed by the teacher are the results of revisions as the units have been taught to the classes each year. Trying a new idea which turns out to be successful, or getting some new plan of attack from something which happens in class generally results in some changes each year. The outlines given below are brief summaries of the sub-topics from the unit plans which are used. The outlines are blocked out in periods, and the aim is to teach the subject matter alloted for the period if all goes well.

With his outline opened for reference if necessary and the pupils' guide sheet for the lesson on the blackboard the assimilation periods of the unit were times for the teacher to give intensive instruction on the subject matter of the unit. The outlines of the units are followed by brief explanations of the development of the content of each unit preparatory to organization-review and recitation-testing.

Unit 1. Parts of a Plant and Uses. - 3 weeks.

1. The uses of plants to people.
2. The importance of the plant's parts to the plant.
3. The parts of a flower and the uses of each in seed produc-

tion.

4. The meaning, methods of, types, and value of pollination.

5. The steps in the formation of a seed.

Unit 2. Seed Scattering. - 2 weeks.

1. The importance of seed dispersal.

2. The four main ways seeds are scattered.

3. The importance of the production of many seeds.

4. Margin of safety seeds.

Unit 3. Insects. - 4 weeks.

1. Common characteristics of insects.

2. The parts and appendages of a honey bee's body.

3. Sex types of honey bees.

4. Life history of the honey bee.

5. The value of honey bees to man.

6. Bee keeping in Manitoba.

7. Insect enemies of plants.

8. Insects harmful to people.

9. Insects useful to people.

10. The body parts and life history of the cabbage butterfly.

11. The meaning and forms of metamorphosis.

12. The main differences between moths and butterflies.

13. The methods of poisoning insects.

14. Animals which help kill insects.

Unit 4. Foods. - 3 weeks.

1. The three main sources of our food.

2. The food classes and foods which give us body heat and energy.

3. The food classes and foods which provide for body growth and

repair.

4. The food classes and foods which are health protecting.

5. Plants as providers of the different food classes.

6. The chemical tests for the different food classes.

The Teaching of Unit 1.

In Unit 1 the teacher tried to emphasize the usefulness of each part of the plant to the growth and reproduction of the plant. What can be done in gardening and farming to aid the plants was brought out as much as possible.

Many objects such as a carrot, pea plant, cotton pods, rayon cloth, piece of plank were used in teaching the uses of plants. In this way it was possible to bring out the main uses of plants to man - food, clothing, shelter; and that different parts of different plants provided these necessities. The pea plant with flowers and pods was also used to develop the concept that a plant grew to reproduce.

The uses of the root, stem, leaves, and flowers were taught with the aid of simple illustrative material. Plants kept with their roots in water, plants left dry to die, and plants in a clod of earth were used to develop the main uses of the roots: forage, anchorage, storage. Dandelions which had been growing on a lawn and dandelions from a vacant lot served to show the use of a stem in holding up the leaves and flowers. The dandelion "milk" could also be discussed. The turning of plants' leaves to the sunlight when kept in windows and the testing of fresh green leaves and leaves from a plant kept in darkness served as a basis for the teaching of photo-synthesis. Faded snapdragon and tomato flowers in different

stages of seed development were used to develop the concept of seed and fruit production by flowers.

Two charts one of the nasturtium flower as a whole and with its parts shown separately and a second similar one of the sweet pea were used to introduce the study of the parts of a flower. The teacher also had a vial of pollen. A bud, opened flower, and faded flower of the same large flower, e.g. a hollyhock or gladiolus, were used in starting to study the parts of a flower. Examination of a number of different flowers followed the study of the flower parts. A piece of paper folded into quarters and marked calyx, corolla, stamens, pistil has been found to be a useful device. The teacher showed the class different flowers beforehand. The pupils then brought a supply of different flowers and traded amongst themselves so each would have two or three different kinds. The pupil separated the flower into its parts and placed each part on the paper in the right place. The teacher checked to see that no pupil had a composite flower, and looked at each pupil's work to see that it was correct, or helped him to correct it. The pupil then did a different flower the same way. It was possible for pupils to do two or three flowers this way in a thirty-five minute period. Pencil drawings were done and labelled of a complete flower and its separate parts, some from the blackboard and some from the text, mostly for examination purposes.

The meaning of pollination, the methods by wind and insects, and the types self and cross were difficult to illustrate with objects. Grass flowers with the stamens exposed and any insect pollinated flowers were compared. The steps in

seed development were treated simply by examination of old snapdragon and sweet pea flowers in different stages of seed development and examination of soaked peas or beans.

It was preferred to get the films planned for the unit near the end of the unit. In this way the students had a working knowledge of the subject matter covered by the films, and the films served to supplement the illustrative material. The films were rented from the Visual Education Branch of the Manitoba Department of Education and the Winnipeg Library Film Service. The films were preceded by a brief introduction given by the teacher, occasionally interspersed with teacher comments, and followed by a brief oral quiz at the end. The Gift of Green was a two reel, sound, color film issued by Precision Films. It was excellent. It explained the process of photosynthesis by animation showing how plants built food, particularly sugar, from water and air; and the vital work of chlorophyll in the process. Plant Growth was a one reel, sound, black and white film issued by Encyclopaedia Britannica Films. The film showed the complete life cycle of the pea plant and was very good for showing reproduction. Life Cycle of a Plant was also one reel, sound, black and white and was issued by United World. It used the lupin for illustrative material. This concluded the assimilation portion of Unit 1.

The Teaching of Unit 2.

In Unit 2 the teacher drilled on the recognition of the main grains particularly wheat, oats, barley both as plants and seeds; and the common weeds such as mustard, sow thistle, Canada thistle, wild oats, and couch grass as plants. The

importance of each group and the interrelation of the two in our economy was taught.

The main reason for seeds scattering - not be over-crowded, was used as a starting point. The scattering of various seeds by means of wind, water, people and animals, and bursting of the pod was demonstrated. Many seeds and fruits were shown to the class repeatedly and many were drawn.

The fact that one seed produces one plant was brought out from examination of soaked beans. By counting the number of grains in a barley head and the number of burs on a plant the conception of the large number of seeds produced by a plant was taught. The value to the plant of producing so many seeds led to the value of the margin of safety seeds to us with emphasis on the grain seeds for human and animal food. Vials containing flour, bran, shorts, and wheat germ were used to show the products we derive from wheat.

The assimilation was concluded with the film Seed Dispersal, a one reel, sound, black and white film issued by Encyclopaedia Britannica Films. This shows very well the scattering of seeds by wind, people and animals, and bursting of the pod with various special devices possessed by different seeds to aid in scattering.

The Teaching of Unit 3.

In Unit 3 the emphasis was placed on recognition of the more common insects, particularly the harmful ones, and the recognition of some of the common poisons and how to use them in killing insects.

The honey bee was taught first as a typical insect

because it was most convenient to obtain. A large colored picture of a honey bee was used first followed by the use of slides, showing different parts of the bee's body with a micro-projector. Each pupil was given a preserved worker bee and a period was spent on examination of its body. This was followed by doing a pencil drawing and marking in the parts and main appendages of the bee's body. Preserved queen, worker, and drone bees were used to discuss the sex types of bees. The life history of the bee was taught using old cells with dead bees in various stages of metamorphosis still in the cells; and preserved egg, larva, pupa, and adult.

In the sections on useful and harmful insects as many preserved specimens as possible were used. Emphasis was placed on their identifying characteristics as to appearance, where they live, how and what they eat.

Preserved specimens were used in teaching the body structure and life history of the cabbage butterfly. The preserved cabbage butterfly stages were also used to compare to preserved grasshoppers in taking up metamorphosis. They were compared to adult moths in teaching the difference between moths and butterflies.

The killing of harmful insects involved bringing some of the common poisons such as Paris Green, Derris Dust, D.D.T., Black Leaf 40 to school so the pupils could see and smell them. A classification was arrived at that insects eat by biting or sucking various parts of a plant, and which poisons are used in each case, and how they are applied.

Four films were shown in this unit. The Realm of the Honey Bee was a four reel, silent, black and white film issued

by the United States Department of Agriculture and is excellent. It tells the story of the bee from the time the bees are bought in the spring and put in the hive, to the bottling and uses of the honey in the fall. Grasshoppers, a two reel, sound, black and white film, also issued by the United States Department of Agriculture shows the life of this insect, methods of control, and incomplete metamorphosis. Insects is a one reel, sound, color film produced by Encyclopaedia Britannica Films. It shows the general characteristics of insects, the identifying characteristics and life cycles of a number of common insects, and how beneficial insects can be encouraged and pests fought. Vegetable Insects is a two reel, sound, color film issued by the National Film Board. It is excellent for showing the life history, feeding habits, and methods of control of common insect pests.

The Teaching of Unit 4.

Unit 4 on foods was taught from the viewpoint of the benefit of the different food classes and foods in those classes to the body. The teacher had to rely on charts and posters for illustrative material, some provided by the teacher and some made by the pupils as part of the assignment.

This was the first unit where experiments of a chemical nature were done. The pupils were taught how to use the alcohol lamp, to heat things in a test tube or beaker, to put out alcohol fires, and to treat ordinary acid, and base burns. The teacher did the experiment for each food class first and then had pupils demonstrate testing different foods for the presence of food classes.

As many suitable films as the teacher could find were used to supplement the material in this unit. Foods and Nutrition is a one reel, sound, black and white film produced by Encyclopaedia Britannica Films. Animated treatment is used to show the normal dietary requirements of carbohydrates, fats, proteins, minerals. Food that Builds Good Health is a one reel, sound, black and white film. It shows the foods necessary for good health and also the effects of poor unbalanced diets. The Cell, Structural Unit of Life is a one reel, sound, black and white film produced by Coronet. This shows the structure of a cell, its eating, growing, and dividing, showing both plant and animal cells, The above films completed the assimilation of Unit 4.

The Testing Program

The assimilation periods of each unit were followed by the organization of the subject matter and the giving of the unit test again. With the completion of Unit 4 the original equating of the pairs in Groups A and B was adjusted to allow for drop - outs and irregular attendance, and the final composition of the two groups determined.

All the tests used in the investigation were given to all the Grade 7 students even after the final selection of Groups A and B. This was done to eliminate any variable factor, although the marks of Groups A and B were of more importance to the investigation.

The marks secured by each individual in Groups A and B on the final and preliminary unit tests with the resulting increase in knowledge on the unit are given in Tables 4 and 5.

TABLE 4

GROUP A

FINAL, PRELIMINARY, AND INCREASE IN SCORES

Pupil	Unit 1 Plants			Unit 2 Seeds			Unit 3 Insects			Unit 4 Foods		
	F.	P.	I.	F.	P.	I.	F.	P.	I.	F.	P.	I.
M.M.	24	5	19	27	9	18	22	10	12	20	6	14
J.D.	21	8	13	15	5	10	22	5	17	12	2	10
B.T.	29	4	25	29	9	20	26	7	19	24	5	19
J.W.	21	5	16	23	6	17	20	8	12	18	3	15
V.G.	28	6	22	28	6	22	24	5	19	23	5	18
G.C.	21	4	17	24	5	19	27	9	18	19	8	11
J.M.	20	4	16	26	6	20	25	7	18	24	3	21
W.T.	20	3	17	21	4	17	22	2	20	18	2	16
L.K.	17	3	14	12	4	8	24	5	19	12	4	8
D.P.	20	4	16	24	6	18	29	6	23	22	7	15
J.R.	13	2	11	15	3	12	19	5	14	18	6	12
B.M.	22	5	17	27	6	21	27	9	18	16	9	7
D.B.	11	5	6	18	6	12	26	6	20	12	2	9
B.B.	15	3	12	17	4	13	24	6	18	13	7	6
S.F.	17	4	13	21	6	15	20	6	14	12	3	9
V.G.	13	5	8	14	3	11	23	2	21	13	4	9
B.A.	16	4	12	23	9	14	22	5	17	19	5	14
J.L.	23	8	15	17	10	7	22	7	15	13	8	5
W.P.	24	3	21	19	5	14	20	6	14	12	2	10
J.M.	17	5	12	20	3	17	25	2	23	24	5	19
B.A.	17	6	11	22	5	17	24	4	20	15	4	11
J.C.	22	6	16	17	10	7	26	5	21	14	9	5
E.S.	15	3	12	14	6	8	23	4	19	10	2	8
P.B.	7	2	5	10	2	8	22	2	20	13	0	13
J.W.	16	4	12	8	3	5	19	6	13	13	5	8
G.C.	19	3	16	16	4	12	21	4	17	14	2	12

TABLE 5

GROUP B

FINAL, PRELIMINARY, AND INCREASE IN SCORES

Pupil	Unit 1 Plants			Unit 2 Seeds			Unit 3 Insects			Unit 4 Foods		
	F.	P.	I.	F.	P.	I.	F.	P.	I.	F.	P.	I.
L.K.	28	6	22	24	6	18	23	9	14	20	6	14
D.H.	21	2	19	24	6	18	21	6	15	14	4	10
M.T.	26	5	21	26	4	22	20	7	13	23	8	15
D.B.	26	6	20	21	6	15	26	10	16	12	6	6
S.K.	28	4	24	24	5	19	21	6	15	23	5	18
R.S.	20	5	15	28	7	21	22	11	11	17	8	9
E.L.	19	5	14	24	6	18	26	8	18	18	3	15
K.H.	23	3	20	21	5	16	20	6	14	14	1	13
J.C.	13	4	9	22	5	17	23	3	20	11	6	5
T.B.	21	3	18	20	5	15	21	7	14	19	7	12
M.P.	18	5	13	23	3	20	23	5	18	9	2	7
B.B.	23	4	19	22	8	14	24	7	17	12	5	7
B.P.	26	5	21	19	4	15	29	7	22	24	4	20
S.W.	24	4	20	24	9	15	23	5	18	19	5	14
M.S.	19	6	13	23	5	18	22	6	16	17	2	15
D.S.	17	3	14	11	4	7	18	4	14	15	4	11
B.S.	25	6	19	23	4	19	26	8	18	19	9	10
R.S.	17	5	12	19	8	11	18	11	7	13	8	5
P.K.	15	2	13	13	1	12	24	8	16	17	3	14
V.B.	18	4	14	25	4	21	24	5	19	16	0	16
J.H.	16	4	12	20	5	15	21	2	19	13	3	10
P.M.	19	5	14	16	7	9	22	10	12	10	5	5
F.S.	19	3	16	14	6	8	19	4	15	13	6	7
G.G.	11	1	10	15	3	12	18	3	15	12	1	11
G.M.	8	3	5	13	4	9	16	1	15	12	4	8
G.W.	16	1	15	13	4	9	21	4	17	20	3	17

These were to be used to determine the effect of the teaching methods. The final unit test papers and scores of all the Grade 7 pupils were used for re-validation of the unit tests and a determination of their reliability.

The total final score of the unit tests of each individual in Groups A and B was also used for purposes of correlations between the marks secured by the same individual on the intelligence quotient, school district examination, and Dvorak's General Science Scale. The scores and ranks secured by the students in Group A on these four tests are given in Table 6, and in Group B are in Table 7.

The application of statistical procedures to the scores secured by the pupils to determine the findings of the proposed uses will be the author's concern in the following chapter.

TABLE 6

MARK AND RANK OF EACH STUDENT IN GROUP A

Pupil	I.Q.	RANK	Unit Tests	Rank	School Exam.	Rank	Stand. Test	Rank
M.M.	128	1	93	5	79	4.5	80.5	9.5
J.D.	127	2	70	17	59	16.5	76	20
B.T.	122	3	108	1	84	1	87.5	1
J.W.	121	4	82	9	62	13	86	2.5
V.G.	117	5	103	2	83	2	77	15.5
G.C.	111	6	91	7	72	9	82.5	5
J.M.	108	7.5	94	4	79	4.5	77	15.5
W.T.	108	7.5	81	10	73	7	76.5	17.5
L.K.	106	9	65	21.5	57	18.5	76.5	17.5
D.P.	104	10	95	3	60	14.5	79	12.5
J.R.	103	11	65	21.5	73	7	80.5	9.5
B.M.	101	12	92	6	65	12	86	2.5
D.B.	100	13	67	20	81	3	82	6.5
B.B.	98	14.5	69	19	73	7	83.5	4
S.F.	98	14.5	70	17	55	21	74.5	23
V.G.	92	16	63	23	42	25	79.5	11
B.A.	91	17	80	11	57	18.5	76	20
J.L.	90	19	75	14.5	70	10.5	75	22
W.P.	90	19	75	14.5	59	16.5	79	12.5
J.M.	90	19	86	8	70	10.5	81	8
B.A.	89	21	78	13	56	20	74	24
J.C.	86	22	79	12	60	14.5	76	20
E.S.	85	23.5	62	24	48	22	82	6.5
P.B.	85	23.5	52	26	38	26	73	25
J.W.	82	25.5	56	25	44	23	70	26
G.C.	82	25.5	70	17	43	24	78.5	14

TABLE 7

RANK AND MARK OF EACH STUDENT IN GROUP B

Pupil	I.Q.	Rank	Unit Tests	Rank	School Exam.	Rank	Stand. Test	Rank
L.K.	129	1	95	3.5	87	2	79	13
D.H.	128	2	80	14	61	17	82	4
M.T.	122	3	95	3.5	94	1	82.5	2.5
D.B.	118	4	85	9.5	59	20.5	80	8
S.K.	117	5	96	2	76	7	82.5	2.5
R.S.	108	6.5	87	7.5	84	3	77	21
E.L.	107	8	87	7.5	77	6	85	1
K.H.	108	6.5	78	15	81	4	78.5	16
J.C.	105	10	69	20.5	63	15.5	79	13
T.B.	106	9	81	12.5	57	22.5	73.5	26
M.P.	100	12	73	16	68	9	78	18.5
B.B.	98	13	85	9.5	63	15.5	78	18.5
B.P.	102	11	98	1	79	5	81	5.5
S.W.	96	15	90	6	67	10.5	79.5	10.5
M.S.	97	14	81	12.5	67	10.5	75.5	22.5
D.S.	92	16.5	61	24	64	14	81	5.5
B.S.	91	18	93	5	73	8	79	13
R.S.	92	16.5	67	22	60	18.5	80	8
P.K.	90	19.5	69	20.5	66	12.5	80	8
V.B.	90	19.5	83	11	59	20.5	77.5	20
J.H.	89	21	70	18.5	56	24	78.5	16
P.M.	83	26	71	17	51	25	75	24.5
F.S.	87	22	65	23	57	22.5	78.5	16
G.G.	85	24	56	25	60	18.5	75	24.5
G.M.	85	24	50	26	33	26	75.5	22.5
G.W.	85	24	70	18.5	66	12.5	79.5	10.5

CHAPTER VI

FINDINGS OF THE INVESTIGATION

The Comparative Effectiveness of the Lecture Demonstration and Developmental Discussion

The marks secured from the unit tests were first used to determine the effectiveness of the teaching methods on the equated groups.

In the first analysis the final marks secured by each group were used. Since the two groups were equated at the beginning of the investigation the mean of the lower group can be used as the measurement of the two groups' knowledge at the beginning of the unit, and the mean of the higher group as a measurement of the groups' increase in knowledge due to being taught by the selected method. The mean, standard deviation, and standard error of the mean were determined by use of formulae. The coefficient of correlation was determined by the rank-order method and conversion. The value of t which gives the significance of a difference in means for small samples was determined by use of the formula for groups equated in pairs. The total final mark on Units 1 - 4 when taught by the lecture demonstration and the total final mark when taught by the developmental discussion were secured for each equated pair. The value of t only was determined for this. The results are given in Table 8.

TABLE 8

STATISTICAL RESULTS OF TEACHING METHODS USING FINAL SCORES

Unit	Developmental Discussion				Lecture Demonstration				D.D. : L.D.		
	Group	M.	S.D.	σM	Group	M.	S.D.	σM	r	σr	t
1	A	18.76	5.01	1.00	B	19.85	5.07	1.01	.40	.16	1.049
2	B	20.27	4.80	.96	A	19.50	5.76	1.15	.58	.13	.898
3	A	23.25	2.76	.55	B	21.96	2.64	.53	.22	.19	1.857
4	B	15.85	3.90	.78	A	16.27	4.53	.91	.33	.17	.376
1-4	A&B				A&B						.325

Total Scores of Each Pair on Lecture Demonstration and Developmental Discussion

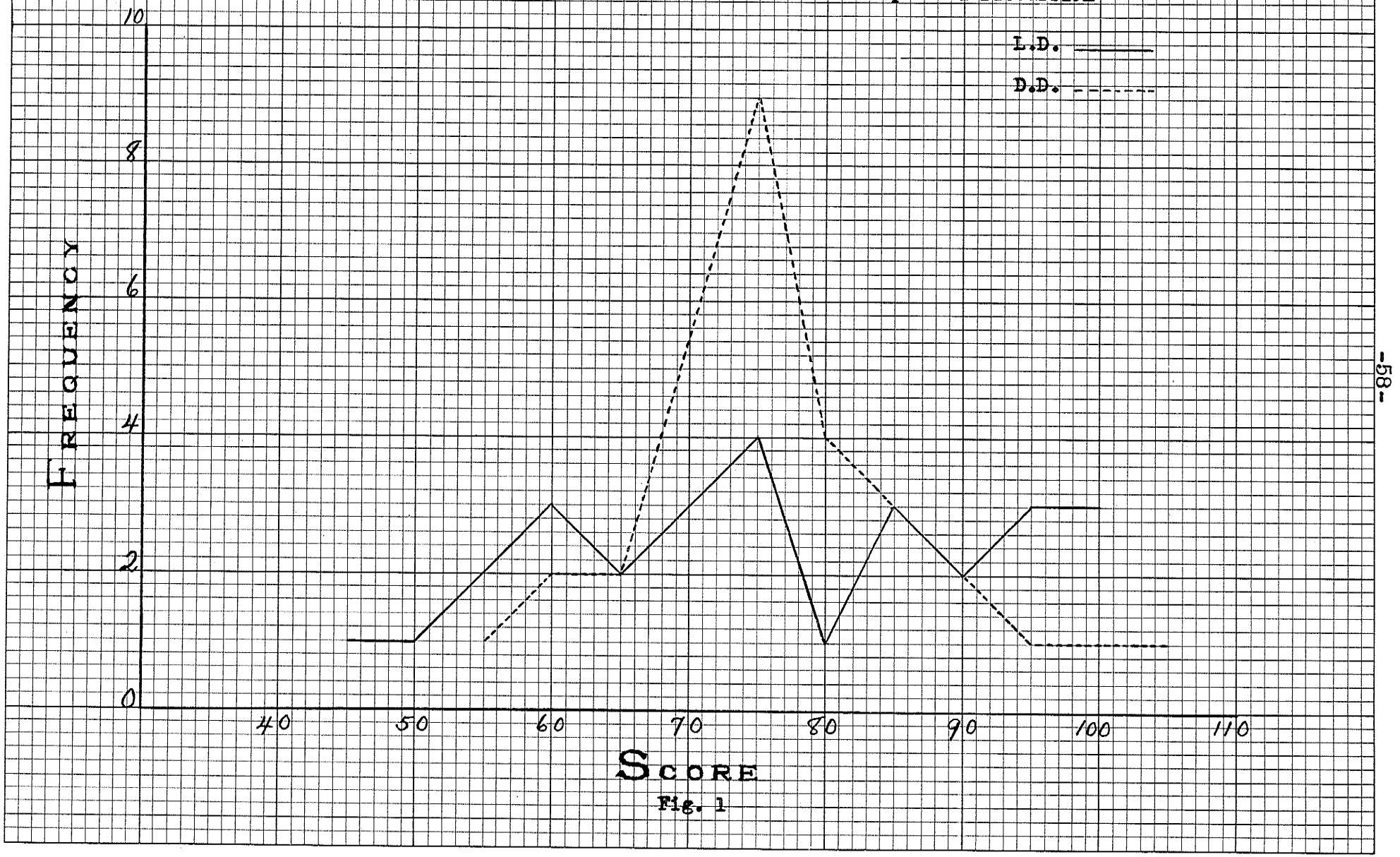


Fig. 1

The increase in score secured by the pupils on the unit tests was also subjected to statistical analysis. The mark on the final test, less the mark on the preliminary test gave the increase. These were determined for each unit separately and the four units together. The value of t was again determined in each case. The results are given in Table 9.

TABLE 9

STATISTICAL RESULTS OF TEACHING METHODS USING INCREASE IN SCORES

Unit	t
1	1.531
2	1.519
3	2.469
4	.465
1-4	.959

The significance ratio required for 26 pupils using 1 degree of freedom as taken from Table 3[1.] is at the 1 per cent level t = 2.787. A study of the values of t secured as a measurement of the comparative effectiveness of the two methods of teaching as used in this investigation shows the following:

1. Using the final marks to secure the significance of the difference in means the null hypothesis is accepted at the one per cent level. No value of t exceeds 2.787.
2. Using the increase in score to secure the significance of the difference in means the null hypothesis is accepted at the one per cent level. No value of t exceeds 2.787.
3. The lecture demonstration produced the higher mean in Units 1 and 4, and the developmental discussion in Units 2 and 3.

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[1]Lindquist, op. cit., p.53.

4. Group B had the higher mean in Units 1 and 2, and Group A in Units 3 and 4.

Comparison of the Marks of the Various Tests

The total final score on the four unit tests, intelligence quotient, school district examination mark, and score on the standardized science test were examined. Correlations were done by the rank-order method and converted. The results of the correlations for each group are given in Table 10. The results of the correlations of these same tests for Group A and Group B are given in Table 11.

TABLE 10

CORRELATIONS OF TESTS FOR GROUPS A AND B

Tests	Group A		Group B	
	r	σr	r	σr
Unit tests : I.Q.	.60	.12	.65	.12
Unit tests: S.D. test	.65	.12	.67	.12
Unit tests: Standard test	.35	.18	.36	.18
I.Q. : S.D. test	.71	.10	.61	.12
I.Q. : Standard test	.43	.16	.45	.16
S.D. test : Standard test	.51	.15	.42	.16

TABLE 11

CORRELATIONS OF TESTS FOR GROUP A TO GROUP B

Tests	r	σr
I.Q.	.99	.01
Final Unit tests	.68	.09
S.D. test	.65	.10
Standard test	.30	.18

The value of the correlation coefficient required for significance for 26 cases at the 5 per cent level is .388 and at the 1 per cent level is .496 as taken from Table 13.[1] Examination of the coefficients of correlation secured from the various tests administered to the groups shows:

1. The correlation between unit tests and I.Q. is significant at the 1 per cent level.

2. The correlation between unit tests and school district test is significant at the 1 per cent level.

3. The correlation between intelligence quotient and school district examination is significant at the 1 per cent level.

4. The closest correlations of the above for both groups are between the unit tests and the school district test, Group A .65, Group B .67.

5. The correlations for Group A to Group B of the unit tests and school district test are significant at the 1 per cent level.

6. The standardized science test does not produce high correlations with the other tests. Most of the correlations secured using the marks on this test are significant at the 5 per cent level.

The Validity and Reliability of the Unit Tests

The validation and determination of the reliability of the unit tests was done using the results from all the Grade 7 pupils. The individual items were again validated by the use of upper and lower thirds. The index of discrimination was secured by taking the per cent in the upper group with the

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[1] Ibid., p. 212.

question correct minus the per cent in the lower group with the question correct. The statistical material necessary is in Appendix E. The index of discrimination for each item on the unit tests as secured in this investigation is given in Table 12. The Index of Reliability is also a measurement of the validity of the unit tests.

The coefficient of correlation to measure the reliability of the unit tests was obtained by the use of the split-half technique. The number of odd numbered questions correct and the number of even numbered questions correct were determined for each pupil. This material is in Appendix E. The odd numbered questions correct were correlated against the even numbered questions correct for each pupil, using the Pearson product-moment of correlation.

$$r_{XY} = \frac{\frac{\Sigma X_1 Y_1}{N} - \left(\frac{\Sigma x_1}{N}\right)\left(\frac{\Sigma y_1}{N}\right)}{\sqrt{\frac{\Sigma x_1^2}{N} - \left(\frac{\Sigma x_1}{N}\right)^2} \cdot \sqrt{\frac{\Sigma y_1^2}{N} - \left(\frac{\Sigma y_1}{N}\right)^2}}$$

The coefficient of reliability of the whole test was determined by the use of the Spearman Brown Prophecy Formula.

$$r_{12} = \frac{2 r_{\frac{1}{2}\frac{1}{2}}}{1 + r_{\frac{1}{2}\frac{1}{2}}}$$

The Index of Reliability was secured by use of the formula.

$$\text{Index} = \sqrt{r_{12}}$$

The statistical results are given in Table 13.

TABLE 12

INDEX OF DISCRIMINATION IN PER CENT

Question	Plants	Seeds & Fruits	Insects	Foods
1	14	15	3	43
2	3	18	6	33
3	6	42	21	20
4	40	42	3	23
5	20	33	3	13
6	51	49	12	57
7	40	42	21	50
8	54	27	18	20
9	43	55	6	63
10	40	55	6	30
11	46	45	41	40
12	57	52	12	37
13	54	61	6	60
14	31	67	3	57
15	31	27	53	43
16	57	21	6	30
17	43	24	44	43
18	60	18	29	30
19	43	36	38	30
20	20	52	38	57
21	31	42	9	40
22	46	49	15	37
23	40	21	12	33
24	49	6	41	40
25	49	18	3	50
26	51	42	15	27
27	57	33	12	13
28	40	18	32	20
29	40	52	35	30
30	43	15	38	13

TABLE 13

CORRELATIONS OF THE UNIT TESTS

Unit	N	$\Sigma x_i y_i$	Σx_i	Σy_i	Σx_i^2	Σy_i^2	r_{xy}	r	Index
1	98	287	117	103	375	289	.79	.88	.94
2	99	277	127	110	353	300	.74	.85	.92
3	98	108	101	72	165	126	.51	.68	.82
4	95	94	35	-27	191	155	.64	.78	.88

Coefficients of correlation secured by the split-half method are spuriously high because the distribution is skewed. The Z function may be used to find the limiting values of the true coefficient. To find the limits at the 1 per cent level the formulae given are used with Table 14, Values of Z for various values of r.[1]

$$2.576 = \frac{Z_H - Z_0}{\sigma Z}$$

$$Z = \frac{1}{\sqrt{N - 3}}$$

A spot check was done using the correlation .68 secured on Unit 3. This shows the true correlation is within the limits .511 and .798. Table 13[2] shows for 100 cases the correlation coefficient required for significance at the 1 per cent level is .256.

Examination of the correlation coefficients secured shows the following:

1. The correlation coefficients for the four unit tests are

---

[1] Ibid., p. 215. [2] Ibid., p. 212.

all significant at the 1 per cent level. All exceed .256.

2. The correlation coefficients for the four unit tests using the minimum value of the correlation coefficient are all significant at the 1 per cent level.

3. The validity of the four unit tests as judged by the index of reliability is considered to be reasonably high. The lowest index of reliability is .82, the highest .94.

The statistical results and major aspects which have been given are now to be examined for the conclusions which may be derived.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

From the statistical results of the investigation and his experiences during the investigation, the author has derived certain conclusions and recommendations. The conclusions will be given first, grouped about the major and minor parts of the investigation.

The study of the effectiveness of the lecture demonstration and developmental discussion methods of teaching general science as used in this investigation led to the following conclusions:

1. No significant difference at the 1 per cent level as shown in the achievement test results was found in the effectiveness of the lecture demonstration and developmental discussion as means of imparting facts and the practical use of these facts as taught in general science.

In Unit 3 on insects, using the increase in individual score, there was a difference at the 5 per cent level sufficiently significant to place it in the region of doubt. However, in the over all results using the significance of a difference in means for small samples for both final scores and increase in scores, there was not a significant difference at the 1 per cent level.

2. No tendency was found for either method to consistently excel the other.

3. The two equated groups continued to show equality in achievement as measured by the unit tests.

Examination of the correlation coefficients secured by correlating the various tests led the writer to conclude:

1. The unit tests indicated a more valid and reliable means of ranking the students in science than the school district examination. The individual items on the unit tests were valid as judged by the objective type used.

2. The low but comparatively similar correlations secured by correlating the standardized science test with the other tests may be due to either the age of the test or the method of securing the score. The test was for pupils in Grades 7 to 12. The test was standardized in 1924 and curricula have changed much since then. The test was in three sections of increasing difficulty and each section was scored separately with the aid of a mathematical formula. The total score was equated to a percentile rank for a Grade 9 class.

The indices of discrimination secured for the individual items on each unit test and the split-half correlations of the unit tests caused the writer to conclude that:

1. The validity of the unit tests as judged by the item indices of discrimination and the indices of reliability was considered to be sufficiently high for tests of a non-standardized nature.

2. The reliability was considered to be sufficiently high for determining the mean difference between the groups and ranking within the group since the groups were pupils of one grade.

Recommendations

The recommendations which the author wishes to make are influenced by both the findings of the investigation and experiences during the investigation and include:

1. A combination of the two methods would seem to be most effective for teaching an alloted area of knowledge in a certain time with most benefit to the pupils and the teacher. The easier portions could be taught using the developmental discussion and the more difficult by means of the lecture demonstration.

2. The lecture demonstration can be used to advantage to teach a large amount of subject matter in a period if the teacher wishes to do work more quickly. It required less time and less mental and physical effort on the part of the teacher.

3. The developmental discussion can be used to give more training to the pupils in reading and interpreting what they read. The slower pupils seemed to improve in these abilities as they did more of this work.

4. An investigation of this type requiring a longer period of time or with more rotation of the methods might show significant advantages for one method. The pupils would become more accustomed to the methods. In the local situation the amount and forms of nature study learned in the elementary grades depended on the interests of the teachers. There was no text.

5. The more visual aids to which the pupils have access, the more they appear to learn. Students do not do as well in separating a flower into its parts unless they have had frequent reference to drawings or pictures of a whole flower showing the relation of these parts. Similarly the use of the

large colored picture of the bee seems to improve their ability to identify the bee's body parts and appendages. The teaching of the unit on foods to emphasize the value of different foods to the body suffers particularly from the lack of concrete experiences even with the aid of charts identifying the foods and their value to the body. The pupils should preferably have experiments feeding white rats or guinea pigs different diets over a period of time, or be shown more films on dietary requirements, or even repetition of good films on the subject.

6. The use of validated teacher made tests has much to recommend it. The results show what has not been well learned and put a certain pressure on the students, whether or not the marks are allowed to be used in some way for reports. Tests of the form used in this study do not require too much of the pupil's or teacher's time and are the closest of the short answer forms to the essay type examination. The writer considers their use improves a pupil's chances of passing on the final examinations with its accompanying satisfaction on the part of the pupil and enhancing the reputation of the teacher.

Summary

This investigation was undertaken to find out if there were any significant difference in the effectiveness of the lecture demonstration and developmental discussion as methods of teaching general science using the unit plan. The hypothesis assumed was that there is no significant difference.

To carry out the investigation two groups of Grade 7 students were secured, equated pupil for pupil. The groups

were equated on the bases of their intelligence quotients and their preliminary scores on the unit tests of the four units they were to be taught. The unit tests had been previously validated and checked for reliability. The population from which the groups were chosen was normal as judged by the standardized intelligence test. The two groups had the same means and were equally variable in both tests used for equating.

The groups were taught by the same teacher who had been accustomed to the use of both methods. The teacher used the selected teaching method for the unit for each group, which gave the pupils more opportunity to become accustomed to the method since it was used for a number of consecutive lessons. The teacher always taught in the science room and used the same objects, specimens, pictures, audio-visual aids, reference books, and guide sheet for the unit with both groups.

The writer hoped the careful controls both in selecting the groups and in their teaching would show any difference in the effectiveness of the methods. For each unit if one group were taught by the lecture demonstration the other group was taught by the developmental discussion. The methods were rotated in successive units. The repetition of the unit test served to measure what the groups had learned by the selected method. The writer found no significant difference nor any tendency for either method to be more effective in teaching general science to the groups used as samples of this population.

APPENDIX

THE DOMINION TESTS

GROUP TEST OF LEARNING CAPACITY

INTERMEDIATE—GRADES 7, 8, 9

(1950 EDITION, OMNIBUS TYPE) FORM A

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

Fill in the blanks below, giving your name, age, etc., and when you have done so, read the rest of this cover page. Only a short time will be given for this so you will need to work rapidly.

Name.....Boy or Girl.....
(IN CAPITALS) LAST FIRST

Age last Birthday.....Birthdate.....Grade.....
MONTH DAY YEAR

School.....Teacher.....Today's Date.....

City, Town, or Municipality.....Province.....

Five sample questions are given below to show you what this test is like. In questions such as 1, 2, and 3, you must in each case select the best answer from the five choices presented, and write the number of your choice in the brackets following the question. In questions in which no choices are given, such as 4 and 5 below, it will be quite clear what you are expected to do. The sample questions have all been answered for you. The questions in the test must be answered in the same manner.

In doing this test you must work as rapidly as possible, since you are not likely to do all the questions in the 30 minutes allowed for it. Each question is worth one point. Skip any questions which appear to be too difficult, or which take up too much of your time, and return to them later if you have any time left. Spend your time now studying the samples below. **Do not open the booklet until you are told to do so.**

1. Which word does not belong in this list?
   (1) green (2) purple (3) red (4) sweet (5) yellow.....(4)

2. **Fish** is to **Swim** as **Bird** is to
   (1) feathers (2) fly (3) nest (4) chirp (5) egg.....(2)

3. Which word means the opposite of COME?
   (1) late (2) home (3) run (4) ride (5) go.....(5)

4. What number comes next in this list?
   12, 11, 10, 9, 8, ...(7)

5. Jim spent half of his money and has 15 cents left. How much did he have at first?.....(30)

DEPARTMENT OF EDUCATIONAL RESEARCH
ONTARIO COLLEGE OF EDUCATION
371 BLOOR STREET WEST, TORONTO 5

SCORE..... **M.A.**..... **C.A.**..... **I.Q.** $= \frac{\text{M.A.}}{\text{C.A.}} \times 100 =$ .....

A

PAGE 1

1. Which word means the opposite of **Create?**
(1) acquire (2) disband (3) destroy (4) resume (5) finish.....( )

2. **Teacher** is to **Pupil** as **Doctor** is to
(1) patient (2) medicine (3) nurse (4) sick (5) hospital.....( )

3. What number comes next in this list?
1, 8, 2, 7, 3, 6, 4, ...( )

4. If Sam had 5 cents more he would have twice as much money as Bill. Bill has 30 cents. How many cents has Sam?.....( )

5. Which word does not belong in this list?
(1) stoop (2) bow (3) jump (4) bend (5) curtsy.....( )

6. **Sheep** is to **Flock** as **Bee** is to
(1) sting (2) flowers (3) shepherd (4) honey (5) swarm.....( )

7. I had 9 apples and John had 10 apples. I gave him 7 of mine. How many more has he than I now?.....( )

8. What number comes next in this list?
2, 3, 3, 3, 4, 3, 5, 3, ...( )

9. Which word means the opposite of **Uncertain?**
(1) possible (2) doubtful (3) careful (4) positive (5) hopeful.....( )

10. It is 76 yards around a square lawn. How many yards is it along each side?.....( )

11. **Fish** is to **Water** as **Bird** is to
(1) nest (2) egg (3) air (4) feather (5) fly.....( )

12. Which word does not belong in this list?
(1) valley (2) hill (3) gully (4) ravine (5) gorge.....( )

13. What fraction comes next in this list?
$\frac{11}{5}, \frac{10}{7}, \frac{9}{9}, \frac{8}{11},$ .....( )

14. What is the smallest number that may be subtracted from 77 to make the remainder exactly divisible by 9?.....( )

15. Which word means the opposite of **Hasten?**
(1) tarry (2) quiet (3) return (4) hurry (5) late.....( )

16. Which word does not belong in this list?
(1) girl (2) maid (3) damsel (4) lass (5) child.....( )

17. **Spade** is to **Earth** as **Spoon** is to
(1) fork (2) soup (3) table (4) silver (5) bread.....( )

18. What number added to 6 gives a number 2 more than half of 16?.....( )

19. What fraction comes next in this list?
$\frac{2}{3}, \frac{3}{5}, \frac{4}{7}, \frac{5}{9},$ .....( )

GO ON TO PAGE 2

20. Which word means the opposite of **Generous?**
(1) wicked (2) miserly (3) rich (4) careless (5) poor.....( )

21. Which word does not belong in this list?
(1) measure (2) gauge (3) disagree (4) reckon (5) estimate.....( )

22. What number comes next in this list?
29, 30, 28, 29, 27, 28, ...( )

23. **Torrid** means the same as
(1) ugly (2) hostile (3) gloomy (4) rainy (5) hot.....( )

24. What number added to 7 gives a number 2 less than one-third of 36?.....( )

25. To **Predict** is to
(1) recall (2) describe (3) remind (4) foretell (5) prevent.....( )

26. What number comes next in this list?
1, 2, 4, 5, 7, 8, ...( )

27. **Wheat** is to **Granary** as **Books** are to
(1) pages (2) print (3) read (4) paper (5) library.....( )

28. Bill is taller than Joe and Joe is shorter than Harvey. Therefore of the three boys
(1) it is certain that Bill is the tallest
(2) it is certain that Joe is the tallest
(3) it is certain that Harvey is the tallest
(4) it is impossible to tell just who is the tallest.....( )

29. Which word does not belong in this list?
(1) shrink (2) contract (3) enlarge (4) reduce (5) diminish.....( )

30.  is to  as  is to

(1)  (2)  (3)  (4)  (5)  .....( )

31. What number comes next in this list?
4, 2, 5, $2\frac{1}{2}$, 6, 3, 7, $3\frac{1}{2}$, 8, ...( )

32. Which word does not belong in this list?
(1) tremble (2) taunt (3) mock (4) jeer (5) jibe.....( )

33. **Mouse** is to **Cat** as **Fly** is to
(1) moth (2) kitten (3) insect (4) spider (5) cheese.....( )

34. What number comes next in this list?
25, 20, 16, 13, 11, ...( )

GO ON TO PAGE 3

35. Which word means the opposite of **Depart?**
(1) meet (2) walk (3) embark (4) journey (5) return.....( )

36. A horse walks 4 miles per hour and trots 12 miles per hour. How many hours will it take to go 24 miles if it trots half the distance?.....( )

37. What number comes next in this list?
6, 21, 8, 19, 10, 17, ... ( )

38. A prize is to be given to the most proficient pupil in the class. Mary is more proficient than Alice; Alice is in advance of the rest of the class. Therefore
(1) Alice will get the prize
(2) Mary will get the prize
(3) One of the other girls will get the prize
(4) Mary will not get the prize
(5) We do not know who should get the prize.....( )

39. Which word means the opposite of **Probable?**
(1) unlikely (2) possible (3) certain (4) never (5) always.....( )

40. What must I divide 32 by in order to get twice 4?.....( )

41. What fraction comes next in this list?
$\frac{15}{3}$, $\frac{13}{6}$, $\frac{11}{9}$, $\frac{9}{12}$, ... ( )

42. Which word means the opposite of **Double?**
(1) enlarge (2) halve (3) decrease (4) couple (5) treble.....( )

43. Which word does not belong in this list?
(1) swamp (2) slough (3) river (4) bog (5) marsh.....( )

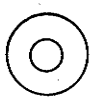
44. What number, if halved, gives us one-third of 24?.....( )

45. What number comes next in this list?
3, 9, 27, 81, ...( )

46. Which word means the opposite of **Answer?**
(1) inquire (2) dictate (3) explain (4) retort (5) reply.....( )

47. Which word does not belong in this list?
(1) bark (2) yelp (3) growl (4) bay (5) purr.....( )

48.  is to  as  is to

(1)  (2)  (3)  (4)  (5)  .....( )

GO ON TO PAGE 4

49. What number comes next in this list?
3, 5, 13, 15, 23, 25, ...( )

50. Which word means the opposite of **Vengeance?**
(1) disgust (2) gratitude (3) justice (4) forgiveness (5) jealousy...( )

51. It rained yesterday. Tomorrow is Thursday. Therefore
(1) it will rain tomorrow (2) Tuesday was wet
(3) it rained on Wednesday (4) it is raining today
(5) yesterday was Wednesday.....( )

52. What number is 2 more than the number which 3 is one-half of?.....( )

53. What number comes next in this list?
2, 3, 5, 8, 12, ...( )

54. Which word does not belong in this list?
(1) seven (2) nine (3) three (4) four (5) five.....( )

55. **Room** is to **Door** as **Field** is to
(1) gate (2) farm (3) wheat (4) fence (5) plough.....( )

56. What number comes next in this list?
92, 97, 72, 77, 52, 57, ...( )

57. What is the number one-third of which is 9?.....( )

58. I have three packets of mixed seed—L, M, N. All the varieties of seeds in packet M are also in packet L, but L has varieties that M does not contain. Packet N has seeds that are in neither L or M. If I wish to grow as many varieties of seeds as possible, I can give away
(1) L (2) M (3) N (4) none.....( )

59. Which word means the opposite of **Acquire?**
(1) lose (2) borrow (3) accept (4) receive (5) detain.....( )

60. **Was** is to **Now** as **Yesterday** is to
(1) tomorrow (2) hour (3) after (4) today (5) soon.....( )

61. It is 16 feet around the edge of my table. If it is 3 feet wide, how many feet long is it?.....( )

62. **Gaudy** means the same as
(1) worthless (2) expensive (3) showy (4) noisy (5) clumsy.....( )

63. How many sheets of tin 3 inches by 5 inches can be cut from a sheet 15 inches by 12 inches?.....( )

64. **Stand** is to **Sit** as **Sit** is to
(1) fly (2) walk (3) rest (4) run (5) lie.....( )

65. What number comes next in this list?
1, 4, 9, 16, 25, ...( )

GO ON TO PAGE 5

66. Multiply each of the numbers, 9, 8, by a number 7 less than itself. What is the sum of the two products?.....( )

67. **Mouse** is to **Mice** as **He** is to
(1) they (2) we (3) us (4) him (5) she.....( )

68. The faces of a cube are numbered, 1, 2, 3, 4, etc. What is the sum of all the numbers on the faces?.....( )

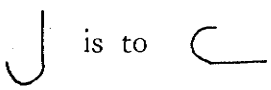
69. An **Adversary** is
(1) a misfortune (2) an opponent (3) a gossip (4) a counsellor
(5) a superior.....( )

70. Jack is one year older now than Jim was 2 years ago. Jack is 7. How old is Jim?..( )

71. Which word means the opposite of **Cautious?**
(1) rash (2) confident (3) severe (4) quick (5) angry.....( )

72. What number comes next in this list?
5, 6, 8, 12, 20, ...( )

73. I spent half of my money and one-third of the remainder. How many cents have I left if I had 84 cents at first?.....( )

74.  is to as  is to

(1) (2)  (3)  (4)  (5)  .....( )

75. If the day before yesterday was the day after Tuesday, the day after tomorrow will be
(1) Thursday (2) Friday (3) Saturday (4) Sunday (5) Monday...( )

END OF TEST

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APPENDIX B

Grade 7. **S C I E N C E** Chapters 1 - 4.

1. What is the main use of plants to us?_____
2. What is the name of a plant which gives us material for cloth?_____
3. What main job does the root perform for the plant? _____
4. What is a second job the root performs for the plant? _____
5. What part of the plant does a stem hold up to the insects and wind? _____
6. What is the name of the wide part of a leaf? _____
7. What food do the roots take in to give to the leaves?_____
8. What food do the leaves take in for their own work in daytime? _____
9. What is the green coloring matter in a leaf called? _____
10. What is the source of power for the work of leaves? _____
11. What food do the leaves make first? _____
12. What is inside a seed? _____
13. What part of the flower protects the bud? _____
14. What is generally the color of the bud protectors? _____
15. What flower circle is generally bright colored? _____
16. What part of the flower produces the pollen? _____
17. What sex is pollen? _____
18. With what does pollen join to form a seed? _____
19. Which part of the pistil forms a fruit? _____
20. What is one thing flowers have to attract bees to them? _____
21. From which flower product do bees make honey? _____
22. What makes it possible for bees to pollinate flowers?

23. How does pollen get to the pistil in grain plants? _____
24. What is the name of the sweet pea petal which is a landing field for insects? _____
25. What is the name of the two sweet pea petals which cover the stamens and pistil? _____
26. What kind of pollination occurs when the pollen is transferred to the pistil from the same flower? _____
27. Which kind of pollination makes better seeds and fruits? _____
28. What is an example of a flower part which dies after pollination? _____
29. How many cells are formed in fertilization? _____
30. What has occurred when one cell becomes two? _____

Grade 7. S C I E N C E Chapters 5, 6.

1. What is formed when pollen and ovule unite? _____
2. Of what are peas in a pod and tomatoes examples? _____
3. What is the main importance of seed scattering? _____
4. Why can the dandelion seeds be scattered by wind? _____
5. What is the floral stem like in plants whose seeds are scattered by shaking? _____
6. What part of the plant tumbles to scatter seeds? _____
7. What is an example of a plant whose seeds are scattered in the mud on the feet of animals? _____
8. What part of a seed cleaner cleans the grain? _____
9. What are the stems of grain called? _____
10. How are most vegetable seeds scattered? _____
11. What substance inside seed cases makes floating possible?

12. How does the weight of a floating object compare with an equal amount of water? _____

13. What trees are generally found here on river banks because their seeds are scattered by water? _____

14. What trees are found on Pacific islands because their seeds are scattered by the ocean waves? _____

15. What is an example of a plant whose seeds are scattered by a bursting pod? _____

16. How many plants grow from a single seed? _____

17. What is the number relationship of seeds to a plant? _____

18. Why plant seeds less deeply in clay than in black earth?

_____

19. What is one way you could make sure the bean plants would grow 4 in. apart in the row? _____

20. What are the extra seeds of plants called? _____

21. What is the main value of the extra seeds of corn to us?

_____

22. What is the importance of extra seeds in a weed? _____

23. What is the name of the plant? _____

24. What is the name of the plant? _____

25. What is the name of the plant? _____

26. What is the name of the plant? _____

27. What is the name of the plant? _____

28. What is the name of the plant? _____

29. What is the name of the plant? _____

30. What is the name of the plant? _____

Grade 7. SCIENCE Chapters 12, 11, 14.

1. How many legs has an insect? _____
2. What is one use of the antennae? _____
3. Which eyes does an insect use to see distant objects? ____
4. Which legs of a bee have the pollen baskets on them? _____
5. Why can an insect walk on a ceiling? _____
6. What is the name of the body division on which the spiracles are found? _____
7. What is the best way to remove a bee's stinger from our hand? _____
8. What is the hard outer part of an insect's body called? ___
9. What is the name of the first stage of an insect's life? __
10. What is another name for the caterpillar stage of an insect's life? _____
11. What is the name of the first stage of a bee's life spent outside the brood cell? _____
12. For what purpose do bees make honey? _____
13. What is the value of hairy bodied insects to flowers? _____
14. What can some flowers not do if insects do not pollinate them? _____
15. What is the use of leaves to a plant? _____
16. Which plants are the main food of grasshoppers? _____
17. What method do plant lice use to attack plants? _____
18. What is an example of a poison that may be used to kill plant lice? _____
19. Why must the poison be put on the body of the plant lice to kill them? _____
20. How do wood eating insects cause a tree to die? _____

21. What does a gall on a plant resemble? _____
22. What is one use of the gall to the insect? _____
23. How are houseflies harmful to us? _____
24. How are body lice and fleas most harmful to us? _____
25. What is one type of cloth eaten by clothes moths? _____
26. From what product of the silkworm do we get silk? _____
27. How are lady beetles useful to us? _____
28. What is meant by parasitic insect? _____
29. What is the purpose of the chrysalis stage of an insect's life? _____
30. What is an example of an animal that is a natural enemy of insects? _____

Grade 7. SCIENCE Chapters 7, 8, 9.

1. How does the body use starchy foods? _____
2. What is the value of fatty foods to the body? _____
3. What is an example of a common protein food? _____
4. What is the value of protein foods to the body? _____
5. What is the main value of water to the body? _____
6. What is the name of one of the food groups which are carbohydrates? _____
7. What is an example of a part of our body which is mostly calcium? _____
8. What is an example of a common food containing large amounts of calcium? _____
9. What is an example of a part of our body which needs large amounts of phosphorus? _____
10. What part of our body needs much iron? _____
11. What is an example of a common food containing much iron?

12. What does the thyroid gland control? _____

13. What mineral does the thyroid gland need to work properly? _____.

14. What food can we eat to provide the mineral the thyroid gland needs? _____

15. What does the salt we eat help control? _____

16. What is one use of Vitamin A to the body? _____

17. What is an example of a food which has much Vitamin A in it? _____

18. What is one use of Vitamin B to the body? _____

19. What is an example of a food which has much Vitamin B in it? _____

20. What is an example of a food we can eat to prevent scurvy? _____

21. What is one way rickets shows on the body? _____

22. What can we eat or do to prevent rickets? _____

23. What is the general use of vitamins in the body? _____

24. What material in the leaf carries on the food making? ____

25. What is the first food made in the leaf? _____

26. What is one food the leaf can make directly from the first food? _____

27. Where do plants get their minerals? _____

28. What is the name of one of the elements combined with the first food? _____

29. In which part of the plant are most foods made? _____

30. When we eat meat and eggs why are we eating food first made by plants? _____

Answers to Unit Tests

It is to be understood that these are not necessarily the only acceptable answers to all the questions.

Chapters 1 - 4.

Unit 1

1. food
2. cotton
3. forage
4. anchorage
5. flower
6. blade
7. soil water
8. carbon dioxide
9. chlorophyll
10. sun
11. sugar
12. embryo
13. calyx
14. green
15. corolla
16. stamen
17. male
18. ovule
19. ovary
20. perfume
21. nectar
22. hairy body
23. wind
24. standard
25. keel
26. self
27. cross
28. corolla
29. 1
30. cell division

Chapters 5, 6.

Unit 2

embryo
fruit
not to be crowded
tufted
hard
top
knot weed
screens
straw
man
air
less
willow
coconut
pea
1
many
Clay is hard soil.
Plant 2 or 3 together.
margin of safety
food
Most are killed
oats
barley
wheat
sweet clover
sow thistle
Canada thistle
couch grass
mustard

Chapters 12, 11, 14.

Unit 3

1. 6
2. to feel
3. compound
4. back
5. sticky feet
6. abdomen
7. scrape
8. to protect it
9. egg
10. larva
11. adult
12. winter food
13. pollinate
14. to make seeds
15. to make food
16. grain
17. suck the sap
18. D.D.T.
19. It smothers them.
20. The tree decays.
21. a swelling
22. home
23. carry germs
24. carry germs
25. wool
26. cocoon
27. predators
28. lives on another insect
29. to become an adult
30. frogs

Chapters 7, 8, 9.

Unit 4

heat and energy
heat and energy
meat
growth and repair
growth and repair
starch
teeth
milk
bone
blood
liver
energy release
iodine
fish
sweating
good eyesight
carrots
good nerves
cereals
fruit
crooked bones
take cod liver oil
to help keep us healthy
chlorophyll
sugar
starch
soil
iron
any part
Animals eat plants.

APPENDIX C

Grade VII SCIENCE December 1953

Name_____ Room___

Part A Answer any 25 questions of the following.

In this section each sentence suggests a number of answers, of which only one is correct. Pick out the number of the correct word or phrase and place that number in the bracket opposite the sentence. Study the sample question.

Sample: Most birds are very useful to farmers because they (3)
(1) sing, (2)are beautiful, (3)eat insects,
(4)are kept as pets, (5)fly south.

The phrase "eat insects" is the correct answer. The number of this answer is 3 and this is the number that is placed in the brackets.

1. The green colouring substance in leaves is called: (1)chloroform, (2)chlorophyll, (3)sugar, (4)starch, (5)carbon dioxide. ( )
2. The separate parts of the second circle of a flower are called: (1)sepals, (2)nectar, (3)petals, (4)stamen, (5)peduncle. ( )
3. The first circle of a flower is called: (1)corolla, (2)seed, (3)filament, (4)stamen, (5)calyx. ( )
4. When the pistil of a flower receives pollen it is said to be: (1)fertilized, (2)pollinated, (3)capped, (4)withered, (5)matured. ( )

25x1

5. The part of the pea flower that attracts the bee is: (1)calyx, (2)keel, (3)standard, (4)pistil, (5)wings. ( )
6. Each year the part of all the crops grown in Canada that is destroyed by insects is about: (1)one half, (2)one fifth, (3)one third, (4)one tenth, (5)three eighths. ( )
7. Insects that live in or on the bodies of animals or plants are called: (1)drones, (2)parasites, (3)worms, (4)predacious, (5)larvae. ( )
8. That part of the flower that produces the pollen is called: (1)style, (2)anther, (3)stigma, (4)pollination, (5)ovary. ( )
9. The use of the stigma is to: (1)catch pollen, (2)make nectar, (3)make seeds, (4)protect the flower, (5)make a pod. ( )
10. The use of the filament is to: (1)hold up the stigma, (2)hold up the petals, (3)hold up the anther, (4)enclose the ovules, (5)attract the insects. ( )
11. The use of the corolla to the plant is to: (1)beautify the world, (2)protect the growing parts, (3)attract insects, (4)make seeds, (5)produce an ovary. ( )
12. The use of the flower to the plant is to: (1)make food, (2)make seeds, (3)help the bees, (4)beautify the world, (5)help growth. ( )
13. A fully developed ovule is: (1)a seed, (2)a pod, (3)a fruit, (4)a thistle, (5)a weed. ( )

14. One fruit scattered by water is: (1)maple, (2)orange, (3)banana, (4)sour dock, (5)wild mustard. ( )
15. Some flowers attract insects because insects (1)must have food, (2)must find a home, (3)help pollination, (4)use nectar, (5)make honey. ( )
16. The use of the stem to the plant is to: (1)make food, (2)anchor the plant, (3)take in minerals, (4)hold the leaves up to the sun, (5)sway in the wind. ( )
17. The following plant produces a winged fruit: (1)poppy, (2)dandelion, (3)maple, (4)milkweed, (5)tumbling mustard. ( )
18. Self pollination can take place only: (1)in the same plant, (2)between different plants, (3)when it rains, (4)between plants of the same kind, (5)when bees look for nectar. ( )
19. The following plant produces a tufted seed: (1)elm, (2)maple, (3)gladiolus, (4)milkweed, (5)oak. ( )
20. The seeds of the coconut tree are dispersed by: (1)wind, (2)water, (3)explosion, (4)hooks catching on to the coats of animals, (5)animals. ( )
21. The most "Dangerous" insect to have in our home is: (1)the book louse, (2)house fly, (3)wasp, (4)hover fly, (5)sawyer beetle. ( )
22. The insect that spends a long period of its life under the skin of cattle is the: (1)dragon fly, (2)aphid, (3)wasp, (4)flea, (5)warble fly. ( )
23. The honey bee shapes the wax cells in the hive with: (1)its antennae, (2)its abdomen, (3)its jaws, (4)its legs, (5)its wax pincers. ( )
24. The honey bee hears with its: (1)antennae, (2)abdomen, (3)spiracles, (4)head, (5)wings. ( )
25. The stage during which the worker bee is fed by other bees is the metamorphosis, (2)spring, (3)resting, (4)larva, (5)winter. ( )
26. Cabbage butterflies do the greatest damage during the: (1)adult stage, (2)larva stage, (3)resting stage, (4)night, (5)egg stage. ( )
27. The second stage in the Complete metamorphosis of an insect is: (1)egg, (2)feeding stage, (3)resting stage, (4)nymph, (5)pupa. ( )
28. The grasshopper does the greatest damage to farmer's crops during the: (1)egg stage, (2)the nymph stage, (3)the adult stage, (4)the spring season, (5)the late fall season. ( )
29. Sugar is tested with: (1)iodine, (2)Fehling's solution, (3)starch, (4)Nitric acid, (5)Ammonium hydroxide. (( )
30. Starch is contained in: (1)sugar, (2)iodine, (3)potato, (4)Phosphorus, (5)Fehling's solution. ( )
31. The class of foods which give the human body heat and energy is: (1)carbohydrates, (2)proteins, (3)vitamins, (4)mineral salts. ( )
32. Which of the following does NOT belong with the others? (1)carbohydrates, (2)fats, (3)proteins, (4)vitamins, (5)sugar. ( )
33. In the experiment "to show the effects of iodine upom starch" the teacher heated the starch and water. Under what heading would you place the underlined statement? (1)method, (2)conclusion, (3)observation, (4)object, ( )

Part B Answer any 25 questions.

Complete the following with suitable words:

1. Another name for "margin of safety" seeds is _____
2. The name given to the stem of a leaf is _____
3. The name given to the canoe-shaped part of the sweet pea flower is _____
4. A ripened ovary with the seeds in it is called _____
5. An example of a bur with barbs is the _____
6. The original home of the dandelion was _____
7. The separate parts of the outside circle of a flower are called _____
8. Unwelcome insects are kept out of nasturtium flowers by a _____
9. One use of a root to a plant is _____
10. An example of a "pepper box" pod with seeds is the _____
11. The name given to the stem of a flower is _____
12. The pistil is able to produce seeds only after _____
13. An example of a plant that produces tufted seeds is _____
14. The part of a flower in which seeds are formed is called the _____
25x1 15. Insects which pollinate flowers have to be covered with _____
16. From the carbon dioxide of the air and water from the soil a plant makes a substance called _____
17. An example of plant that produces winged seeds is the _____
18. Cross-pollination is _____
19. The part of a stamen that holds up the anther is called the _____
20. The sticky part of the pistil is called the _____
21. A common butterfly that has four legs is the _____
22. The larva of the miller moth is usually called _____
23. One of the plants on which galls may be found is the _____
24. Compound eyes of an insect are composed of tiny _____
25. An insect which destroys aphids is the _____
26. A substance that dissolves in water is said to be _____
27. Nitric Acid and Ammonium Hydroxide are used to test foods for _____
28. A substance produced by plants that gives heat and energy to our bodies is _____
29. Vitamin C is necessary in our foods to prevent a disease called _____
30. Cod liver oil is given to children to prevent a disease called _____

Part C TO BE DONE BY ALL STUDENTS ON FOOLSCAP.

SEEDS

2 (1)Name four different ways in which fruits and seeds are scattered.

2 (2)Name one tufted fruit and one shaking fruit.

2 (3)What becomes of the extra seeds produced by the wheat plant?

2 (4)What does "margin of safety" mean?

2 (5)What special device has the caragana for scattering its seeds?

NOTE: STUDENTS WILL DO EITHER D OR E

Part D - FOODS

(1) Using the headings employed in performing an experiment, describe how you would test:
(a) A potato to see if it contained starch.

10 OR

(b) A piece of apple to see if it contained sugar.

(2) Calcium, Phosphorus, Iron, and Iodine are mineral salts which play an important part in the growth of our bodies.

4 (a) For each of these four minerals, name one food containing that mineral.

4 (b) Name one important use to our body of each of the four minerals mentioned above.

(3) Many of our foods contain Vitamins. Because they protect our bodies against diseases such as Pellagra, Scurvy, Rickets, and Berberi, they are essential to life.
Using a title you think is proper, write an interesting account of these vitamins. Here are some suggested items, which, when explained more fully, would make a

12 fairly complete discussion.
(a) An introduction explaining the importance of vitamins.
(b) An interesting paragraph mentioning how people suffered from any one of these diseases before scientists brought it under control.
(c) The cause, effect on our body, and prevention of each disease mentioned.
(d) The importance of research work on foods done by scientists.
(e) Other information which you consider important may also be used.

Part E - INSECTS

4 (1) In paragraph form tell the life history of EITHER a drone bee OR a grasshopper. Do not try to be brief.

7 (2) Rule three columns. At the top write the headings: HEAD, THORAX, ABDOMEN. Underneath each heading list all the parts belonging to that particular main heading for EITHER the bee OR the grasshopper.

8 (3) Tell all you can about the legs and wings of EITHER the worker bee OR the grasshopper. Discuss the special features, the quantity, the uses, size, and other things you consider to be important.

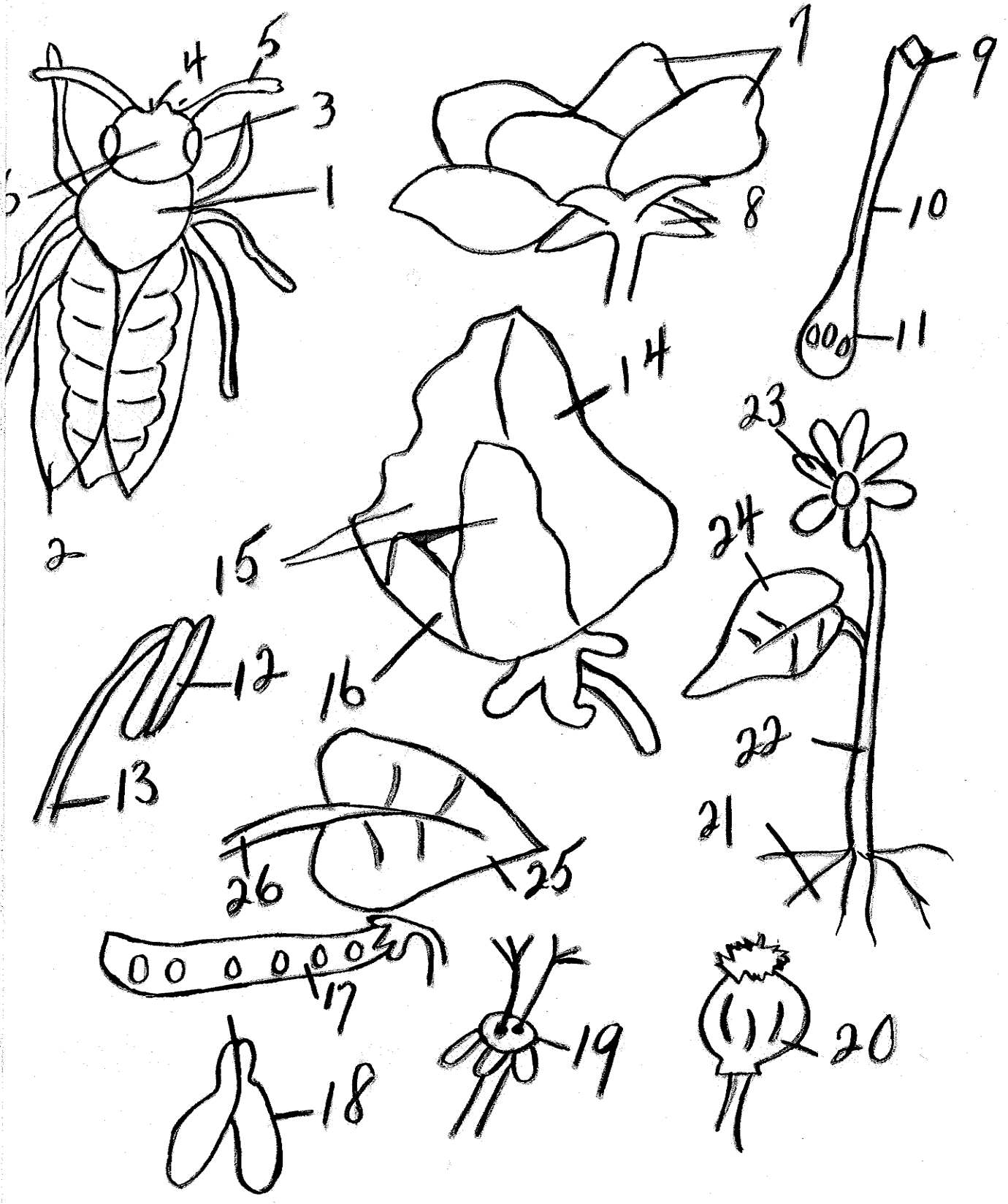
11 (4) Insects may be classified as being beneficial or harmful to plants, Write an interesting paragraph (about half a page of foolscap) telling different ways that insects might harm plants. Name at least one insect that belongs to the classes you have described. Tell how you might destroy each of the kinds you have mentioned.

10 Part F - Drawings (TO BE DONE BY ALL STUDENTS)

Drawings of parts of insects and plants. On the next page you will see several drawings with numbers pointing to different parts. Opposite each number PRINT NEATLY in the spaces provided what the corresponding number on the drawing represents. ANSWER ONLY 20 PARTS.

NOTE: Numbers 17, 18, 19, and 20 represent fruits. In the proper space print the name of the plant that has a fruit of this kind.

1. _____	2. _____	3. _____
4. _____	5. _____	6. _____
7. _____	8. _____	9. _____
10. _____	11. _____	12. _____
13. _____	14. _____	15. _____
16. _____	17. _____	18. _____
19. _____	20. _____	21. _____
22. _____	23. _____	24. _____
25. _____	26. _____	


4
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Dvorak
General Science
Form S-2

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	Number items incorrect		Errors	Scores Corrected (See direction—booklet, page 4)
Group III	.....	÷2	.....	(Key A) Uncorrected Score .....
Group II	.....	÷2	.....	Total Errors, Groups I & II .....
Group I	.....	÷2	.....	
				First Corrected Score .....
				Number Errors, Group I (Key B) .....
				Final Score .....

GENERAL SCIENCE SCALE

Arranged by AUGUST DVORAK

Name.....
(i.e., last name; first name; middle name)

Age: .....years.....months. Grade.....
(i.e., 7th, 8th, 9th, 10th, 11th, 12th)

Sex..... Date.....
(Girl or boy)

School.....

City..... State.....

Room..... Teacher.....

DIRECTIONS

On the following pages are statements, such as—

"A fly is an animal, a fish, an insect, a reptile, a building."

You can make each of these a true statement by underlining the correct black type. A fly is an insect. So if you underline "an insect," the statement above, it is plain that a fly can not be all of the five things printed in large, black type. A fly is an insect. So if you underline "an insect," the statement will read—

"A fly is an animal, a fish, an insect, a reptile, a building."

By underlining "an insect" you have shown that you know which of the five parts is correct.

In the statement—"The heart pumps blood, water, oil, air, sand." "Blood" should be underlined.

Underline the one of the five parts in each of the statements on the following pages which will make the statement most true.

Work rapidly and carefully.

265-4p

No. incorrect.....

GROUP I. FORM S-2. (Average value 71.5)

1. Tuberculosis is prevented by
medicine, hygienic living, massage, osteopathy, chiropractic.
2. Soil deposited at the mouth of a river is called a
peninsula, delta, strait, island, cape.
3. The normal temperature of a human being is
100 F., 104 F., 98.6 F., 93 F., 90 F.
4. Volcanoes are most likely to be found in
deserts, coastal plains, mountains, deltas, islands.
5. The telephone was invented in 1876 by
James Watt, Samuel Morse, Alexander G. Bell, Marconi, S. F. B. Morse.
6. An airplane can not remain in air when
at rest, in motion, upside down, gliding, descending.
7. The age of a tree is told by
branches, rings in cross section of trunk, height, size of trunk, color.
8. To treat a cut use
lime water, iodine, linseed oil, salve, nothing.
9. The passage of the moon between the sun and the earth is called
winter solstice, an eclipse of the sun, full moon,
third quarter, an eclipse of the moon.
10. The home gas consumption is measured by a
velocipede, speedometer, meter, galvanometer, ammeter.
11. The muscles are benefited most by
rest, hard work, systematic diet, play, systematic exercise.
12. The purpose of the mouthpiece on a telephone is
to concentrate the sound waves, to protect the transmitter, for sanitary
purposes, to keep moisture from the wires, to protect the speaker.
13. Oil is used in an automobile engine to
cool it, clear it, lubricate it, burn it, silence it.
14. Soft coal is also known as
anthracite, asphalt, lignite, bituminous, peat.
15. The first electric incandescent lamp was made by
Edison, Burroughs, Watt, Priestly, Westinghouse.
16. The process by which a plant is made to grow on the stem of another plant is
pruning, slipping, grafting, spraying, planting.
17. Alcoholic fermentation is produced by
mold, yeast, bacteria, germs, air.
18. A stove radiates more heat when it is all
black, rusted, nickel plated, aluminum, silvered.
19. Animals which secure food directly from the bodies of other animals are
parasites, hydrophytes, mesophytes, saphrophytes, sulphites.
20. Trees that have needles are called
birch, pine, oaks, gums, evergreen.

No. incorrect.....

GROUP II. FORM S-2. (Average value 81.5)

21. Combustion is another name for
drying, shrinking, boiling, burning, melting.

22. The light from the moon is
direct, reflected, invisible, abstracted, refracted.

23. The covering of electric wires is called
convention, radiation, illumination, insulation, isolation.

24. We pay for electricity by the
watt, ampere, volt, ohm, kilowatt-hour.

25. The simplest independent living structure is the
nucleus, protoplasm, cell, embryo, atom.

26. The device for protecting lights and motors from an overcharge of electricity is called a
magnet, fuse, switch, barometer, rectifier.

27. The term induction is used most in connection with
levers, pumps, falling bodies, solutions, electrical currents.

28. The act of transfer of pollen from anther to stigma is called
pollination, reproduction, fertilization, transpiration, mitosis, filtration.

29. Limewater is used to test for
carbon-dioxide, oxygen, alcohol, hydrogen, chlorides.

30. Tuberculosis is contracted by contact with patient, by contact with clothing, from bacilli of sputum, by taking cold, by bathing.

31. Humidity relates to
dryness, heat, cold, freezing, temperature.

32. The boiling point on the Centegrade thermometer is
0, 32, 100, 120, 212.

33. The smallest of these things is the
molecule, bacterium, paramoecium, dust particles, atom.

34. Foods which contain nitrogen as a part of their chemical composition are called proteins, fats, carbohydrates, hydrocarbons, liquids.

35. The ovum or egg cell is produced in the
kidney, embryo, ovary, gamete, sporagium.

36. Electrolysis of water liberates hydrogen and
chlorine, nitrogen, carbon-dioxide, ammonia, oxygen.

37. Poisonous products secreted by bacteria are called
legumes, enzymes, antibodies, toxins, vaccines.

38. The centrifugal force of a cream separator separates milk from cream because the cream is lighter, heavier, thicker, denser, greasier.

39. Sewer gas is kept from entering a house from the sewer by a
valve, trap, faucet, damper, drain.

40. A mirage is a kind of
body of water, optical illusion, vision, desert, warfare.

No. incorrect.....

GROUP III. FORM S-2. (Average value 91.5)

41. Sunlight can be broken up into the spectrum by means of a
mirror, lens, prism, microscope, color-mixer.

42. A general term for any living thing is
plant, larva, animal, organism, mammal.

43. The temperature at which pure water boils is affected by the
height of the flame, amount of water, air pressure, density of the water, depth of the water.

44. The process of food manufacture in green plants is called
respiration, mitosis, pollination, photosynthesis, pasteurization.

45. Fanning the body on a dry day produces a cool sensation because of
movement of the air, rapid evaporation of moisture into the air, amount of heat taken from the body, creation of a draught, fresh air.

46. A food rich in carbohydrates is
beefsteak, olive oil, cucumbers, watermelon, honey.

47. An example of a fungus plant is the
orchid, pondscum, breadmold, mother of vinegar, Indian pipe.

48. An anemometer is an instrument used by the weather bureau to measure the
amount of sunshine, amount of rainfall, air pressure, wind velocity, atmospheric pressure.

49. Potential energy is energy possessed by an object by virtue of its
weight, combustibility, motion, position, density.

50. The unborn young of an animal is termed the
larva, embryo, chrysalis, ovum, sperm.

51. A star is really a
comet, satellite, planet, sun, light.

52. The greatest damage is done to trees by
birds, worms, larva of moths, grasshoppers, bees.

53. All space is believed to be filled by
air, oxygen, ether, heat, moisture.

54. The main purpose of respiration is
energy-release, elimination of CO_2, manufacture of food, secretion of water, purification of air.

55. Substances without crystalline structure are termed
inert, dense, elastic, opaque, amorphous.

56. Open wounds should be bathed with a dilute solution of
hydrogen peroxide, alcohol, sulphuric acid, soda, tobacco juice.

57. Heat is measured in
degrees, calories, candle power, kilowatts, grams.

58. A ferment is another name for a
bacterium, enzyme, toxin, vaccine, serum.

59. One of the excretory organs in the body is the
heart, liver, skin, duodenum, spleen.

60. Water expands when raised above or cooled below
0 C., 40 C., 32 C., 4 C., 100 F.

APPENDIX E

TABLE 14

SCORES SECURED BY ALL PUPILS IN UNIT TESTS

Score	Unit 1	Unit 2	Unit 3	Unit 4
1				
2				
3				
4	1			
5				2
6		1		
7	1			2
8	2	1		4
9				4
10	2	3		1
11	3	1		6
12	2	1		11
13	4	4	1	11
14		7		8
15	5	6		5
16	5	3	1	6
17	10	6	1	5
18	4	5	6	5
19	10	8	4	8
20	8	7	7	5
21	6	4	14	
22	4	9	18	2
23	4	5	12	5
24	6	10	14	3
25	5	6	4	1
26	5	5	11	1
27	2	2	3	
28	8	4		
29	1	1	2	
30				
Total	98	99	98	95
Upper and Lower Third	35	33	34	30

TABLE 15

NUMBER WITH EACH QUESTION CORRECT IN UPPER AND LOWER GROUPS OF EACH UNIT TEST

Question	Unit 1		Unit 2		Unit 3		Unit 4	
	U.	L.	U.	L.	U.	L.	U.	L.
1	34	29	31	26	34	33	15	2
2	34	33	9	3	34	32	16	6
3	26	24	32	18	32	25	30	24
4	22	8	32	18	34	33	10	3
5	30	23	32	21	33	32	7	3
6	33	15	32	16	26	22	18	1
7	34	20	28	14	34	27	29	14
8	35	16	32	23	31	25	23	17
9	31	16	30	12	34	32	27	8
10	27	13	27	9	33	31	27	18
11	17	1	33	18	19	5	26	14
12	34	14	30	13	34	30	30	19
13	33	14	30	10	34	32	24	6
14	34	23	29	7	6	5	24	7
15	35	24	33	24	23	5	27	14
16	32	12	33	26	34	32	18	9
17	33	18	28	20	23	8	24	11
18	30	9	24	18	29	19	12	3
19	25	10	28	16	23	10	12	3
20	34	27	29	12	15	2	21	4
21	31	20	24	10	33	30	14	2
22	31	15	25	9	34	29	14	3
23	31	17	32	25	34	30	26	16
24	31	14	32	30	26	12	24	12
25	30	13	33	27	32	31	23	8
26	28	10	30	16	31	26	12	4
27	33	13	31	20	34	30	27	23
28	21	7	33	27	20	9	10	4
29	20	6	25	8	18	6	22	13
30	16	1	8	3	28	15	22	18

TABLE 16

QUESTIONS CORRECT ODD AND EVEN HALVES ON UNIT 1

Paper	Odd	Even	Paper	Odd	Even	Paper	Odd	Even
1	8	9	34	12	9	67	10	14
2	8	8	35	9	7	68	13	11
3	10	7	36	14	12	69	11	11
4	5	6	37	12	15	70	7	8
5	6	9	38	11	10	71	10	11
6	4	3	39	8	10	72	13	10
7	12	10	40	16	12	73	9	9
8	9	10	41	14	12	74	8	9
9	11	10	42	6	6	75	8	8
10	10	11	43	6	7	76	6	5
11	9	8	44	14	12	77	8	8
12	15	13	45	12	13	78	11	9
13	7	6	46	14	14	79	6	5
14	10	10	47	15	13	80	7	8
15	8	9	48	13	12	81	8	11
16	6	6	49	11	12	82	2	2
17	11	12	50	11	10	83	9	8
18	5	5	51	12	12	84	10	9
19	8	9	52	15	13	85	8	11
20	11	9	53	15	13	86	11	8
21	11	11	54	14	13	87	4	4
22	13	11	55	14	14	88	3	5
23	8	7	56	9	10	89	5	5
24	12	12	57	12	13	90	9	8
25	6	7	58	9	9	91	10	9
26	11	9	59	9	8	92	13	13
27	6	7	60	10	10	93	10	8
28	11	14	61	10	7	94	8	11
29	10	10	62	10	9	95	14	11
30	12	10	63	11	12	96	14	14
31	8	7	64	10	9	97	9	11
32	15	14	65	13	13	98	9	7
33	12	8	66	14	10			

TABLE 17

QUESTIONS CORRECT ODD AND EVEN HALVES ON UNIT 2

Paper	Odd	Even	Paper	Odd	Even	Paper	Odd	Even
1	12	10	34	4	4	67	14	10
2	12	11	35	11	10	68	13	11
3	8	8	36	11	11	69	9	9
4	8	10	37	9	8	70	10	10
5	10	7	38	11	11	71	12	10
6	5	5	39	12	13	72	12	13
7	8	9	40	14	14	73	11	11
8	10	6	41	8	11	74	3	3
9	12	12	42	12	10	75	7	8
10	7	8	43	13	12	76	9	6
11	10	11	44	12	13	77	11	9
12	14	14	45	14	14	78	7	11
13	6	8	46	14	11	79	5	5
14	11	9	47	13	13	80	6	7
15	7	5	48	11	10	81	8	7
16	8	6	49	12	12	82	6	7
17	10	7	50	11	8	83	11	11
18	4	6	51	13	11	84	9	7
19	11	9	52	12	12	85	10	9
20	13	13	53	12	13	86	11	9
21	14	13	54	11	11	87	7	6
22	14	13	55	11	13	88	8	6
23	10	9	56	12	14	89	9	8
24	9	10	57	10	13	90	11	9
25	10	8	58	5	6	91	10	7
26	11	13	59	15	13	92	11	8
27	7	8	60	10	9	93	7	7
28	5	9	61	6	8	94	12	12
29	10	9	62	13	11	95	12	11
30	8	6	63	10	13	96	8	7
31	15	14	64	14	12	97	14	12
32	11	10	65	8	10	98	9	11
33	12	10	66	11	12	99	6	7

TABLE 18

QUESTIONS CORRECT ODD AND EVEN HALVES ON UNIT 3

Paper	Odd	Even	Paper	Odd	Even	Paper	Odd	Even
1	12	12	34	10	9	67	12	13
2	9	13	35	13	13	68	13	12
3	12	10	36	11	12	69	11	10
4	15	11	37	9	11	70	11	10
5	12	12	38	11	8	71	13	11
6	11	11	39	11	11	72	12	12
7	13	13	40	11	10	73	13	11
8	10	11	41	12	11	74	9	9
9	14	13	42	11	12	75	7	6
10	11	11	43	13	13	76	12	9
11	11	9	44	13	11	77	9	9
12	14	10	45	12	11	78	9	8
13	13	10	46	12	12	79	13	11
14	11	10	47	12	9	80	11	11
15	13	10	48	10	10	81	11	7
16	11	11	49	11	10	82	12	11
17	11	11	50	11	11	83	11	11
18	9	12	51	9	12	84	12	12
19	12	13	52	12	11	85	14	9
20	14	11	53	12	14	86	9	7
21	14	13	54	13	13	87	10	10
22	12	10	55	12	14	88	8	10
23	10	12	56	13	13	89	10	12
24	9	11	57	12	11	90	13	11
25	11	10	58	10	8	91	14	15
26	15	14	59	12	10	92	11	10
27	10	9	60	10	8	93	11	11
28	11	12	61	10	9	94	12	14
29	13	11	62	13	11	95	11	11
30	12	11	63	11	11	96	14	13
31	14	12	64	11	9	97	11	10
32	12	10	65	12	12	98	10	11
33	11	9	66	14	12			

TABLE 19

QUESTIONS CORRECT ODD AND EVEN HALVES ON UNIT 4

Paper	Odd	Even	Paper	Odd	Even	Paper	Odd	Even
1	9	6	34	8	5	67	11	8
2	10	9	35	8	4	68	8	8
3	7	6	36	7	4	69	9	7
4	7	5	37	12	10	70	5	7
5	6	7	38	11	9	71	4	1
6	7	6	39	8	7	72	5	7
7	8	6	40	4	7	73	4	3
8	8	6	41	12	13	74	6	7
9	11	8	42	11	8	75	4	3
10	7	5	43	15	11	76	5	6
11	7	5	44	11	8	77	9	8
12	13	10	45	9	5	78	6	8
13	7	6	46	8	6	79	8	6
14	4	4	47	8	9	80	6	5
15	7	5	48	13	10	81	4	1
16	7	4	49	10	10	82	4	7
17	7	6	50	8	6	83	3	5
18	6	7	51	12	8	84	6	3
19	12	12	52	11	7	85	4	5
20	12	11	53	11	6	86	7	5
21	9	7	54	3	6	87	11	13
22	10	10	55	8	7	88	9	9
23	7	5	56	8	9	89	9	4
24	7	5	57	7	6	90	10	9
25	5	4	58	7	6	91	6	2
26	12	10	59	12	8	92	9	7
27	10	8	60	10	7	93	8	7
28	13	10	61	12	11	94	10	9
29	9	7	62	7	9	95	7	7
30	5	5	63	4	4			
31	12	12	64	10	9			
32	9	9	65	10	5			
33	11	7	66	9	3			

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