A COMPARATIVE STUDY OF
CONSUMER AND PRODUCER BIOLOGY COURSES
IN A HIGH SCHOOL

by

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CHAPTER I

INTRODUCTION

It has often been said that a public imbued with the scientific attitude is the hope of democracy. In today's crisis it is more important than ever that our citizens speak and act only after thinking scientifically. In an address delivered to the Western Pennsylvania Education Conference, Mellon Institute, Pittsburgh, P. B. Mann voiced the thought of many modern thinkers when he declared, "It is through scientific thinking that democracy can be saved." Benjamin C. Gruenberg in his book, Science and the Public Mind, states, "If society is to maintain its health and sanity, the public at large must either be trained to accept the guidance and direction of a special class.....or else it must be trained to take part in the knowledge, the culture, the thought and concepts upon which its civilization rests." In his opinion the former is oligarchic and the latter is democratic and scientific. He, therefore, accepts the latter. Robert A. Millikan once said, "The supreme

2. Gruenberg, Benjamin C., Science and the Public Mind, p. ix.
question for all mankind is how it can best stimulate the
application of the scientific method to all departments
of human living."

However, Nicholas Murray Butler, 4 President of Co-
lumbia University, in his annual report for 1927, ex-
presses the general criticism of science education made
by today's writers, as well as science educators them-
selves, by saying, "The scientific method is everywhere
extolled and within certain limits is rigorously applied.
Yet the public mind, reinforced each year by a veritable
army of youth which is marched through scientific labora-
tories and lecture rooms, museums and observatories, is
as untouched by scientific methods as if no such thing
existed." John Dewey extends this line of thought in the
following statements:

The obligations incumbent upon science
cannot be met until representatives cease to be
contented with having a multiplicity of courses
in various sciences represented in the schools
and devote even more energy than was spent in
getting a place for science in the curriculum,
to seeing to it that the sciences which are
taught are themselves more concerned about
creating a certain mental attitude than they
are about purveying a fixed body of information,
or about preparing a small number of persons
for further specialized pursuits of some partic-
ular science.

I do not mean, of course, that every

4. Butler, Nicholas Murray, Annual Report of the Presi-
dent of Columbia University, Columbia University
Bulletin of Information, Twenty-eighth series,
No. 25, p. 25, March 17, 1928.
opportunity should not be afforded the comparatively small number of selected minds that have both taste and capacity for advanced work in a chosen field of science. But I do mean that the responsibility of science cannot be fulfilled by educational methods that are chiefly concerned with the self-perpetuation of specialized science to the neglect of influencing that much larger number to adopt into the very make-up of their minds those attitudes of open-mindedness, intellectual integrity, observation, and interest in testing their opinions and beliefs that are characteristic of the scientific attitude.5

E. R. Downing believes also that only in a small way have the valuable outcomes of science teaching been achieved.6 G. W. Hunter also contends that science should be a vital force in the development of useful members of society, but that to date any contributions of this nature have been insignificant.7 It is in beliefs such as those expressed above that this study finds its origin.

Statement of the Problem and Its Purpose

The problem of this thesis is to make a comparative study of a biology course for the non-college student (the consumer biology course) and a biology course for the student who will continue his education in college (the college-preparatory course). It was the purpose of this study to determine, in part at least, how successfully

each course was adapted to meet the needs of the individual students of that particular group and to discover where changes can be made which will enable each course to more nearly fulfill its special objectives.

Need for the Study

Incorporated into this study is the author's agreement with the statement of the purpose of education in a democracy agreed upon by the Committee on the Function of Science in General Education of the Commission on Secondary School Curriculum and expressed in their report, *Science in General Education*. This group maintained that "the purpose of education in a democracy is to meet the needs of individuals in the basic aspects of living in such a way as to promote the fullest possible realization of personal potentialities and the most effective participation in a democratic society." Ira C. Davis in an article, "The Measuring of Scientific Attitudes," quotes the same thought from the general philosophy of education prepared by the Teacher Training Council of Wisconsin, a statement of philosophy that has received national

acclaim, in defining education as "growth through problem-solving so that the individual will act in such a way that he will make the greatest contribution to society and at the same time receive the greatest personal satisfaction." Otis W. Caldwell\(^{10}\) contends that "education needs the kind of science instruction which results in recognizing and using what is known, in defining what is not known, and in desiring and seeking new knowledge about things so defined." Recent writers agree upon the aims of science education as summarized in the following three statements:

1. To develop functional understanding of those generalizations of science which enable one to better interpret nature and invention and their effect on society.
2. To develop the attitudes of wonder at, respect for, curiosity about, openmindedness toward, realization of beauty in, and appreciation of—the truth, and its universal operation in natural law.
3. To establish the habit of using the scientific method of thinking in the solution of all problems.\(^{11}\)

As a result of many forces working together—the writer's understanding of the purpose of education and the aims of science instruction; personal experience in witnessing the failure of science courses in meeting the


needs of its pupils; knowledge that in many progressive centers (New York City\textsuperscript{12}, Detroit\textsuperscript{13}) new types of organization for science courses, particularly for non-college-preparatory pupils, are being tried;\textsuperscript{14} and unlimited faith in the potential values of a biology course for high school students—these forces together are the bases for the need for this study. Otis W. Caldwell\textsuperscript{15} declares "more people will study science when the well-supported conviction becomes widespread that science study is highly useful in its direct and indirect help to people." If this study can but be one more step in the proof of this conviction, it will have fulfilled its purpose.

Definition of Terms of the Problem

Admission is made here that this is not a true comparison which term would connote the collection of data concerning every aspect of comparability in the two courses and would thus be beyond the possible scope of this study. However, it is a comparative study since parallel data on the two courses are cited throughout.

\textsuperscript{15} Caldwell, Otis W., loc. cit.
Consumer biology is a course planned and taught for the student who wants to know the fundamental laws of nature and their application without the tedious acquisition of a technical vocabulary and the factual knowledge important only to the specialist.

Producer or college-preparatory biology is planned primarily with the aim of laying a fine background for continued study in the field. Necessarily the producer course is an elementary and basic survey demanding the acquisition of the elements of biology upon which later study may be satisfactorily built.

Location of the Study

The study was made in the Senior High School of Twin Falls, Idaho, where biology is a required subject for all entering sophomores. Two teachers instruct about three hundred students in five classes of college-preparatory biology and five classes of consumer biology, each instructor teaching both types. Five one hour periods per week including varied amounts of supervised study and allowing no extra time for laboratory work are allotted for each class. Classrooms are well-equipped with modern instructional devices including all forms of visual aids such as casts, lantern slides, preserved specimens, charts, and moving pictures.
Subjects Employed in the Study

Approximately three hundred average small town high school sophomores were the subjects in this study. All of them were required to enroll in biology with a choice of either course. However, those who were capable and had the possibilities of college training were advised to take the college-preparatory course while others were guided into the consumer course. Many of these students came from rural homes; most of them were transferred from the local junior high school.

Procedure of the Study

This study involved the teaching of two types of biology to high school sophomores by two teachers. All tests were administered under the same conditions at the same time to all students, complete data being collected on 120 college-preparatory students and 105 consumer biology students.

The first step in the progress of this study was the development of the two courses based upon the same fundamental principles but varying as to content and emphasis. The outline showing the principles and content as given below was developed for use in the study after preliminary trial work in the design of the two courses in the same school by the same teachers the previous year.

The Cooperative Biology Test, Revised Series, Form Q,
1940, of the American Council on Education by F. L. Fitzpatrick, Teachers College, Columbia University, was chosen as the best available test in measuring knowledge of facts and principles. It was administered to all students during the first week of school as a pre-test and repeated during the last week of the school year as a final test to determine the individual gain. E. R. Downing's test, Scientific Thinking, 1936, was given at the close of the year as a test of attitudes as was also Kenneth G. Love's test, Scientific Attitudes--Thinking Test, April, 1937, published by the State Department of Education, Columbus, Ohio, which included in addition some testing of problem-solving. The intelligence quotients were made available by the permanent records of the Twin Falls High School. The Iowa Silent Reading Test was given at the first of the year in all English classes of the school, and the results were available for this study through that department. A student interest-and-evaluation questionnaire was submitted to a fair sampling of students of the two courses after the completion of the year's study. Copies of all tests and the questionnaire are found in Appendix A.

After scoring all tests and recording results, the study was divided into two units for comparison—the first unit, hereafter to be called the gross study, in which test results of the two groups were compared in
their entirety without selection, and the second unit, hereafter to be called the paired study, in which the results of thirty-one college-preparatory students were compared with those of thirty-one consumer students. The two groups were matched in intelligence rating, sex, teacher, and attendance in the local junior high school. A third supplementary study was made in which twenty-five pairs of students were matched on reading ability and compared in problem-solving through the use of the results of the Kenneth G. Love test.

Throughout the study, the same statistical methods were applied to all data to determine the mean scores, the standard error of the means, the standard deviations, the actual difference of mean scores between the two groups compared, the standard error of the difference, and the reliability of the difference. All tables of frequency are included in Appendix B with the calculations indicated above. Summary tables of data are included in the context of the body of the paper.

Limitations of the Study

This study is limited by the number of cases particularly in the paired study as the reliability of measures varies in proportion to the square root of the number of cases. The tests are largely measures of only factual knowledge and scientific attitudes. The Cooperative Test
includes some measurement of the functional understanding of the fundamental principles, but it would have been desirable to have had a complete measure of this understanding had such a test been available. Tests of attitudes have not as yet been perfected. There was no measurement of appreciations used in the study.

Any study based upon data collected on humans and their intangible attributes, because of its very subjectiveness, is necessarily limited. The fact that both teachers, while progressive and conscientious in spirit, were trained fundamentally in the traditional methods of teaching is undoubtedly a limiting factor in the study.

**Summary of Chapter I**

This chapter has presented the necessary explanatory details of a comparative study of college-preparatory and consumer courses in biology in the Senior High School of Twin Falls, Idaho. The study was made as the result of a definitely felt need on the part of the writer and others in the field as indicated by the literature. Two courses were outlined in detail as a basis for the study as shown in Chapter III. The best available tests were used to measure the achievements of the students of the two courses. Although every effort was made to make the study valuable, it is admitted that it is not without the limitations of number of cases, inadequacy of measuring
devices, and general subjectiveness. However, though this study has its limitations as do most of the previous related studies discussed in Chapter II, it deserves a place as an attempt to further educational research in the field of science education.
CHAPTER II

PREVIOUS STUDIES RELATED TO THE PROBLEM

While there are no studies of this specific problem described in the literature, there are many studies related to the various phases of the problem; namely, scientific attitudes, acquisition of factual knowledge, interests, and terminology.

Much recent work has been done and is being done in the determination of scientific attitudes and their measurement. This work is essential to the discovery of how such attitudes can best be developed. Much is yet to be done even in this phase of the study. Attitudes are abstract and therefore difficult to measure and define.

Studies of scientific attitudes and their measurement have been made by Twiss, Meister, Eikenberry, and Curtis, in 1924, by Craig, Downing, and Curtis, in 1929, and subsequently by Rice, Davis, Hunter and Knapp, Beauchamp, Skewes, Noll, Watkins, Bickel, Caldwell and Curtis, and Crowell.16

V. L. Crowell, in his study of attitudes and skills essential to scientific methods and their treatment in general science and elementary biology textbooks, lists the six most important attitudes (which list seems in

close agreement with the finding of others) as follows:

1. Willingness to revise opinion if evidence warrants.
2. Careful and accurate.
3. Unprejudiced in judgment.
4. Believes nothing happens without cause.
5. Suspends judgment. 17

As a result of this study he lists the six most important skills as ability to:

1. Observe accurately.
2. Record observations accurately.
3. Form independent judgments based on facts.
4. Distinguish between fact and theory.
5. Pick out pertinent facts from complex situations.
6. Recognize errors and defects in conditions and processes. 18

Ira C. Davis, University of Wisconsin, reports the characteristics of scientific attitudes as ranked by 80% of 92 authorities in the field as follows:

1. Willing to change opinion on the basis of evidence.
2. Searches for the whole truth regardless of personal, religious, or social prejudice.
4. Has habit of basing judgment on fact.
5. Is able to distinguish fact from theory.
6. Freedom from superstitious beliefs. 19

Noll in his study defines these attitudes very concisely as follows:

1. Accuracy in observation and calculations.
2. Intellectual honesty.
3. Open-mindedness.
4. Conviction of the universal basic cause and effect relations.
5. Suspended judgment.
6. Habit of criticism.

Curtis in his study of 1924 lists the chief scientific attitudes thus:

1. Conviction of universal basic cause and effect relations.
2. Sensitive curiosity concerning reasons for happenings.
3. Habit of delayed response.
4. Habit of weighing evidence with respect to its soundness, pertinence, and adequacy.
5. Respect for another's point of view, an openmindedness, and willingness to be convinced by evidence.

Elliot R. Downing, from his investigations of scientific thinking, concluded that there is no evidence in the data given...that high school pupils acquire skill in scientific thinking as a necessary by-product of the study of scientific subjects as at present taught, and it would appear from these results that ability to think scientifically is a complex of a number of component abilities and that these develop at varying rates and differently in different communities though what the factors are that cause these differences is not revealed.

J. W. Wrightstone found the correlation between scientific attitudes and intellectual factors among general science students in a high school to be .45 with a probable error of .05.23 M. R. Goodson and Glenn M. Blair, using Noll's test What Do You Think? in a study of two groups of general science students, one of which was given special training in scientific thinking while the other was not and a control group composed of students not studying general science, found data supporting the conclusion that ability to think with open-mindedness and from cause to effect is not something that can be markedly developed by simply taking a course labelled general science, but that marked improvement is developed if special training in thinking is given in the course.24 W. B. Reiner's experiment in high school chemistry led to the conclusion that students can learn facts and fail to get attitudes.25

R. W. Tyler found the correlation between information and the application of principles to be .40 and the correlation between information and the interpretation of experiments to be .41 while the correlation between informa-


tion and the formulation of experiments to test an hypothesis was .41.26

Many studies have been made concerning interests of high school students in science. G. M. Relyea, University of Utah, reports a study of the biological interests of a somewhat selected group of Salt Lake City high school sophomore girls. She found that out of a list of 34 topics, the five ranked most interesting by the girls were animals as pets, wild flowers, garden flowers, birds as pets, and animals in the zoo. The five ranked as least interesting topics were mushrooms, molds, evergreens, snakes, and spiders. She also found that familiar things are more interesting than unfamiliar things and animals are more interesting than plants.27 F. T. Perkins28 of Claremont College, Claremont, California, made a study of 359 junior high school boys which showed only .21% (less than 1%) were interested in science and yet 60% were interested in subjects in the general domain of science. He also made a study of 1263 high school students in which they rated 20 expected outcomes of a high school education with the following results:

91.5% judged the structure and function of sex of average to great importance.
90.3% judged physiology and hygiene of average to great importance.
86.9% judged first aid of average to great importance.
72.5% judged elementary psychology of average to great importance.

F. L. Fitzpatrick in a study of science interests found three consistently preferred by student groups, namely: human disease, human anatomy and physiology, and astronomy. 29

A. W. Hurd, Northern Montana College, Havre, Montana, reported a study of what factors make for poor or good achievement in science from which he concluded that achievement scores are higher for those groups having higher I. Q.'s. 30

Studies of the problem of science terminology in general science courses and in high school biology courses have also been made by many, but probably the most important are (1) the first study, which was made by Luella C. Pressey (1924), in which technical vocabulary lists were developed for school subjects; 31 (2) the subsequent study (1926) of S. R. Powers who through a study of high school science textbooks developed "a vocabulary of scientific

terms for high school students" and who recommended, after making the study, that all technical words be eliminated except those needed once they were introduced;\(^3\)\(^2\)\(^3\) the study (1928) of Curtis which combined the studies of many theses and resulted in the presentation of individual glossary lists for chemistry, biology, and general science validated by indicating the ones that appear also on the lists of scientific terms compiled by Powers and Pressey.\(^3\)\(^3\)

These few previous studies cited merely give an idea of the breadth of the research and the vast variety of it related to the problem of this thesis.


\(^{33}\) Curtis, Francis D., Investigations of Vocabulary, p. 116.
CHAPTER III

ORIGIN AND DIFFERENTIATION OF THE TWO COURSES

Since 1910 there has been an increased emphasis on biology in secondary schools and a gradual development from the early course, which consisted of one-half year of botany and one-half year of zoology, through the period of the "lab-manual" course, when the texts were weakened college texts aiming to produce students who would become biology specialists, and a later period of unification, which developed a course on the activities common to all life, to our present course organized around major principles or generalizations.34 G. L. Bush points out that the increasing favor for biology is significant of the value of its objectives.35

The enrollment since 1910 of the secondary school has not only greatly increased but greatly changed. No longer does it consist of college-preparatory students alone. Now it includes the majority of the eighth-grade graduates, who only in small numbers have the ability and the inclination to pursue the technical science courses which would introduce them to the science of the

college-trained specialist. Thus the demand has increased for simplified courses in science to meet the needs of the great majority of secondary students. The consumer course is one attempt to meet this demand. G. P. Deyoe of the State Teachers' College, Platteville, Wisconsin, describes consumer science as involving a "type of instruction which contributes to the development of the abilities, interests, ideals, and understandings that are basic in an intelligent consideration of many important life problems and in the interpretation of natural phenomena." Grace Bagley, Supervisor of Science in Secondary Schools, Flint, Michigan, in describing the efforts made in that city during the last ten years to determine what science information can best serve the needs of its tenth grade boys and girls who will not go to college, makes this statement:

Science teaching is missing one of its greatest opportunities if it fails to meet at least some of the needs of the average worker of tomorrow. Both the home-maker and the wage-earner are concerned vitally with everyday choices of goods, services and methods of thinking, but they obtain little help from the usual science content. To many, especially those who will not go to college, the term 'good' is applied to knowledge for which they can see an immediate use.

36. Wilson, Sherman R., loc. cit.
(Thus the phrase "practical biology" may be justified.)

George Eby,39 of the science department of the College of Pacific, Stockton, California, affirms that "a qualitative study of a subject is of more value to non-college students than a quantitative view."

The psychological approach is characteristic of the consumer course, the emphasis being placed on the immediate environment with the inclusion of a minimum of technical detail, abstract theory, technical vocabulary, and development of laboratory technique, and a maximum of nature study, problem solving, actual observation, and concrete experiences. The aim is not to make the course easy from the standpoint of doing the work for the students, but easy from the standpoint of giving them tasks they can do with outcomes of value to them.40 According to G. P. Deyoe, the divisions of consumer science should develop intelligent purchasers and consumers, with activities for leisure and good health habits, and should foster improvement of thinking ability and socio-economic betterment of mankind.41

In contrast to the consumer course stands the producer course which is organized with the aim of introducing college-preparatory students to a vast field in

40. Bagley, Grace, loc. cit.
which they may later become specialists. This course should be just as practical for them as the consumer course is for the non-college students. There have been questions as to the value of high school biology to college students, and many statements, with and without justification, have been made to the effect that there is little value. However, Bert Cunningham reports in *School Science and Mathematics* for June, 1934, pp. 578-588, the results of a study of the effect of a course in high school biology on the performance in college biology as follows:

A high-school course in biology does have a beneficial effect on one's performance in college zoology, provided the course has been pursued in our better schools. The beneficial effect on botany, while present, is not so evident.

Edwin E. Jacobs\(^{42}\) of Ashland College, Ashland, Ohio, states: "I have carefully checked students entering biological courses in college and find that those who have had some training leading to the development of a technical vocabulary have a better understanding of the subject than those who have slurred over it and that they are better able to pursue their subjects further." The college-preparatory course uses the logical approach placing emphasis on the acquisition of basic knowledge in the field which will be sufficiently thorough and will include

such fundamental skills as will warrant the beneficial effect in college study discovered above. If we admit that the ultimate limiting factor for college success is intelligence and realize that statistics reveal that only the upper twenty percentile of human intelligence is capable of meeting true standards of college attainment, then we will grant, as Ralph E. Horton of the science department of Seward Park High School, New York City, asserts, that "the tendency to make college preparation in science easier, more descriptive, more practical, less quantitative, less mathematical, should be discouraged" and we will further agree with his ideas that "students with ability should be given intellectual 'meat' not 'soup'" and that "preparation in high school to study more science will begin to train students in habits we know will be required".

As a result of a thorough study of the most recent literature in the field of science education (part of which was made in connection with a course in the Teaching of Non-College Science at Oregon State College in 1941), a year of preliminary work in differentiating and outlining the two courses (with the excellent cooperation of the other teacher in the department), the writer reached the following conclusions concerning the two

43. Horton, Ralph E., loc. cit.
44. Horton, Ralph E., loc. cit.
courses which are listed here with supporting statements:

1. The general aims of both courses are the same, namely: to assist the students to gain factual knowledge and functional understandings of the same fundamental biological principles and to gain satisfactions in and appreciations for the living world, to develop in them skills of observation and reflective thinking, and to develop scientific attitudes. ("The facts are necessary for the development of the principles."45 "If we teach fundamental principles and the scientific method, these principles and this method will be good for a lifetime."46 Noll makes a statement to the effect that the aim which might be chosen as typical of all aims for science teaching is the development of the scientific attitude.)47

2. The methods used in teaching the two courses, though there may be variation in the relative proportion of their use, are fundamentally the same. (A conclusion reached through study and discussion in the course, the Teaching of Non-College Science, was to the effect that any method will produce results if it includes the use of the fundamental principles of methods, namely: learning by doing, variety, interest, use of the unusual,

46. Wilson, Sherman R., loc. cit.
motivation, illustrations, appeal to senses, progress from the known to the unknown, humor, enthusiasm, clarity, questions, attention to individual differences, and an understanding of the adolescent.)

3. The contents of each course must be varied to meet the needs of the individuals of the particular group for which it is adapted. (Kenneth E. Oberholtzer, Superintendant of Schools, Long Beach, California, declares, "Needs should be a principal basis for the reconstruction of the science curriculum." P. V. Beck, Central High School, Tulsa, Oklahoma, asserts, "Only student needs based on community needs can determine what should be taught." One of the conclusions of 79 members of the National Association for Research in Science Teaching was to the effect that the content for secondary school science shall be selected for various levels with some reference to its difficulty.)

4. The emphasis in the consumer course must always be on concrete experiences leading to the interpretation of the immediate environment, while the emphasis in the college-preparatory course will more often embrace the abstract through the more traditional study of the general

environment. ("For those who do prepare for the professions, the science course should be rich with the theoretical as well as the practical developments in science."51 Horton52 in pointing out the need to train college-preparatory pupils in habits for future use, says, "Those who don't go to college or don't continue science might better investigate some environmental problems of science which will undoubtedly enrich their everyday lives.")

5. The approach to the consumer course will be psychological (general over-view of the whole to the specific part, the progress from the known to the unknown) and the approach to the college-preparatory course will be the traditional logical approach (progressing from the specific detail to the whole, beginning with the minute, simple division and progressing to the complex.)

6. The vocabulary of the consumer course must be simplified while the college-preparatory course must give the student a basic technical vocabulary which can be expanded in later work. (This conclusion agrees with the work of Powers,53 Curtis54 and Bush,55 as well as the

52. Horton, Ralph E., loc. cit.
study cited above by Jacobs.)

7. It was decided after the first year's work, in which an assortment of modern high school biology textbooks was used instead of a basic text, that the needs of the students could best be served by the adoption of *A Biology of Familiar Things* by Bush, Dickie, and Runkle as a basic text for the consumer course and *Everyday Biology* by Curtis, Caldwell, and Sherman as a basic text for the college-preparatory course, the reference shelf being maintained for supplementary work in both courses.

As a means of further differentiation of the two courses, an outline of the content of each course follows with the vocabulary list of that course.

Unit I. ALL LIVING THINGS ARE ADAPTED TO THEIR ENVIRONMENT AND ARE RECOGNIZED BY THEIR ADAPTATIONS.

A. Higher species have more specialized adaptations.
B. Organisms are adapted for food-getting, protection, and survival of the species.
C. All organisms are interdependent and must struggle to survive.
D. An organism will die unless it can move or adapt itself to a change in its environment.
E. The present distribution is accounted for in part by adaptations.

College-preparatory course

1. Introduction of adaptations of insects.
   a. Study grasshopper.
   b. Compare with crayfish.
2. Study adaptations of Arthropoda.
   a. Introduce taxonomy.
   a. Introduce microscopic study and continue with study of hydra.
4. Study other Coelenterata and continue through the animal phyla.
5. Study plant phyla.

Consumer course

1. Introduce adaptations of insects.
   a. Study grasshopper and other insects economically important.
   b. Study fitness of crayfish for water life.
2. Study adaptations of fish.
3. Study adaptations of frog.
4. Study bird adaptations for air.
5. Study adaptations of domestic and game animals for land.
6. Study adaptations for food getting, protection, mating, and protection of young.
7. Make maps of distribution.
8. Study plant adaptations.
   a. For food-getting, protection, and seed-dispersal.
   b. For desert, water, and land with rain or irrigation.

Unit II. ALL LIVING THINGS ARE FUNDAMENTALLY ALIKE IN STRUCTURE.

A. The composition of protoplasm is known.

B. The cell is the unit of structure and function in all organisms.

C. Growth requires energy and matter and takes place by cell division.

1. Neither energy nor matter can be created nor destroyed.
2. Organisms derive energy from the oxidation of food.
3. Food supplies also the elements for protoplasm.
4. Therefore food-getting, digestion, absorption, circulation, assimilation, excretion and respiration are essential to all organisms.

D. Foods are classified according to their function in the body.
E. Digestion is the reduction of food to simpler substances by the action of enzymes as described typically in man.
F. Digested food must be absorbed and circulated as described typically in man.
G. Assimilation and oxidation take place in individual cells.

1. Man's respiratory system is typical.
2. Wastes resulting from the use of food must be excreted as described, typically, in man.

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<tr>
<th>College-preparatory course</th>
<th>Consumer course</th>
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| 1. Study structure and composition of protoplasm.  
  a. Introduce chemical composition of matter: distinguish between atom, molecule, element, compound, chemical and physical changes; study properties and preparation | 1. Study composition and properties of protoplasm and chemistry involved in very simplest form.  
  2. Study cell wall, nucleus, and cytoplasm of typical cell.  
  a. Introduce microscopic study by demonstration of several types of cells to give generalization |
of C, H, O, N, S.

2. Study detailed structure of a typical cell with microscopic study of specific cells.

3. Introduce foods: learn to classify, use food tests to review chemical study.

   a. Physical and chemical processes of digestion included tissue structure and enzymes and actions.
   b. Compare with other animals.
   c. Digestion in plants.

5. Adaptations for absorption.

   a. Composition of blood.
   b. Vessels and structure.
   c. Heart and detailed structure.
   d. Divisions of circulatory system: pulmonary, portal, coronary, systemic, and lymphatic.
   e. Evolution in circulatory system.

7. Respiratory organs and system in man compared with systems of other organisms.

8. Excretory system in man.
   a. Study Malpighian body as unit of function and structure.
   b. Compare structure of cell differentiation in size, shape, and use.

3. Introduce foods.
   a. Study kinds of foods and use in the body.
   b. Use all kinds of games and drill devices to build ability to choose balanced diets.
   c. Study food economy.

4. Preparation of food for body use.
   a. Show need for digestion and trace process in man.

5. Absorption takes place by osmosis.
   a. Circulation of digested food.
      (1) Basic blood composition.
      (2) Brief simplified study of structure of heart and vessels.
      (3) General course of the blood in human body.
      (4) Health habits to prevent disorders of circulatory system.
      (5) Demonstration to reveal circulatory systems in other organisms.

   a. Vivify with display of calf, chicken, and frog lungs.
   b. Recall abdominal movement in grasshopper and mouth action of fish.
   c. See stomata with hand lens.

7. Trace waste from cells to excretion through kidneys and sweat glands.
of kidney with organs of other animals. c. Study structure of sweat gland. a. Stress health habits involved in excretion of liquids and carbon dioxide and elimination of solid waste.

8. Summarize with emphasis that all living things must carry on same processes.

Unit III. ALL LIVING THINGS ARE SENSITIVE TO STIMULI AND CAN RESPOND.

A. Responses increase in complexity from the simplest organisms to man.
B. Higher animals have specialized sense organs to receive stimuli.
C. Higher organisms have central nervous systems.
D. A tropism is the simplest type of response.
E. A reflex is the simplest type of response in man.
F. Man's intelligence makes him superior to all species.
G. It is as important to maintain mental health as physical health.
H. The ductless glands of higher animals assist the nervous system in sustained control of body processes.
I. Intelligence may be defined as one's ability to learn and cannot be increased to any extent if at all.
J. Without the ability to sense stimuli and respond to them, an organism would perish.

**College-preparatory course**

1. **Structure of nervous system.**
   a. Cellular structure.
      (1) Neurons and types.
      (2) Nerves and types.
      (3) Ganglia and plexus.
   b. Organs, structure, and use.
      (1) Spinal cord.
      (2) Brain.
      (3) Sense organs.

2. **Responses.**
   a. Tropisms.
   b. Reflexes and reflex arc.
   c. Conditioned reflex.
   d. Instinct.
   e. Trial and error.
   f. Habit.
   g. Reasoned response.
      (1) Memory and problem-solving.

3. **Autonomic system's control of viscera.**

4. **Introduction to psychology.**
   a. Mental hygiene.

5. **Study of endocrine glands, location, function, hyperactivity, hypoactivity.**

**Consumer course**

1. **Responses.**
   a. Of pets and domestic animals.
   b. Of simpler organisms including plants.
   c. Of man.
      (1) Reflex and reflex arc with necessary study of structure.
      (2) Conditioned reflex.
      (3) Trial and error.
      (4) Habit and study of good habits and how they are formed and how bad habits are broken.
      (5) Reasoned responses of thinking and necessary study of brain to increase understanding.
      (6) Simplified idea of involuntary control of vital processes.

2. **Simple rules of mental health.**

3. **Simplified discussion of function of ductless glands in man's body.**

**Unit IV. ALL LIFE COMES FROM EXISTING LIFE.**

A. The theory of spontaneous generation has been disproved.
B. One of the main purposes of the individual is to continue the species.

C. The reproductive process increases in complexity from the lowest forms of life to the highest.

D. Dependence of offspring on parents also increases with complexity of the organism.

E. Higher organisms produce fewer young.

F. There is a marked similarity in embryological development of species.

**College-preparatory course**

1. Introduce unit with the story of spontaneous generation.

2. Two types of reproduction.
   a. Asexual with microscopic study.
      (1) Binary fission.
      (2) Conjugation.
      (3) Budding.
      (4) Spore formation.
   b. Sexual.
      (1) Requires the union of gametes to form zygote.
      (2) Typical structures and process in frog for laboratory study.
      (3) Comparison with that of rabbit which is like that of man.
      (4) Compare with that of spermatophyte.

**Consumer course**

1. Review adaptations among plants and animals for reproduction.

2. Study life of salmon to learn of nature's subordination of the individual to the species.

3. Watch trout eggs and frog eggs develop in the laboratory.

4. Watch development of chicken eggs from incubator.

5. Introduce anatomy and physiology of reproduction through study of fish, frog, chicken, rabbit, and flowering plant.

6. Lead into study of process in simpler organisms, molds, bacteria, mushrooms, and paramecia involving some microscopic observation.
   a. Introduce fascinating story of spontaneous generation and its disproof.
Note adaptations for attracting mates and protecting young.

Introduce study of embryology.

Study development in rabbit.
Study development of chick through stages in incubation.
Comparative embryology.

Unit V. EVERY INDIVIDUAL IS THE RESULT NOT ONLY OF HIS ENVIRONMENT BUT ALSO OF HIS HEREDITY.

A. The genes and chromosomes form the mechanism for heredity according to the gene theory.

B. Mendel's laws are the basis for the study of heredity.

C. Aside from environmental influence, likenesses and differences between offspring and parents are both explained by the laws of heredity.

D. Organisms produced by only one parent have less chance of variation and therefore less chance of improvement.

E. Inherited traits cannot be changed in the individual nor are acquired traits inherited.

F. There is a continuity of the germplasm.

G. Animal and plant breeders apply the laws of heredity.
H. Eugenics and eugenics will build up the human race.

I. Heredity is the basis for the evolution of present forms of life.

<table>
<thead>
<tr>
<th>College-preparatory course</th>
<th>Consumer course</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Review cell structure.</td>
<td>1. Observations of variations and likenesses between parents and offspring and brothers and sister, in pets, domestic animals, humans, and plants.</td>
</tr>
<tr>
<td>a. Acquire basic understanding of mechanism of heredity.</td>
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<td>3. Study historical development of heredity with evolution of laws of heredity.</td>
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<tr>
<td>a. Mendel's work and laws and ratios.</td>
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<td>b. Weiseman's theory of continuity of germplasm.</td>
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<td>c. DeVries and the mutation theory.</td>
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<td>d. Morgan's work with the fruit fly.</td>
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<td>e. Muller and recent work with the effect of X-ray on germ plasm.</td>
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<tr>
<td>4. Practical applications of principles of heredity.</td>
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<tr>
<td>a. Sex and sex-linked traits.</td>
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<td>b. Inbreeding and cross-breeding.</td>
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<tr>
<td>c. Plant and animal breeding.</td>
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<td>d. Laws applied to man.</td>
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<td>(1) Cousin marriages.</td>
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<td>(2) Marriage of defectives.</td>
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<td>5. Heredity as a basis for evolution.</td>
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<tr>
<td>6. Study application of laws of heredity to man.</td>
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</tbody>
</table>
a. Geologic background for evolution.
b. Evidences of changing life.
c. Explanation of changes in terms of heredity.

8. Show how heredity helps to explain the changes in animals and plants.

Unit VI. MAN'S SUCCESSFUL MASTERY OF THE LIVING WORLD REQUIRES CONSERVATION OF LIVING THINGS AND THEIR HABITATS.

A. Man's knowledge of how to conserve human life is ever increasing.

1. Pasteur's introduction of the germ theory of disease was the beginning of man's scientific control of disease.

2. Bacteriologists know much and are learning more about the cause, prevention, and control of disease.

   a. Sanitation is an important factor in eliminating disease.

   b. Rapid progress is being made in the use of vaccines and serums to prevent disease.

   c. Proper diet is important to the health of the nation.

   d. Society must be informed if it is to profit by these advances.

B. Soil conservation is the basis for conserving all life.
C. Man suffers by his interference with the balance of nature.
1. Erosion causing floods and dust bowls is one example.
2. Man's fight with insects is another example.

D. Government agencies are doing much to prevent further waste.
1. America is reaching the age when its soil must be rebuilt.
2. Man must protect plants and animals when he changes their natural environments.
3. Forests and wild life are protected by reserves, control of disease and parasites, replanting, and other safeguards.
4. Irrigation projects conserve water and power.

<table>
<thead>
<tr>
<th>College-preparatory course</th>
<th>Consumer course</th>
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<tbody>
<tr>
<td>1. The study of bacteriology is dependent upon laboratory technique.</td>
<td>1. What man knows of the cause of disease.</td>
</tr>
<tr>
<td>a. Forms of bacteria, their identification, and effect on man.</td>
<td>2. How our bodies are adapted to fight disease.</td>
</tr>
<tr>
<td>(1) Harmful—disease producing.</td>
<td>3. How science through the use of its knowledge of vaccines and serums can assist our bodies in fighting disease.</td>
</tr>
<tr>
<td>(a) How they cause disease.</td>
<td>4. Measures we can take toward the ultimate elimination of disease.</td>
</tr>
<tr>
<td>(b) The body's means of protection.</td>
<td>a. Sanitation practices and laws.</td>
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<tr>
<td>(c) Techniques for killing</td>
<td>(1) Milk and water inspection.</td>
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<td>(2) Quarantine laws.</td>
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<td>(3) Laws concerning</td>
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</table>
and preventing their growth.

(d) Use of serums and vaccines.

(2) Helpful.


3. Man's struggle against insects and scientific means of control.

4. America's protection of wild-life.

5. The problem of reforestation in the U. S.

6. Conservation of water and power.

7. Handling of food.

b. Informing the public on items related to disease control.

5. First aid knowledge and practice is a means of conserving human life.

6. America has reached the age that requires soil and water conservation.

a. The "why" of the dust bowl area.

b. The "why" of floods.

c. The "why" of worn-out soil.

7. Man is doing much now to protect and replenish our forests.

8. Now we protect our wild life.

a. Bird sanctuaries.

b. Game reserves.

c. Fish hatcheries.

d. Game laws govern fishing and hunting.
Vocabulary List for the Consumer Course

Conscious effort through use and drill was made to learn the words included in the list below. Many other terms were used but received no definite drill. The terms are listed in groups according to the groups of the "List of Glossary Terms for Biology" compiled by Frances D. Curtis in his study Investigations of Vocabulary.

Group I (Basic Glossary)

abdomen absorption adaptation annual ring antenna appendage artery bacteria bile biology bladder blood capillary carbohydrate carbon carbon-di- oxide cell cell division cell wall cerebellum cerebrum chlorophyll circulation corpuscle diaphragm dicotyledon digestion dominant ductless

element embryo energy environment epidermis esophagus excretion exoskeleton fat fertilization fin flower food fruit function gastriic germ gill growth habit heredity inorganic invertebrate irritability kidney large intestine larva liver lens membrane metabolism microscope nerve nitrogen nutrition fixing bacteria nucleus organ organic matter osmosis ovary oxidation oxygen pancreas parasite perspiration photosynthesis pistil pith pollen pollination protein protoplasm pulse pupil reproduction respiration root hair saliva seed segment sensation sense organ sepal serum sexual skeleton small intestine sperm spinal cord spore stamen stem stimulus sweat gland taproot thyroid tonsil toxin transpiration variation ventricle white corpuscle
### Group II

<table>
<thead>
<tr>
<th>Term</th>
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<td>acquired</td>
<td>evolution</td>
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<td>anus</td>
<td>hormone</td>
<td>selection</td>
<td>survival</td>
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<td>aorta</td>
<td>immunity</td>
<td>neurone</td>
<td>of fittest</td>
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<td>iris</td>
<td>optic nerve</td>
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<td>loam</td>
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<td>auricle</td>
<td>medulla</td>
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<td>chromosome</td>
<td>oblongata</td>
<td>protective</td>
<td>vocal cord</td>
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<tr>
<td>compound</td>
<td>Mendel</td>
<td>coloration</td>
<td>voluntary</td>
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<td>conifer</td>
<td>metabolism</td>
<td>reaction</td>
<td>action</td>
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<tr>
<td>cornea</td>
<td>mineral food</td>
<td>reflex</td>
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<tr>
<td>division of labor</td>
<td>monocotyledon</td>
<td>regeneration</td>
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<tr>
<td>Mustachean tube</td>
<td>motor nerve</td>
<td>retina</td>
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<td>mutation</td>
<td>saprophyte</td>
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### Group III

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<th>Term</th>
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<tbody>
<tr>
<td>antibody</td>
<td>fibrinogen</td>
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<td>cardiac</td>
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### Group IV

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<td>anvil</td>
<td>association</td>
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<td>neuron</td>
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</table>

**Terms Included in the Course But Not Listed by Curtis**

<table>
<thead>
<tr>
<th>Term</th>
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<tbody>
<tr>
<td>sinus</td>
<td>vaccine</td>
<td>hybrid-reduction</td>
<td>crop rotation</td>
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<tr>
<td>mesentery</td>
<td>disinfectant</td>
<td>division</td>
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<tr>
<td>instinct</td>
<td>germicide</td>
<td>syphilis</td>
<td>green manuring</td>
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<tr>
<td>trial-and-error</td>
<td>fracture</td>
<td>gonorrhea</td>
<td>weed</td>
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<tr>
<td>intelligence</td>
<td>fainting</td>
<td>conservation</td>
<td>independent</td>
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<tr>
<td>goiter</td>
<td>egg</td>
<td>terracing</td>
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<td>diabetes</td>
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<td>strip-cropping</td>
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</table>
Vocabulary List for the College-preparatory Course

Even greater emphasis was placed on vocabulary in the college-preparatory course. The words receiving actual drill in the course are listed below in groups according to the study of Curtis.

**Group I (Basic Glossary)**

<table>
<thead>
<tr>
<th>abdomen</th>
<th>cold-blooded</th>
<th>grafting</th>
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<tbody>
<tr>
<td>absorption</td>
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<td>growth</td>
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<tr>
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<td>corolla</td>
<td>guard cell</td>
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<tr>
<td>Algae</td>
<td>corpuscle</td>
<td>habit</td>
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<tr>
<td>Amphibia</td>
<td>cotyledon</td>
<td>habitat</td>
</tr>
<tr>
<td>annual ring</td>
<td>cranial</td>
<td>heart</td>
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<tr>
<td>antenna</td>
<td>decay</td>
<td>heredity</td>
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<tr>
<td>anterior</td>
<td>diaphragm</td>
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<tr>
<td>anther</td>
<td>dicotyledon</td>
<td>hydrogen</td>
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<td>appendage</td>
<td>digestion</td>
<td>infection</td>
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<tr>
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<td>cell division</td>
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<td>cell wall</td>
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<td>cerebrum</td>
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</table>
segment sensation sense organ sepal serum sexual simple eye skeleton small intestine

species sperm spinal column spinal cord spore stamen stem stigma stimulus stomach sweat gland taproot thorax thyroid tonsil toxin trachea transpiration variation

acquired adenoid air sac alimentary anatomy anus aorta aphid Arthropoda asexual auditory auricle bacillus ball and socket behavior bivalve blood pressure cartilage cell membrane centipede chitin chromosome ciliated class combustion compound compound leaf conifer cornea cortex Crustacea cytoplasm dentine dermis division of labor endocrine endoskeleton epiglottis Eustachian tube evolution extinct family femur fern fission flagella flatworm fossil gall bladder ganglion genus germ cell glycogen hemoglobin hormone immunity incisor Insecta insulin interdependence iris lenticle lichen ligament lymphatic Mammalia mandible medulla oblongata Mendel microorganism mineral food molecule monocotyledon moss motor nerve mutation natural selection neuron nitrate optic nerve order ovipositor oxide palate palisade cells parallel-veined leaf pelvis phylum plasma pituitary Primates protective coloration pseudopodia pulmonary reaction
reflex  survival  valve
regeneration  swimmeret  vascular system
retina  symbiosis  vein
roundworm  system  vitamin
segmented worm  tentacle  vocal cord
selection  testis  voluntary action
spiracle  tympanic  waste
spleen  membrane  yeast
sponge  urea  yolk
style  urinary bladder

Group III

adrenal  hinge joint  pleura
amoeboid  humerus  Porifera
angiosperm  law of dominance  portal vein
Annelida  law of recessiveness  Pteridophyta
antibody  law of unit characters  radially
atom  Metazoa  symmetrical
axon  reflex arc  semicircular canals
bilateral  sensory neuron  seta
Bryophyta  Mollusca  spermatophyte
cephalothorax  operculum  spontaneous
Chordata  papilla  generation
cloaca  pericardium  systemic
cochlea  period of incubation  Thallophyta
coelesterata  peristalsis  tube feet
congregation  peritoneum  vestigial
dendrite  phloem  villus
derm  Pisces  villus
ectoderm  Placenta  xylem
gamete  gymnospem  xylem

group IV

anvil  association neuron  Nemathelminthes
autonomic nervous  platelet  Platyhelminthes
system  system  spirae
conditioned reflex  urogenital system
duodenum  vertebral column
Echinodermata  zygote
Island of Langerhans
While many other terms were used in reference study and class discussion, the preceding list includes the terms which were given drill in class.
CHAPTER IV

RESULTS OF THE STUDY AND THEIR INTERPRETATION

It will be recalled from Chapter I that the Cooperative Test was used as a pre-test in the fall for all students and as a final test in the spring to determine the individual gain, that Kenneth G. Love's test and Downing's test were both used as an index to attitudes, that the intelligence ratings were made available through the high school office, and that the reading scores were supplied by the English department. The results of the gross study in which the students were unmatched and unselected will be considered first followed by the results of the paired study in which students were matched in I. Q., sex, teacher, and attendance previously in the local junior high school.

The college-preparatory group made a mean score of 42.39 with a standard error of .75 on the pre-test while the consumer group made a mean score of 34.29 with a standard error of .82. Thus there was a significant difference in previous achievement at the beginning of the courses of 8.1 in favor of the college-preparatory group. These figures are summarized in Table I.
Table I.

Comparison of Cooperative Scaled Scores in Pre-test—Gross Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>42.39</td>
<td>34.29</td>
<td>8.10</td>
</tr>
<tr>
<td>Standard error</td>
<td>.75</td>
<td>.82</td>
<td>1.09</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>7.59</td>
<td>8.43</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table I.

Study of Tables II and V reveals that a partial explanation of this initial difference of the two groups as well as subsequent differences lies in differences in innate mental ability and reading ability. The college-preparatory group surpasses the consumer group in mean intelligence rating by 12.78 which is a significant difference. The mean score of the consumer group is 99.52 while the mean score of the college-preparatory group is somewhat higher than average being 112.30.

Table II.

Comparison of Intelligence Ratings in Gross Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean I. Q.</td>
<td>112.30</td>
<td>99.52</td>
<td>12.76</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.03</td>
<td>1.15</td>
<td>1.49</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.35</td>
<td>10.75</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table II.

Since the college-preparatory students had a higher mean score in the pre-test they would be expected to have a higher mean score on the final test as they did have. Their mean score was 59.85 which, as shown in Table III,
was 14.91 higher than the mean score of the consumer group. This difference is perhaps not so significant as the difference in gain shown in Table IV.

**Table III.**

Comparison of Cooperative Scaled Scores in Final Test--Gross Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>59.85</td>
<td>44.94</td>
<td>14.91</td>
</tr>
<tr>
<td>Standard error</td>
<td>.65</td>
<td>1.03</td>
<td>1.21</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>7.17</td>
<td>10.59</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table III.

In Table IV the difference between the pre-test score and the final test score was calculated for each student in each group and from these individual gains the mean gain was calculated. Thus in this table the results show a comparison of the two groups which includes a comparison of each group's final achievement with its own initial achievement.

**Table IV.**

Comparison of Individual Gain on Final Test Over Pre-test--Gross Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean gain</td>
<td>17.13</td>
<td>10.86</td>
<td>6.27</td>
</tr>
<tr>
<td>Standard error</td>
<td>.54</td>
<td>.64</td>
<td>.83</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>5.91</td>
<td>6.60</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table IV.

A further explanation of the superior achievement of the college-preparatory group probably lies in their
superior reading ability as revealed by a study of Table V which shows a comparison of the results of the Iowa Silent Reading Test for the two groups. While the basic text of the consumer course was somewhat simplified, still many of this group were handicapped by their inferior reading ability, and, of course, poor readers were at a disadvantage in all tests used in the study.

Table V.

<table>
<thead>
<tr>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>59.10</td>
<td>32.60</td>
</tr>
<tr>
<td>Standard error</td>
<td>2.15</td>
<td>1.92</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>23.25</td>
<td>20.85</td>
</tr>
</tbody>
</table>

*See Appendix B, Table V.

This variation in reading ability undoubtedly has some bearing upon the differences shown in the two tests on attitudes and scientific thinking, the results of which appear in Table VI and Table VII. However, in the results of these tests, as in all above results, the difference in favor of the college-preparatory group is sufficiently great to be significant even though their superior reading ability may be a factor in their favor. The Downing test includes the following phases of scientific attitude: ability to pick out pertinent elements from a complex situation, ability to synthesize, selective recall, ability to test fertility of an hypotheses, ability to define the
problem, ability to hold in mind a complex of relations, ability to judge the adequacy of data, problem solving, habit of suspended judgment, and ability to apply a rule or law. The mean score of the college-preparatory group on this test and on the Kenneth G. Love test was significantly higher than the mean score of the consumer group.

Table VI.

Comparison of Downing Test Scores--Gross Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>49.20</td>
<td>36.70</td>
<td>12.50</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.16</td>
<td>1.22</td>
<td>1.68</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>13.05</td>
<td>13.00</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table VI.

Table VII.

Comparison of Kenneth G. Love Test Scores--Gross Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>30.49</td>
<td>20.20</td>
<td>10.29</td>
</tr>
<tr>
<td>Standard error</td>
<td>.87</td>
<td>.87</td>
<td>1.23</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.66</td>
<td>8.91</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table VII.

Summary of the Gross Study

Throughout the gross study there is a significant difference in favor of the college-preparatory group in factual knowledge, understanding of principles, scientific attitude, and ability to think scientifically which is partially explained by the significant difference in
favor of this group in intelligence rating and reading ability.

Many of the findings in the paired study coincided with those of the gross study. However, the difference in intelligence was eliminated by matching the members of each of the 31 pairs on intelligence rating. (See Table VII.)

Table VIII.

Comparison of the Intelligence Ratings in the Paired Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean I. Q.</td>
<td>107.80</td>
<td>107.96</td>
<td>0.16</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.02</td>
<td>1.05</td>
<td>1.46</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>6.10</td>
<td>6.25</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table VIII.

When the difference in intelligence was eliminated by selection, the difference in reading ability was greatly reduced. The large standard error and the great variability as shown in Table IX signify that the mean of this sampling of subjects in the paired study is not

Table IX.

Comparison of Iowa Silent Reading Test Scores--Paired Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>44.94</td>
<td>41.12</td>
<td>3.82</td>
</tr>
<tr>
<td>Standard error</td>
<td>3.32</td>
<td>3.84</td>
<td>5.07</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>18.12</td>
<td>21.00</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table IX.
typical of the group, but that fact is irrelevant here as the importance of the paired study lies in demonstrating the effect of eliminating the factor of intelligence.

Table X and XI show the results of the pairs on the Cooperative Test as a pre-test and a final test, respectively. It will be noted that there is no significant difference between the means of the two groups on the pre-test, but that the mean of the college-preparatory group is 8.94 more than that of the consumer group on the final test. This significant difference in achievement during the year's course is also shown in Table XII where the mean gain for each group is computed upon the individual gain. It is seen that the mean individual gain during the course is 16.05 for the college-preparatory group as compared with 11.61 for the consumer group.

Table X.

Comparison of Cooperative Scaled Scores in Pre-Test--Paired Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>39.56</td>
<td>38.39</td>
<td>1.17</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.20</td>
<td>1.11</td>
<td>1.63</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>6.72</td>
<td>6.21</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table X.
Table XI.

Comparison of Cooperative Scaled Scores in Final Test--Paired Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>56.18</td>
<td>47.24</td>
<td>8.94</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.48</td>
<td>1.46</td>
<td>2.07</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.25</td>
<td>8.16</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table XI.

Table XII.

Comparison of Individual Gain on Final Test Over Pre-Test--Paired Study*

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean gain</td>
<td>10.05</td>
<td>11.61</td>
<td>1.44</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.06</td>
<td>.99</td>
<td>1.45</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>5.91</td>
<td>5.52</td>
<td></td>
</tr>
</tbody>
</table>

*See Appendix B, Table XII.

According to the Downing test there is no significant difference in attitudes in the two groups, the college-preparatory group having a mean score .87 above the mean score of the consumer group as shown by the figures in Table XIII, a difference too small to be significant. However, the results of Love's test of attitudes and thinking (see Table XIV) show a significant difference in favor of the college-preparatory group. Because reading was considered a definite factor in this difference, a supplementary study was made at this point in which twenty-five students from the gross college-preparatory group were matched in reading ability as denoted by the Iowa Silent Reading Test scores with twenty-five from the
gross consumer group. The scores on Love's test of these twenty-five selected pairs were then compared. However, it is seen in Table XV that there is still a significant difference in favor of the college-preparatory group even when reading ability as a factor of difference is eliminated.

Table XIII.

Comparison of Downing Test Scores--Paired Study*

<table>
<thead>
<tr>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>42.05</td>
<td>41.23</td>
</tr>
<tr>
<td>Standard error</td>
<td>2.25</td>
<td>2.28</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>12.51</td>
<td>13.56</td>
</tr>
</tbody>
</table>

*See Appendix B, Table XIII.

Table XIV.

Comparison of Kenneth G. Love Test Scores--Paired Study*

<table>
<thead>
<tr>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>27.64</td>
<td>21.94</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.90</td>
<td>1.31</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>10.59</td>
<td>7.80</td>
</tr>
</tbody>
</table>

*See Appendix B, Table XIV.

Table XV.

Comparison of Scientific Attitude and Thinking as Measured by Love Test in Supplementary Study of Twenty-five Pairs Matched in Reading Ability*

<table>
<thead>
<tr>
<th>College-preparatory</th>
<th>Consumer</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean score</td>
<td>29.80</td>
<td>24.76</td>
</tr>
<tr>
<td>Standard error</td>
<td>1.76</td>
<td>1.43</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.82</td>
<td>7.16</td>
</tr>
</tbody>
</table>

*See Appendix B, Table XV.
Summary of the Paired Study

In the paired study, in which intelligence as a differentiating factor is removed, there is a significant difference favoring the college-preparatory group in factual knowledge and understanding of principles. However, there is a disagreement in the results of the two attitude tests. According to the Downing test there is no significant difference between the two groups and according to the Love test, even when the reading-ability factor is removed, there is a significant difference in favor of the college-preparatory group. These results are in exact agreement with the results of the gross study except in findings of the Downing test.

Supplementary Study of Interests

A supplementary study of interests was made through the use of a questionnaire submitted to a fair sampling of unselected college-preparatory and consumer students. Thirty-nine replies from the former group and twenty-seven replies from the latter group were received. Thorough study of Table XVI is required for a complete understanding of the findings of this questionnaire, but the most significant results may be summarized as follows:

1. The majority of students in both groups liked biology.
2. Heredity and human biology are listed as most interesting by the greatest number of both groups.
3. Likewise, however, heredity and human biology were agreed by the greatest number of college-preparatory students to be most disliked. Heredity, dissection, and human biology were named by the consumer students as being most disliked.

4. The majority of consumer students would like to take another course in biology.

5. The majority of students of both groups have used what they have learned in biology in daily living.

6. Both groups name nutrition as one of the three topics most often used in daily living.

7. The majority of students in both groups have acquired new interests in biology though these interests vary for the two groups.

8. All but two of the 39 college-preparatory students, and all of the practical students agree that the school is justified in requiring sophomores to study biology.

9. The majority of both groups feel that the value of biology is equal to the value of other subjects studied.

10. The majority of college-preparatory students felt that biology was more difficult than other subjects, but the majority of consumer students felt that it was less difficult. This difference may be more significant than it at first appears to be.

11. The majority of students in both groups think that biology is more interesting than other subjects.
<table>
<thead>
<tr>
<th>Question</th>
<th>College-preparatory</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you like biology?</td>
<td>Yes--28</td>
<td>Yes--25</td>
</tr>
<tr>
<td></td>
<td>No---11</td>
<td>No---2</td>
</tr>
<tr>
<td>What topic did you like best?</td>
<td>First 4 choices:</td>
<td>First 4 choices:</td>
</tr>
<tr>
<td></td>
<td>Heredity</td>
<td>Heredity</td>
</tr>
<tr>
<td></td>
<td>Human biology</td>
<td>Human biology</td>
</tr>
<tr>
<td></td>
<td>Dissection</td>
<td>Conservation</td>
</tr>
<tr>
<td></td>
<td>Disease</td>
<td>Nutrition</td>
</tr>
<tr>
<td>What topic did you dislike most?</td>
<td>First 3 choices:</td>
<td>First 3 choices:</td>
</tr>
<tr>
<td></td>
<td>Heredity</td>
<td>Heredity</td>
</tr>
<tr>
<td></td>
<td>Human biology</td>
<td>Dissection</td>
</tr>
<tr>
<td></td>
<td>Plants</td>
<td>Human biology</td>
</tr>
<tr>
<td>Would you like to take another course in biology?</td>
<td>Yes--19</td>
<td>Yes--20</td>
</tr>
<tr>
<td></td>
<td>No---19</td>
<td>No---7</td>
</tr>
<tr>
<td>Have you used what you have learned in biology in daily living?</td>
<td>Yes--24</td>
<td>Yes--25</td>
</tr>
<tr>
<td></td>
<td>No---15</td>
<td>No---2</td>
</tr>
<tr>
<td>Have you acquired new interest in biology?</td>
<td>Yes--26</td>
<td>Yes--17</td>
</tr>
<tr>
<td></td>
<td>No---13</td>
<td>No---10</td>
</tr>
<tr>
<td>Name one new interest?</td>
<td>First 3 choices:</td>
<td>First 3 choices:</td>
</tr>
<tr>
<td></td>
<td>Heredity</td>
<td>Nutrition</td>
</tr>
<tr>
<td></td>
<td>Bacteria</td>
<td>Flowers</td>
</tr>
<tr>
<td></td>
<td>Insecta</td>
<td>Insects</td>
</tr>
<tr>
<td>Should biology be required?</td>
<td>Yes--37</td>
<td>Yes--27</td>
</tr>
<tr>
<td></td>
<td>No---2</td>
<td>No---0</td>
</tr>
<tr>
<td>Is the value of biology equal to greater or less than that of other subjects?</td>
<td>Equal to-----26</td>
<td>Equal to-----18</td>
</tr>
<tr>
<td></td>
<td>Greater than- 7</td>
<td>Greater than- 8</td>
</tr>
<tr>
<td></td>
<td>Less than-----6</td>
<td>Less than-----1</td>
</tr>
</tbody>
</table>
### Table XVI (continued)

Comparison of Answers to Interest Questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>College-preparatory</th>
<th>Consumer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you think biology is more or less difficult than other subjects?</td>
<td>More-----27</td>
<td>More-----6</td>
</tr>
<tr>
<td></td>
<td>Less-----11</td>
<td>Less-----19</td>
</tr>
<tr>
<td></td>
<td>No answer-----2</td>
<td></td>
</tr>
<tr>
<td>Do you think biology is more or less interesting than other subjects?</td>
<td>More-----28</td>
<td>More-----22</td>
</tr>
<tr>
<td></td>
<td>Less-----10</td>
<td>Less-----5</td>
</tr>
<tr>
<td></td>
<td>No answer-----1</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER V.

CONCLUSIONS AND RECOMMENDATIONS RESULTING FROM THE STUDY

Since complete summaries of the results of the gross study, the paired study, and the questionnaire are given in Chapter IV, it is sufficient, in summary, to state here that the general indication of the results is that the college-preparatory students surpass the consumer students in gaining factual knowledge, understanding of fundamental principles, scientific attitudes, and ability to think while the responses of the two groups to the courses denoting their interest in biology show marked similarity.

Conclusions

The data of the study included in Chapter IV led to the following conclusions:

1. Although intelligence is undoubtedly a factor in determining achievement in biology, it is not the sole factor.

2. The gaining of scientific attitudes may not be entirely independent of the acquisition of factual knowledge and the understanding of fundamental principles; or perhaps the traditional methods of teaching biology are more conducive to the gaining of scientific attitudes and methods of thinking.

3. The college-preparatory course, developed in the
study, more nearly approaches the objectives set for it than does the consumer course as it is now organized; or else the tests available at the present time, since they were made to measure results in traditional courses, fail to measure accurately the gains of the students of consumer courses. There may be significant differences in favor of consumer students in the development of interests and appreciations which cannot be measured objectively and so are in no way indicated by tests used. Students of consumer courses encountered vocabulary difficulties in tests.

4. Greater conscious effort to develop scientific attitudes is needed in both courses.

5. Greater emphasis is needed upon problem-solving activity in both courses.

6. There is a tendency to simplify the consumer course by lowering standards of scholarship rather than by modifying requirements according to the objectives of the course.

7. The emphasis of secondary teachers, texts, and measuring devices remains largely upon gaining factual knowledge even today.
Recommendations

1. This study is not complete. It is the initial attempt to measure the effectiveness of two courses established in a high school striving to adapt its curriculum to the needs of its students. This study shows where improvements must be made in the two courses, which the author believes are justified, if they are to approach the objectives set for them. The author will necessarily continue this study until results are reached which more nearly coincide with the aims herein stated, since presentation of biology courses adapted to the needs of her students is her profession.

2. A further study arising from this problem would be an attempt to meet the need for better measuring devices particularly for attitudes, thinking, interests, appreciations, and functional understanding of fundamental principles.

3. A final recommendation concerns the provision for better in-service as well as preparatory professional courses for teachers who are striving to fulfill the objectives of education characteristic of a democracy. At present only the theory is emphasized. How can they learn the method?
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APPENDIX A

TESTS USED IN THE STUDY
AMERICAN COUNCIL ON EDUCATION

COOPERATIVE BIOLOGY TEST

REVISED SERIES FORM Q

by

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with the editorial assistance of

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Please print:

Name. ............................................ Date. ............................................

Last First Middle

Grade or Class. .................................. Age. Yrs. .................................. Date of Birth. Mes. ..................................

School. ............................................ City. ............................................ Sex. ............................................

Instructor. ........................................

Number of years you have studied biology: (one semester = ½ year; one quarter = ½ year)

General Directions: Do not turn this page until the examiner tells you to do so. This examination consists of two parts, and requires 40 minutes of working time. The directions for each part are printed at the beginning of the part. Read them carefully, and proceed at once to answer the questions. DO NOT SPEND TOO MUCH TIME ON ANY ONE ITEM. ANSWER THE EASIER QUESTIONS FIRST; then return to the harder ones if you have time. There is a time limit for each part. You are not expected to answer all the questions in any part in the time limit; but if you should, go on to the next part. If you have not finished Part I when the time is up, stop work on that part and proceed at once to Part II. If you finish Part II before the time is up, you may go back and work on either part. No questions may be asked after the examination has begun.

You may answer questions even when you are not perfectly sure that your answers are correct, but you should avoid wild guessing, since wrong answers will result in a subtraction from the number of your correct answers.

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Scaled Score | Percentile
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15 Amsterdam Avenue, New York City
PART I

Directions: Each of the incomplete statements or questions below is followed by five possible answers. For each item, select the answer which best completes the statement or answers the question, and put its number in the parentheses at the right.

1. A scientist tests the truth of a theory by
   1-1 performing controlled experiments.
   1-2 consulting books written by other scientists.
   1-3 debating the matter with a group of educated people.
   1-4 carefully considering all of the factors involved in the situation.
   1-5 finding out what experts think about it. ............... 1(  )

2. Which one of the following types of plant life would you expect to find growing in a desert?
   2-1 A liverwort
   2-2 A moss
   2-3 A fern
   2-4 A cactus
   2-5 A horsetail ............... 2(  )

3. When early studies of heredity are mentioned, we are likely to be reminded of experiments performed by
   3-1 Linnaeus.
   3-2 Galen.
   3-3 Harvey.
   3-4 Mendel.
   3-5 Leeuwenhoek. ............... 3(  )

4. Horses eat plant materials almost entirely. They are therefore said to be
   4-1 carnivorous.
   4-2 saprophytic.
   4-3 omnivorous.
   4-4 parasitic.
   4-5 herbivorous. ............... 4(  )

5. Which one of the following organisms can grow to maturity in the dark?
   5-1 Elm tree
   5-2 Spirogyra
   5-3 Mushroom
   5-4 White clover
   5-5 Radish ............... 5(  )

6. If you lived in the northern part of the United States, and went out on a midwinter field trip, there would be little or no chance that you would see a
   6-1 crow.
   6-2 weasel.
   6-3 rabbit.
   6-4 chickadee.
   6-5 frog. ............... 6(  )

7. In the animal body, energy for muscular activity comes from the
   7-1 secretion of digestive fluids.
   7-2 oxidation of food materials.
   7-3 excretion of wastes.
   7-4 absorption of water.
   7-5 absorption of mineral salts. ....... 7(  )

8. Which one of the following organisms is a mammal that lays eggs?
   8-1 A duckbill
   8-2 A koala bear
   8-3 A mole
   8-4 A bat
   8-5 A salamander ............... 8(  )

9. Which plant in the following list does not make its own food?
   9-1 A hickory tree
   9-2 A fern
   9-3 A geranium
   9-4 A moss
   9-5 A mold ............... 9(  )

10. Which one of the following insects is known to bite man and thus convey disease germs to him?
    10-1 Rat flea
    10-2 Termite
    10-3 Ant
    10-4 Codling moth
    10-5 Cockroach ............... 10(  )

11. Which insects in the following list are most likely to eat the leaves of cherry and apple trees?
    11-1 Praying mantes
    11-2 Tent caterpillars
    11-3 Codling moths
    11-4 Blister beetles
    11-5 Bot flies ............... 11(  )

12. The nucleus of a full-grown Amoeba elongates and begins to divide, and the cytoplasm to separate into two portions. Finally two nearly equal cells are formed. This represents
    12-1 symbiosis.
    12-2 budding.
    12-3 simple fission.
    12-4 sporulation.
    12-5 maturation. ............... 12(  )

13. Which one of the following organisms is an animal?
    13-1 A kelp
    13-2 A Venus flytrap
    13-3 A reindeer moss
    13-4 A liverwort
    13-5 A sea anemone ............... 13(  )

14. Which of the following causes of erosion is most important in dry countries under normal conditions?
    14-1 Freezing and thawing
    14-2 High temperature
    14-3 Chemical changes
    14-4 The wind
    14-5 High altitude ............... 14(  )

Go on to the next page.
15. An effective way to get rid of cockroaches is to
   15-1 clean all furniture and fixtures thoroughly.
   15-2 put poison powders in cracks and crevices.
   15-3 put out poisoned pieces of bread.
   15-4 keep the floors very clean.
   15-5 place moth balls in cracks and crevices. 15( )

16. One reason why we say that a frog is a vertebrate is that it
   16-1 develops gills in one stage of its life cycle.
   16-2 hibernates in cold weather.
   16-3 develops from a fertilized egg.
   16-4 has a backbone.
   16-5 cannot live without oxygen. 16( )

17. We suspect that our water supply may be polluted. One way to make the water safe to drink is to
   17-1 filter it through a mixture of charcoal and sand.
   17-2 add a pinch of salt to each gallon.
   17-3 boil it for at least twenty minutes.
   17-4 filter it through two or three thicknesses of filter paper.
   17-5 add a half teaspoonful of soda to each gallon. 17( )

18. The enzyme in the human mouth which changes starches into sugar is
   18-1 trypsin.
   18-2 erepsin.
   18-3 lipase.
   18-4 ptyalin.
   18-5 maltase. 18( )

19. A farmer discovers that termites have become numerous near his home. He would begin to worry about
   19-1 the health of his chickens.
   19-2 the walls and floors of his house.
   19-3 his water supply.
   19-4 the walls of his concrete silo.
   19-5 the vegetables in his garden. 19( )

20. Other factors being equal, in which of the following places is the soil likely to be eroded most rapidly?
   20-1 A flat grass-covered field
   20-2 A hillside covered by a forest
   20-3 A level area that is covered by a forest
   20-4 A hillside upon which few if any plants are growing
   20-5 A hillside covered with grasses and bushes 20( )

21. In which one of the following plants does food-making take place mostly in the stem?
   21-1 Cactus
   21-2 Turnip
   21-3 Radish
   21-4 Clover
   21-5 Cabbage 21( )

22. An epidemic of diphtheria appears in your community. This indicates that
   22-1 an epidemic of influenza will probably follow.
   22-2 the diet of many people lacks necessary vitamins.
   22-3 many children have not been made immune to the disease.
   22-4 the air is full of goldenrod pollen.
   22-5 sulphur should be burned daily in all homes. 22( )

23. The structures of a seed plant that absorb water from the soil are the
   23-1 lenticels.
   23-2 root caps.
   23-3 root hairs.
   23-4 stomata.
   23-5 petioles. 23( )

24. Which of the following insects are most likely to reduce the yield from hay fields?
   24-1 European corn borers
   24-2 Scale insects
   24-3 Stable flies
   24-4 Boll weevils
   24-5 Grasshoppers 24( )

25. Which one of the following substances is a hormone?
   25-1 Trypsin
   25-2 Insulin
   25-3 Erepsin
   25-4 Lipase
   25-5 Lactase 25( )

26. In the following list, a mammal that commonly hibernates during the winter season is a
   26-1 frog.
   26-2 salamander.
   26-3 rabbit.
   26-4 wolf.
   26-5 woodchuck. 26( )

27. A vitamin whose absence in the diet is related to the development of rickets is
   27-1 vitamin A.
   27-2 vitamin B.
   27-3 vitamin C.
   27-4 vitamin D.
   27-5 vitamin G. 27( )

28. Which of the following factors is part of the normal environment of deep sea organisms and not of land organisms?
   28-1 The presence of oxygen
   28-2 The presence of mineral salts
   28-3 Great pressure
   28-4 The presence of natural enemies
   28-5 Freezing temperatures 28( )

29. Two Paramecia, lying side by side, exchange some of their nuclear material. This is called
   29-1 cell division.
   29-2 recession.
   29-3 regeneration.
   29-4 conjugation.
   29-5 mitosis. 29( )

Go on to the next page.
30. It is found that a certain species of animal feeds and protects its young. Probably such an animal
30-1 produces relatively large numbers of young.
30-2 lays eggs.
30-3 produces relatively few young.
30-4 is cold-blooded.
30-5 nests in trees.

31. Protoplasm is largely composed of nitrogen, carbon, hydrogen, and
31-1 oxygen.
31-2 sulphur.
31-3 iron.
31-4 calcium.
31-5 phosphorus.

32. Gastric juice is secreted by cells that line the human stomach. It contains several substances which serve to break down foods into simpler compounds. It would therefore be classified as
32-1 a fluid containing hormones.
32-2 a food material.
32-3 a circulatory fluid.
32-4 an oxidizing agent.
32-5 a fluid containing enzymes.

33. An elongated human cell whose main function is contraction and which carries on other functions only to a limited extent could be a
33-1 gland cell.
33-2 muscle cell.
33-3 sex cell.
33-4 nerve cell.
33-5 bone cell.

34. All organisms are similar in that they
34-1 have the same organs.
34-2 have the same tissues.
34-3 have the same systems.
34-4 are cellular.
34-5 have the same habitats.

35. The fact that a certain plant bears flowers indicates that it
35-1 is a seed plant.
35-2 will grow from cuttings.
35-3 is a perennial.
35-4 is a cultivated variety.
35-5 is an alga.

36. Which one of the following insects destroys insect pests?
36-1 The gypsy moth
36-2 The potato beetle
36-3 A ladybird beetle
36-4 The Hessian fly
36-5 A squash bug.

37. It is a good idea to cook pork until it is well done because
37-1 rare pork cannot be digested.
37-2 thorough cooking kills worm parasites.
37-3 eating rare pork is likely to cause cancer.
37-4 rare pork is harder to chew.
37-5 cooking increases the vitamin content.

38. If you developed a case of hay fever in late summer and it was traceable to ragweed pollen, it would be reasonable to say,
38-1 "I shall have to stop eating starchy foods."
38-2 "I seem to have an allergy."
38-3 "This is due to being overweight."
38-4 "What I need is a dose of common soda."
38-5 "Apparently there is not enough iron in my blood."

39. We find that the temperature of an animal varies considerably, and that these variations parallel changes in the temperature of the environment. This indicates that the animal is
39-1 cold-blooded.
39-2 predaceous.
39-3 complex.
39-4 degenerate.
39-5 aquatic.

40. Which one of the following is a plant cell that normally develops a new plant without having been fertilized?
40-1 Parenchyma cell
40-2 Guard cell
40-3 Spore
40-4 Root hair
40-5 Egg cell.

41. If you had lived in France sixty years ago and had met Louis Pasteur, it would have been sensible to say,
41-1 "Are you still studying the formation of coral reefs?"
41-2 "I have been very much interested in your discoveries about bacteria."
41-3 "Have you made any new discoveries in the field of cancer research?"
41-4 "Do you still believe that organisms arise spontaneously?"
41-5 "Your demonstration of blood circulation is very convincing."

42. When you live in a community where smallpox has been practically unknown for years, it is a good indication that
42-1 smallpox is no longer to be feared.
42-2 the community has a good water supply.
42-3 the diet of the people is adequate.
42-4 vaccination has been commonly practiced.
42-5 other diseases are unusually common.

43. One obvious reason why a frog is not a mammal is that it has
43-1 a nervous system.
43-2 no fins.
43-3 no hair.
43-4 a stomach and an intestine.
43-5 ductless glands.

Go on to the next page.
44. A certain species of animal is found to have a heart, a backbone, and a nervous system. The evidence indicates that this animal is:
   44-1 a flatworm.
   44-2 a protozoan.
   44-3 a vertebrate.
   44-4 an aquatic type.
   44-5 an air-breather.

45. Which one of the following types of plants exhibits alternation of generations?
   45-1 Pleurococcus
   45-2 A bacterium
   45-3 A mold
   45-4 A moss
   45-5 A mushroom

46. It is found that many people in a certain locality are infested by hookworms. Probably most of these people
   46-1 do not wear shoes.
   46-2 are excessive users of alcohol.
   46-3 live in swampy areas.
   46-4 do not eat enough green vegetables.
   46-5 do not get enough sunshine.

47. We study a mushroom and find that its tissues do not contain chlorophyll. We find that it grows upon decaying wood. The evidence suggests that
   47-1 it is a parasite.
   47-2 it reproduces by budding.
   47-3 the mushroom is a seed plant.
   47-4 it is a saprophyte.
   47-5 the mushroom is edible.

48. A cell from the human body is found to secrete the enzyme pepsin. It does not perform other functions except to a limited degree. Such a cell would best be described as a
   48-1 gland cell.
   48-2 blood cell.
   48-3 nerve cell.
   48-4 formative cell.
   48-5 supporting cell.

49. A certain species of land plant develops broad leaves which contain chlorophyll. This indicates that this plant
   49-1 grows best in dry regions.
   49-2 will grow only on acid soils.
   49-3 is able to make food from carbon dioxide and water.
   49-4 is able to survive extreme variations in temperature.
   49-5 is probably a type of fungus.

50. Which of the following human foods is likely to be least fattening?
   50-1 A half pound of milk chocolate
   50-2 A half loaf of white bread
   50-3 A head of lettuce
   50-4 A quarter pound of brick cheese
   50-5 A pint of cream

51. Suppose that you had some milk from cows that were known to be free from tuberculosis. It would still be a good idea to pasteurize the milk because
   51-1 this would add to its vitamin content.
   51-2 pasteurized milk is more digestible.
   51-3 the cows might have undulant fever.
   51-4 most people prefer the flavor of pasteurized milk.
   51-5 pasteurization adds to the food value of milk.

52. An effective way to rid a garden of insect pests which are eating the leaves of the plants is to
   52-1 destroy all weeds in the garden.
   52-2 spray the plants with a poison spray.
   52-3 provide more moisture.
   52-4 hoe the plants so that they will grow better.
   52-5 release a poison gas in the garden.

53. A fertilized ovum divides several times, forming a hollow sphere of cells. This process is called
   53-1 commensalism.
   53-2 cleavage.
   53-3 maturation.
   53-4 molting.
   53-5 budding.

54. There is an epidemic of influenza in your community. One of the best ways to avoid getting the disease is to
   54-1 keep away from other people as much as possible.
   54-2 get plenty of exercise.
   54-3 eat plenty of fresh fruit.
   54-4 gargle daily with warm salt solution.
   54-5 take an aspirin tablet after each meal.

55. Which of the following statements about bacteria is true?
   55-1 All bacteria cause disease.
   55-2 Most bacteria carry on photosynthesis.
   55-3 All diseases are caused by bacteria.
   55-4 Most bacteria have well-developed nuclei.
   55-5 Some bacteria are useful to man.

56. Division of labor among tissues is accompanied by
   56-1 degeneration.
   56-2 specialization.
   56-3 atrophy.
   56-4 photosynthesis.
   56-5 generalization.

Go on to the next page.
57. You store a summer suit in a sealed paper bag. In the spring you find that it has been damaged by clothes moths. It is reasonable to say:

57-1 “It is simply impossible to avoid these moths.”
57-2 “This happened because we had a warm winter.”
57-3 “We ought to have had our windows screened.”
57-4 “Next winter I shall put out some poisoned baits.”
57-5 “I should have had the suit steam-pressed before I put it away.”

58. One function of the haemoglobin in blood is to
58-1 destroy wastes.
58-2 destroy foreign organisms.
58-3 carry food.
58-4 combine with oxygen.
58-5 destroy worn-out white cells.

59. You do not feel very well and have a temperature of 102° F. Which of the following is the most sensible procedure?

59-1 Consult a physician.
59-2 Take a couple of aspirin pills.
59-3 Take a half teaspoonful of soda in a glass of water.
59-4 Stay out-of-doors in the fresh air.
59-5 Take a laxative.

60. Which one of the following animal types was not found in North America by the early Spanish explorers?

60-1 Horses
60-2 Alligators
60-3 Wolves
60-4 Rabbits
60-5 Squirrels

61. If you were on a camping trip in “darkest” Africa, which of the following ought you to fear most?

61-1 Lions
61-2 Tigers
61-3 Boa constrictors
61-4 Disease germs
61-5 Head hunters

62. Milk is good for young people to drink because it

62-1 is always pure.
62-2 quiets the nerves.
62-3 keeps the blood from becoming too acid.
62-4 is soothing to the stomach.
62-5 contains all of the vitamins.

63. When light enters your eye, it comes in contact with certain nerve endings, and impulses are carried through the optic nerve to the brain. These nerve endings are located in the

63-1 iris,
63-2 retina,
63-3 choroid,
63-4 lens,
63-5 cornea.

64. You wake up one morning and find that you have a sore throat. This indicates that

64-1 you have been chilled during the past twenty-four hours.
64-2 you have influenza.
64-3 various germs have become established in the tissues of your throat.
64-4 you have not been getting enough sleep.
64-5 there is too much acid in your system.

65. Which one of the following is a very common cause of death in the United States today?

65-1 Infantile paralysis
65-2 Sleeping sickness
65-3 Smallpox
65-4 Diphtheria
65-5 Accidental injury.

66. Which one of the following foods would be most dangerous to eat when it is in a partially spoiled or decayed condition?

66-1 An apple
66-2 A steak
66-3 A half-dozen oysters
66-4 An orange
66-5 A slice of bread

67. An individual is given a metabolism test. The results show that the rate of basal metabolism is abnormally low. This suggests that

67-1 vitamin D is lacking in his diet.
67-2 secretion of the thyroid may be deficient.
67-3 he has a heart disease.
67-4 he is allergic to some foods.
67-5 secretion of the adrenal glands is abnormally large.

68. A fertilized ovum contains twenty-eight chromosomes. A mature sperm of this species would probably contain

68-1 fourteen chromosomes.
68-2 twenty-eight chromosomes.
68-3 seven chromosomes.
68-4 twenty-one chromosomes.
68-5 fifty-six chromosomes.

69. A canning company wishes to preserve a supply of vegetables for several months in such a way that they will retain as much of their natural flavor and appearance as possible. The best way to do this is to

69-1 use the quick-freezing process.
69-2 keep them in an icebox at a temperature of 40° F.
69-3 can them in a sugar solution.
69-4 dry them in the sun or in an oven.
69-5 put them into an antiseptic solution.

Go on to the next page.
70. Plants A and B live together. A makes food which is used by both plants. B absorbs water, and some of this water is used by A. Neither plant injures the other. This is a case of  
70-1 nepotism.  
70-2 commensalism.  
70-3 symbiosis.  
70-4 parasitism.  
70-5 variation.  

71. You know that black is dominant over white in a certain species. If a pure black is crossed with a pure white and eight offspring are produced,  
71-1 all will be black.  
71-2 four will be black and four will be white.  
71-3 all will be grey.  
71-4 two will be black, four will be grey, and two will be white.  
71-5 six will be black and two will be white.  

72. An outcrop of rock is found to contain some fossils, among them crinoids, brachiopods, and large colonial corals. It would be reasonable to conclude that  
72-1 prehistoric brachiopods fed upon corals.  
72-2 colonial corals have become extinct.  
72-3 the rock was formed on the bottom of a lake.  
72-4 the rock was formed under the sea.  
72-5 all life comes from pre-existing life.  

73. We get a culture of pond materials, bring it back to the classroom, and examine the contents. A week later we examine it again, and find some thread-like, unsegmented worms that we did not see the first time. Probably  
73-1 the worms have "arisen" spontaneously.  
73-2 worm eggs were present, but passed unnoticed the first time the culture was examined.  
73-3 worm eggs got into the culture from the air.  
73-4 the worms have developed from algae in the pond water.  
73-5 the worms are the larvae of insects that have laid their eggs in the water.  

74. The young which emerge from certain insect eggs resemble their parents except that they are smaller and have no wings or sex organs. These nymphs grow through a series of molts and have no pupal stage. They might be  
74-1 mosquitoes.  
74-2 houseflies.  
74-3 butterflies.  
74-4 moths.  
74-5 grasshoppers.  

75. The wheat in a certain area in the northern part of the United States is badly affected by rust. Which one of the following plants is likely also to be found in the region?  
75-1 White cedar.  
75-2 Giant ragweed.  
75-3 Common barberry.  
75-4 Canada thistle.  
75-5 Scrub oak.
PART II

Directions: In each of the parentheses referring to the following diagrams, place the number of the word or phrase in the left-hand group which is most appropriate.

Diagram: Section of a tooth

1 The pulp cavity 13. A indicates ... ( )
2 The enamel 14. B indicates ... ( )
3 The condyle 15. C indicates ... ( )
4 The dentine 16. D indicates ... ( )
5 The dura mater

Diagram: Shore of a Fresh-water Pond

Which organisms would probably be in the places indicated?
1 Starfish 19. At A . . . . . ( )
2 Clam 20. At B . . . . . ( )
3 Pleurococcus 21. At C . . . . . ( )
4 Cactus 22. At D . . . . . ( )
5 Earthworm 23. At E . . . . . ( )
6 Hibernating frog 24. At F . . . . . ( )
7 Fish
8 Lichen
9 Spirogyra
10 Barnacle

* * * * *

Go on to the next page.
Directions: Select the best answer and put its number in the parentheses.

25. Which of the following environmental factors is most unfavorable to life in most desert regions?
   25-1 High temperature
   25-2 High atmospheric pressure
   25-3 Lack of soil fertility
   25-4 Lack of rainfall
   25-5 High solar radiation

26. It is found that a certain blood vessel contains blood which is flowing toward the heart. This indicates that this vessel is
   26-1 an artery.
   26-2 a lymphatic.
   26-3 a lacteal.
   26-4 a ureter.
   26-5 a vein.

27. We go into an old forest where the tall trees stand close together. There are not many small green plants growing upon the forest floor. This is largely because
   27-1 very little sunlight reaches the forest floor.
   27-2 the soil in such a place is not fertile.
   27-3 seeds of small plants never reach such a spot.
   27-4 the large trees use too much of the carbon dioxide in the air.
   27-5 the soil is not sufficiently moist.

28. The scientist who examined thin slices of cork and first described the walls of cells was
   28-1 August Weismann.
   28-2 Robert Hook.
   28-3 Theodor Schwann.
   28-4 Joseph Lister.
   28-5 Hugo De Vries.

29. If you were planning a camping trip in a snake-infested region and were worried about the dangers of snake bite, it would be wise to take along
   29-1 a pint of alcohol.
   29-2 a supply of garlic.
   29-3 some antivenom.
   29-4 a package of soda.
   29-5 a canvas tent.

30. Which one of the following diseases can be made less common by providing a better diet?
   30-1 Diphtheria
   30-2 Yellow fever
   30-3 Cancer
   30-4 Scarlet fever
   30-5 Scurvy

31. One of the functions of white cells in human blood is to
   31-1 destroy invading germs.
   31-2 break down acid wastes into harmless compounds.
   31-3 liberate energy for the muscle cells.
   31-4 carry oxygen.
   31-5 excrete excess moisture from the body.

32. A given area is notorious for the fact that many people living there have malaria. This indicates that the following animals are fairly common in the region:
   32-1 Anopheles mosquitoes
   32-2 Trichina worms
   32-3 Dragonflies
   32-4 Culex mosquitoes
   32-5 Hookworms

33. Generally speaking, the simpler animals are better able to regenerate lost or injured parts than are the more complex animals. In the following list, the type we might expect to exhibit the greatest powers of regeneration is a
   33-1 starfish.
   33-2 fish.
   33-3 frog.
   33-4 bird.
   33-5 bat.

34. You are living in a town near a river. In early summer there is a week of heavy rain. The stream rises, overflows its banks, and floods the town. Which of the following factors has probably contributed most to this disaster?
   34-1 Stream pollution
   34-2 The drying up of springs
   34-3 Widespread deforestation
   34-4 Accumulation of too much top-soil
   34-5 Fall of the ground water level

35. A sample of urine from a given person is tested, and the results indicate that a good deal of sugar is present. This may indicate that the person has
   35-1 cancer.
   35-2 tuberculosis.
   35-3 malaria.
   35-4 rickets.
   35-5 diabetes.

36. A single-celled organism is found to have a cytoplasm, a nucleus, chloroplasts, vacuoles, and a cell membrane. Which of these indicates that the organism is a plant rather than an animal?
   36-1 The cytoplasm
   36-2 The chloroplasts
   36-3 The nucleus
   36-4 The cell membrane
   36-5 The vacuoles

37. In the human body epinephrine (adrenaline) is secreted by the adrenal glands. It passes to various parts of the body in the blood plasma, and normally acts as a chemical regulator. It is, therefore, classified as
   37-1 an antibody.
   37-2 a toxin.
   37-3 a vitamin.
   37-4 a hormone.
   37-5 a waste.

Go on to the next page.
38. If you were talking with a friend, and the friend mentioned Darwin’s theory of natural selection, you might naturally be expected to think of the
germ concept of disease.
38-2 survival of the fittest.
38-3 theory of the gene.
38-4 variation due to mutation.
38-5 three primary germ layers. . . . 38( )

39. By means of two carbon rods connected to a dry cell (battery), an electric current is passed through the water in a small culture dish containing some Paramecia. They immediately collect near one of the rods. This type of behavior is called
39-1 a stimulus.
39-2 a tropism.
39-3 a reflex.
39-4 a habit.
39-5 an interaction. . . . . . . . . . 39( )

40. Which one of the following types of prehistoric man probably lived earliest?
40-1 Folsom man
40-2 Cro-Magnon man
40-3 Heidelberg man
40-4 Neanderthal man
40-5 Peking man . . . . . . . . . . . 40( )

41. You are studying an unknown single-celled animal with the aid of a microscope. You find that it has a more or less permanent shape, contains a nucleus, and possesses cilia which enable it to swim through the water. To which of the following is it most closely related?
41-1 Hydra
41-2 Amoeba
41-3 A bacillus
41-4 Paramecium
41-5 A sponge . . . . . . . . . . . . 41( )

42. L represents long-haired, which is dominant; s represents short-haired, which is recessive. LL is crossed with ss. The offspring in the first generation will be in the ratio of
42-1 2LL + 2ss.
42-2 4LL.
42-3 4ss.
42-4 4Ls + 2Ls + ss.
42-5 4Ls. . . . . . . . . . . . . . . . . . . 42( )

43. You find that the leaves on a rosebush are beginning to curl, and that some of them are withered and brown. You notice that a few weeds are growing nearby, that there are several grasshoppers on the ground and a number of aphids and ladybird beetles on the bush. You might reasonably think,
43-1 “These grasshoppers are ruining the roses.”
43-2 “We shall have to get rid of these weeds.”
43-3 “This soil ought to be hoed.”
43-4 “We shall have to kill these aphids.”
43-5 “Ladybird beetles are a pest.” 43( )

44. We sprinkle a little dust from the floor on ten slices of bread. Then the slices are placed in ten dishes on a table top. Five of the slices are moistened with water, and five are not. After a week has passed, the five slices that were kept moist are covered with mold. Which of the following facts explains what has happened?
44-1 Molds are fungus plants.
44-2 The presence of moisture favors the growth of molds.
44-3 There are many different types of molds.
44-4 Molds do not make their own foods.
44-5 Molds are very common. . . . 44( )

45. We plant an unknown seed. In a few days the seed sprouts. The seedling has two seed leaves; it soon develops a root system, a green stem, and green leaves. We supply it with water, and the plant continues to grow. Which of the following conclusions is indicated by this evidence?
45-1 The plant is parasitic.
45-2 The plant will grow from slips or cuttings.
45-3 It is a cultivated species of plant.
45-4 It is a dicot plant.
45-5 The plant can live on relatively dry soil. . . . . . . . . 45( )

Number wrong
\[ \begin{array}{cccccccccccccccccccccc}
\end{array} \]

Amount to be subtracted
\[ \begin{array}{cccccccccccccccccccccc}
\end{array} \]

Number right.

Subtract

(See table above)

Raw Score = Difference

Scaled Score

(See table on key)
1. If a figure in the upper row has one just like it in the lower row, join the two by a line. Do the same for all such pairs.

2. Write the numbers in the figure at the left that
   1. Are in the rectangle only.
   2. Are in the circle only.
   3. Are in all three figures.
   4. Are in the triangle only.
   5. Are only in both the rectangle and circle.

3. Write all the words you can make by combinations of any or all the letters of “Owen.”
   Do not use any letter more than once in the same word.
   
   ---------------------------------------------
   
   ---------------------------------------------
4. Each of these pictures has something missing. You are to draw in with your pencil the missing part.

Example. Here is a rabbit with only one ear. You would put on the other ear.

5. A boy sits alone in a boat in the middle of a pond. He looks repeatedly over the sides, meanwhile crying bitterly. Give all the suggestions you can in regard to what may have happened.

6. Two trucks start out together from the same place on the same straight road. The one ton truck is driven twenty miles per hour, the five ton truck thirty miles. If, ten minutes after the start, the former hits the latter, which will probably be damaged most by the collision?
7. A paper is folded three times along the dotted line as shown in the figures below. A hole is then punched through the several thicknesses of paper at the point shown by the little circle. Show on the blank square by drawing little circles where these holes will appear when the paper is unfolded.

8. If you notice how the numbers are related in the following series, you can write the next numbers in the series in the blank spaces provided. Please do so.

\[
2, 3, 5, 8, 12, \ldots, \ldots \quad 1, 4, 10, 28, 76, \ldots, \ldots
\]

\[
1, 5, 9, 13, \ldots, \ldots \quad 2, 3, 4, 6, 8, \frac{12}{3}, \frac{4}{6}, \frac{8}{12}, \ldots, \ldots
\]

9. Check the conclusion below which should be drawn from the following facts:

A. Recently several cases of typhoid fever broke out among the students in a western college.

B. The milkman who supplied the college dining room with milk also carried milk to many homes in the city.

C. Typhoid fever is caused by a tiny living germ.

D. The well on the campus was a shallow one only ten feet deep.

E. All the students who were sick took their meals at the college dining room.

F. Typhoid is a disease of the intestines, the discharge from which in one who is sick contains millions of germs.

G. The germs of typhoid fever usually get into one on raw vegetables that are eaten or in the milk or water one drinks.

H. The vegetables for the college were supplied by one of the large grocery stores of the town.

Conclusion.

1. The germs of typhoid fever were in the milk.

2. The water from the well likely carried the germs.

3. The data are insufficient. No conclusions can be drawn as to the source of the infection.

4. The vegetables served to the students carried the typhoid infection.

10.

Put your pencil point at the head of the left-hand entering arrow and trace the path your pencil will take to come out at the right-hand arrow. The pencil point must not cross any line. Do not make any erasures.
11. If you care to express an opinion on the following, mark each one that is true with a T and each that is untrue with a W.

A. The prohibition amendment should be re-enacted to reduce intemperance.
B. Fossil remains, the evidence from embryology and from geographical distribution of plants and animals prove the theory of evolution.
C. Laborers are seldom given a square deal by their employers.

12. Cross out each 4 in the following list of numbers if the sum of the two numbers that precede it is greater than 4, but do not cross the 4 out if it is followed by a 7.

| 3 | 4 | 8 | 2 | 9 | 6 | 3 | 7 | 8 | 9 | 2 | 3 | 4 | 2 | 8 | 3 | 7 | 6 | 4 | 7 | 5 | 4 | 3 | 9 | 6 | 4 | 8 | 5 |
| 2 | 6 | 7 | 1 | 2 | 4 | 5 | 9 | 6 | 2 | 4 | 7 | 1 | 9 | 7 | 2 | 4 | 5 | 6 | 3 | 2 | 2 | 4 | 5 | 4 | 7 | 1 | 2 |
| 4 | 5 | 5 | 7 | 1 | 2 | 3 | 8 | 1 | 4 | 9 | 3 | 2 | 6 | 4 | 7 | 8 | 2 | 1 | 7 | 4 | 5 | 7 | 9 | 2 | 8 | 4 |

How many 4's have you crossed out?--------

13. Which of these lines is the longer—the dotted one or the solid one?

14. If the conclusion follows from the data given, put a check in front of the statement.

A. A block of wood floats in the ocean. It will therefore float in Lake Michigan.
B. A body falls 16 feet in the first second. It will therefore fall 32 feet in the first two seconds.
C. Rubber stretches easily and is an elastic material. Steel does not stretch easily and therefore it is not an elastic material.
D. Chlorophyll is a substance necessary in order that a plant may make its own food. Mushrooms contain no chlorophyll. Therefore mushrooms do not make their own food.

15. Write these sentences in the space below in the order that makes it easiest for you to see which word, heavier or lighter, is to be written in the conclusion.

A. Iron is heavier than sodium.  B. Platinum is heavier than mercury.
C. Lead is heavier than iron.  D. Mercury is heavier than lead.

Conclusion: Platinum is...............than sodium.
DIRECTIONS:
To the Teacher:
Work as carefully as you can. You will have exactly 40 minutes.

To the Pupil:
Please return the high papers of the last, and form quadrants, and Forms 2 and 4 for each name, to the state office. When Forms are returned, the quadrants papers later, if preferred.

Assumption:
Before person following Weekly Herald. Your answer might be accepted as the final answer in the test, and the test will be used as a basis for a final conclusion.

Every Pupil Test
April, 1937
The State Department of Education
Columbus, Ohio

Name:  
Age:  
Grade:  
Date:  

School:  
Town:  
State:  

A Test in Some Elements of Scientific Thinking

General Directions: (To be read by pupils and teachers)
This test is not intended as a test to see how many facts of science you know. It is rather a test to measure your inclination and ability to think as a true scientist would think.

Perhaps you have never before taken a test of this kind. Follow the directions for each part and do the best you can. If you come to an item which you do not understand after careful study, go on to the next item. Do not spend too much time on any one exercise; answer the easier items first and go back to the more difficult items later.

It will be to your advantage not to guess. You will have plenty of time if you work steadily and do not waste your time. After the test starts, you are not to ask any questions but are to study the directions and examples for each part. Read everything in this test very carefully. There are fewer items than in most tests, and consequently each response is given more weight.

PART I  Score =  [Rights] x 2  -  [Wrong] x 16

Directions: Read the following experiment carefully. It is the basis for answers to items in Part II.

Martha has read that singeing the stems of cut flowers before putting them into water will make them keep longer. She thought she would conduct an experiment to prove the truth of the statement. Here is how she did her experiment.

Sunday morning she cut some roses and placed them in a vase of water. Monday morning she cut some sweet peas and after singeing the stems put them into some cold water from the refrigerator. She then set the vase containing the sweet peas in the library beside the vase of roses. Wednesday morning she noticed that the roses were very wilted although the sweet peas still looked fresh. The sweet peas did not begin to show signs of wilting until Thursday evening.

Martha concluded that singeing the stems of cut flowers makes them stay fresh longer.

Directions: Below are three items based upon this experiment. Choose the phrase that best completes the meaning of the statement, and place its number on the line to the left of the statement.

1. Martha's experiment proves that (1) the singering of the stems of cut flowers makes them keep longer (2) that the singering of the stems of sweet peas makes them keep longer (3) nothing (4) that sweet peas keep longer than roses.
2. The most important objection to this experiment is that she (1) did not use roses altogether (2) allowed several factors to vary instead of keeping all the same throughout the experiment (3) did not perform the experiment several times in a manner similar to the way she did it at first (4) did not use sweet peas altogether.
3. The experimental factor in this experiment was the (1) kind of flowers used (2) time of day the flowers were cut (3) kind of water in which the flowers were placed (4) singeing of the stems of the flowers.

Directions: Suppose you were going to perform an experiment to answer the question: Does singeing the stems of cut flowers make the flowers stay fresh longer? How would you do the experiment by answering the following questions. Select the phrase that best answers each question, and place its number on the line to the left of the question.

1. What kind of flowers should be used?
   (1) Use the only roses and always get them from the same bush so that they will be as near the same as possible.
   (2) Use as many different kinds of flowers as possible, but always use the same kinds in the part of the experiment in which the stems are singered.
   (3) Use only sweet peas.
   (4) Use as many different kinds of flowers as possible, but always use different kinds in the part of the experiment in which the stems are singered than in the part in which the stems are not singered.

2. When should the flowers be cut?
   (1) Cut the flowers in the morning while the dew is still on them.
   (2) Always cut the flowers about noon when the sun is hot.
   (3) Always cut the flowers in the evening when it is cool, so the flowers will keep as long as possible.
   (4) Whether the flowers are cut in the morning, at noon, or in the evening is unimportant, but it is important that all the flowers be cut at the same time throughout the experiment.

3. Into what kind and temperature of water should the flowers be placed?
   (1) Place some of the flowers in distilled water (or rain-water) and some of them in cool well-water to see in which kind of water they keep better.
   (2) Always place the flowers in cold water in slightly singered stems.
   (3) Place all the flowers in the same kind of water and in ordinary temperature.
   (4) Place some of the flowers in water to which a pinch of salt has been added; this will determine the effect of salt upon the flowers.

4. How many times should the experiment be performed?
   (1) It is impossible to say exactly how many times it should be performed, until the results of a few trials are studied.
   (2) Cut the flowers at exactly the same time of day.
   (3) Perform the experiment until the results obtained agree with your idea of the matter.
   (4) Cut the flowers at exactly the same time of day, but always use different kinds in the part of the experiment in which the stems are singered than in the part in which the stems are not singered.

Part II  Score =  [Rights] x 2 (20)

Directions: Each item in this part of the test consists of a statement which expresses a conclusion. Good thinkers are able to see the reasoning back of a conclusion. You are to analyze each statement and decide upon what fundamental thought (assumption) each conclusion is based.

Example: Franklin D. Roosevelt must be at least thirty-five years old because he is President of the United States.

Assumption: The President of the United States must be at least thirty-five years old.

Trial: I know the statement is true because it was printed in the Weekly Herald. Write the assumption for this trial exercise before reading the next paragraph.

Assumption: The assumption here is: Nothing but true statements are printed in the Weekly Herald. Your answers will be accepted as true if they are printed in the Weekly Herald. You should note, however, that such an answer as the following is not accepted: All statements printed in the Weekly Herald are true. A person has to assume that every statement printed in the Weekly Herald is true before he can begin to make the conclusion expressed in the trial exercise.

9. Mr. Harrison is a teacher; therefore, he must have gone to college.
Assumption: He was the teacher; therefore, he must have gone to college.

10. It will rain tomorrow because it is the last day of the Fair.
Assumption: It will rain tomorrow because the last day of the Fair.

11. Mary will make a good teacher because she loves children.
Assumption: She loves children because she will make a good teacher.

12. The United States should have a large army because it is a rich country.
Assumption: It is a rich country because the United States should have a large army.

13. John has six-ply tires on his car while Bill has four-ply tires on his car; therefore, John's tires will last longer than Bill's.
Assumption: Bill's tires will not last as long as John's.

14. Mr. Jones is not a good citizen because he will not pay his taxes.
Assumption: He will not pay his taxes because Mr. Jones is not a good citizen.
PART II (Concluded)

16. Harry will get good grades in college because his father is president of the university.

Assumption: 

16. We shall win the war because we are in the right.

Assumption: 

17. Mr. Hader was a good congressman so he will make a good governor.

Assumption: 

18. I am sure Donald will get a promotion because he is a good worker.

Assumption: 

PART III SCORE = [RIGHTS (5) x 2] - WRONGS (10) (............)

DIRECTIONS: This section of the test is similar to Part II in that it also is intended to measure your ability to reason out the assumptions which are behind a conclusion. When you have decided which one assumption must be used to justify the conclusion, write its number on the line to the left.

Example: 

Statement of facts: Mr. Brown owns a farm south of Lancaster, Ohio. He recently attended a horse sale at Lancaster and purchased four horses for $1600.

Conclusion: Each horse cost exactly $400.

This conclusion is not entirely justified, but it could be justified, however, if we assume certain other factors to be true. Consider the conclusion in the light of the facts given in the "Statement of facts" and select true the following list the condition which we must assume to be true before we can accept the above conclusion. Indicate your choice of the correct assumption by placing its number on the blank line.

... Assumptions: 

(1) Each horse was a good one.
(2) Each horse must have been worth the same amount as each other horse.
(3) The man paid the same for each horse.
(4) The man paid too much for the horses unless they were exceptionally good ones.

The correct answer is statement number three and consequently a "T" has been written on the line. Answer number three in the only correct answer because it is the only assumption essential to justify the conclusion. Although several of the other answers are true statements, they are not correct answers because they are not necessary to prove the conclusion.

10. Statement of facts: John Lewis who is in the fourth grade is able to do examples in addition, multiplication, and subtraction more accurately and more rapidly than any other member of his class.

Conclusion: John Lewis can do examples in long division more accurately and rapidly than any of his classmates.

Assumptions: 

(1) John is an intelligent boy.
(2) John likes arithmetic.
(3) The most intelligent boy in the class will do the best work in long division.
(4) A child's ability to do long division is dependent upon his ability to do the fundamental operations of addition, subtraction, and multiplication.

20. Statement of facts: The following table shows the relationship between the yearly income of certain families and the medical attention they receive:

<table>
<thead>
<tr>
<th>Family Income</th>
<th>Percent of Family Members Who Received No Medical Attention During the Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under $1000</td>
<td>47%</td>
</tr>
<tr>
<td>$1000 to $2000</td>
<td>42%</td>
</tr>
<tr>
<td>$2000 to $4000</td>
<td>39%</td>
</tr>
<tr>
<td>$4000 to $10,000</td>
<td>24%</td>
</tr>
<tr>
<td>Over $10,000</td>
<td>16%</td>
</tr>
</tbody>
</table>

Conclusion: Members of families with small income are healthier than members of families with large incomes.

Assumptions: 

(1) Healthy families have more money to spend for medical care.
(2) All members of families who needed medical attention received it.
(3) Many members of families with low incomes were not able to pay their doctor's bills.
(4) Members of families with low incomes often did not receive needed medical attention.

21. Statement of facts: The following advertisement appeared recently in a local magazine: "To many mothers it comes as news—and welcome news, too—that it is not necessary to feed children hot cereal in winter for them to get all the cereal benefits. Contrary to old-fashioned ideas, it is an established scientific fact that the heat energy supplied by cereals is supplied by the food itself—not the heat of cooking."

Conclusion: Therefore, not breakfast cereals contain no more heat-producing units to keep the body warm in cold weather than cold breakfast food.

Assumptions: 

(1) The food energy supplied by cold breakfast food is at least equal to that supplied by hot breakfast cereal.
(2) Cold breakfast cereal contains the necessary vitamins.
(3) Cold breakfast cereal contains the necessary vitamins.
(4) Cold breakfast cereal contains all the necessary vitamins.

22. Statement of facts: A company which sells musical instruments recently made this statement in one of its advertisements: In Oxford University only ten per cent of the students study music, yet this small group of students take seventy-five percent of the scholarships and prizes for high grades.

Conclusion: Music is the best mind trainer there is.

Assumptions: 

(1) The 10% of the students who studied music would not have taken 75% of the prizes and scholarships if they had not studied music.
(2) The group which took music also probably excelled in athletics.
(3) All students who study music select easy subjects in college.
(4) Students who take music have native musical ability.

Select another assumption which is essential to justify the conclusion "Music is the best mind trainer there is."

23. Statement of facts: In the year 1935, 100 billion pounds of milk were produced on our farms. In 1934, the first year of repeal, the production of milk fell to 95 billion pounds.

Conclusion: The sale of liquor caused a decrease in the use of milk.

Assumptions: 

(1) The drinking of milk is more beneficial than the drinking of alcoholic beverages.
(2) The farmers did not keep as many cows in 1934 as they did in 1933.
(3) Several billions of dollars which were spent for liquor in 1934 would have been spent for milk if the liquor had not been available.
(4) There was more liquor sold annually during prohibition than after repeal.
STUDENT INTEREST-EVALUATION QUESTIONNAIRE

1. Did you like biology?
2. What topic did you like best?
3. What topic did you dislike most?
4. Would you like to take another course in biology?
5. Have you used what you have learned in biology in daily living?
6. Name one phase of biology you have used in daily living.
7. Have you acquired new interests in biology?
8. Name one new interest.
9. Do you feel that the school is justified in requiring sophomores to take biology?
10. Do you feel that the value of biology is equal to, greater or lesser than other subjects?
11. Do you think biology is more or less difficult than other subjects?
12. Do you think biology is more or less interesting than other subjects?
APPENDIX B

CALCULATIONS USED IN CHAPTER IV

Table I

Frequency Table for Table I

<table>
<thead>
<tr>
<th></th>
<th>College-preparatory</th>
<th></th>
<th></th>
<th>Consumer</th>
<th></th>
<th></th>
<th></th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>fd</td>
<td>fd²</td>
<td></td>
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<td>56--58</td>
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<td>5</td>
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<td>12</td>
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<td>-24</td>
<td>48</td>
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<td>-18</td>
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<td>-1</td>
<td>-12</td>
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<td>5</td>
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<td></td>
<td></td>
<td>119</td>
<td>1</td>
<td>-7</td>
<td>7</td>
</tr>
</tbody>
</table>

\[ M = \frac{42 \times 131 - 115x3}{119} = 42.39 \]

\[ \sigma = \sqrt{\frac{764 - 13^2 \times 3}{119}} = 7.59 \]

\[ \sigma_m = \frac{7.59}{\sqrt{119}} = 0.75 \]

\[ M = \frac{36 \times 82 - 142x3}{105} = 34.29 \]

\[ \sigma = \sqrt{\frac{784 - 57^2 \times 3}{105}} = 8.43 \]

\[ \sigma_m = \frac{8.43}{\sqrt{105}} = 0.82 \]

\[ AD = 42.39 - 34.29 = 8.10 \]

\[ \sigma_{diff.} = \sqrt{75^2 + 82^2} = 1.09 \]

8.10 divided by 1.09 equals 7.43 which shows that the difference is significant.
### Table II

**Frequency Table for Table II**

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\[ M = \frac{112 \times 64 - 59 \times 5}{81} = 112.30 \]
\[ M = \frac{97 \times 97 - 53 \times 5}{87} = 99.52 \]

\[ \sigma = \sqrt{\frac{285 - 0.06^2 \times 5}{81}} = 9.35 \]
\[ \sigma = \sqrt{\frac{424 - 0.52^2 \times 5}{87}} = 10.75 \]

\[ \sigma_m = \sqrt{\frac{9.35^2}{81}} = 1.03 \]
\[ \sigma_m = \sqrt{\frac{10.75^2}{87}} = 1.15 \]

\[ AD = 112.30 - 99.52 = 12.78 \]

\[ \sigma_{diff.} = \sqrt{(1.15^2 + 1.03^2)} = 1.54 \]

12.78 divided by 1.54 = 8.29 which shows that the difference is significant.
Table III

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M=60*112-118x3=59.85 M=45*136-138x3=44.94

\[ \frac{718-.05^2x3=7.17}{120} \]

\[ \frac{1300-.02^2x3=10.59}{104} \]

\[ \frac{7.17=65}{120} \]

\[ \frac{10.59=1.03}{104} \]

AD=59.85-44.94=14.91

\[ \frac{65^2=1.03^2=1.21}{120} \]

14.91 divided by 1.21 equals 12, which shows that the difference is significant.
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\[ M = \frac{15 \cdot 133 - 48 \cdot 3}{119} = 17.13 \]
\[ \sigma = \sqrt{\frac{517 - 512 \cdot 3}{119}} = 5.91 \]
\[ \sigma_m = 5.91 \cdot 0.54 = 3.24 \]

\[ \frac{M}{104} = 12.74 - 114 \cdot 3 = 10.86 \]
\[ \sigma = \sqrt{\frac{520 - 382 \cdot 3}{104}} = 6.60 \]
\[ \sigma_m = 6.60 \cdot 0.64 = 4.23 \]

\[ AD = 17.13 - 10.86 = 6.27 \]
\[ \sigma_{AD} = \sqrt{542 + 642} = 83 \]

6.27 divided by .83 equals 7.55 which shows that the difference is significant.
Table V

Frequency Table for Table V

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\[
\text{M} = \frac{62 \times 197 - 266 \times 5}{118} = 59.1 \\
\text{M} = \frac{27 \times 287 - 150 \times 5}{122} = 32.6 \\
\sigma = \sqrt{\frac{2595 - 58^2 \times 5}{118}} = 23.25 \\
\sigma = \sqrt{\frac{2505 - 1.12^2 \times 5}{122}} = 20.85 \\
\sigma_m = \frac{23.25}{\sqrt{118}} = \frac{20.85}{\sqrt{122}} = 2.15 \\
\sigma_m = 1.92 \\
\text{AD} = 59.1 - 32.6 = 26.5 \\
\sigma_{\text{diff}} = \sqrt{\frac{(2.15^2 + 1.92^2)}{2}} = 2.88 \\
\]

26.5 divided by 2.88 equals 9 which shows that the difference is significant.
Table VI

Frequency Table for Table VI

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\[ M = \frac{47 \times 170 - 114 \times 5}{127} = 49.20 \]

\[ M = \frac{37 \times 114 - 121 \times 5}{113} = 36.70 \]

\[ \sigma = \sqrt{\frac{992 - 49.20^2 \times 5}{127}} = 13.05 \]

\[ \sigma = \sqrt{\frac{779 - 36.70^2 \times 5}{113}} = 13.00 \]

\[ \sigma_m = 13.05 = 1.16 \]

\[ \sigma_m = 13.00 = 1.22 \]

\[ AD = 49.2 - 36.70 = 12.50 \]

\[ \sigma_{diff.} = \sqrt{1.16^2 + 1.22^2} = 1.68 \]

12.50 divided by 1.68 equals 7.44 which shows that the difference is significant.
**Table VII**

**Frequency Table for Table VII**

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\[ M = \frac{31 \times 155 - 176 \times 3}{123} = 30.49 \]

\[ M = \frac{19 \times 158 - 116 \times 3}{105} = 20.2 \]

\[ \sigma = \sqrt{\frac{1313 - .17^2 \times 3}{123}} = 9.66 \]

\[ \sigma = \sqrt{\frac{1082 - .4^2 \times 3}{105}} = 8.91 \]

\[ \sigma_m = \frac{9.66}{9.23} = .87 \]

\[ \sigma_m = \frac{8.91}{8.72} = .87 \]

\[ AD = 30.49 - 20.2 = 10.29 \]

\[ \sigma_{diff} = \sqrt{.87^2 + .87^2} = 1.23 \]

10.29 divided by 1.23 equals 8.36 which shows that the difference is significant.
**Table VIII**

Frequency Table for Table VIII

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\[ M = \frac{107.15 \times 10^5}{31} = 107.8 \]

\[ M = \frac{107.18 \times 12^5}{31} = 107.96 \]

\[ \sigma = \sqrt{\frac{47 - 16^2}{31} \times 5} = 6.10 \]

\[ \sigma = \sqrt{\frac{50 - 19^2}{31} \times 5} = 6.25 \]

\[ \sigma_m = \frac{6.10}{\sqrt{31}} = 1.02 \]

\[ \sigma_m = \frac{6.25}{\sqrt{31}} = 1.05 \]

\[ AD = 107.96 - 107.8 = .16 \]

\[ \sigma_{ss} = \sqrt{1.05^2 + 1.02^2} = 1.46 \]

.16 divided by 1.46 equals .11 which shows that there is no significant difference.
### Table IX

**Frequency Table for Table IX**

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\[
M = \frac{41.5 \times 79 - 4.1 \times 44}{30} = 44.94
\]

\[
M = \frac{29.5 \times 115 - 27 \times 44}{30} = 41.12
\]

\[
\sigma = \sqrt{\frac{782 - 0.86^2 \times 44}{30}} = 18.12
\]

\[
\sigma = \sqrt{\frac{1086 - 2.93^2 \times 44}{30}} = 21.00
\]

\[
\sigma_m = \frac{18.12}{30} = 3.32
\]

\[
\sigma_m = \frac{21.0}{30} = 3.84
\]

\[
AD = 44.94 - 41.12 = 3.82
\]

\[
\sigma_{diff.} = \sqrt{\frac{3.32^2 + 3.84^2}{5.07}} = 5.07
\]

3.82 divided by 5.07 shows a difference significant in 77/100 cases.
Table X

Frequency Table for Table X

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<td>28--30</td>
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<tr>
<td>25--27</td>
<td>31</td>
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</tbody>
</table>

\[ M = \frac{41 \times 20 - 35 \times 3}{31} = \frac{39.56}{31} \]

\[ \sigma = \sqrt{\frac{167 - .48^2 \times 3}{31}} = 6.72 \]

\[ \sigma_m = \sqrt{6.72} = 1.20 \]

\[ AD = 39.56 - 38.39 = 1.17 \]

\[ \sigma_{diff.} = \sqrt{1.20^2 + 1.11^2} = 1.63 \]

1.17 divided by 1.63 equals .71 which shows that the difference is not significant.
Table XI

Frequency Table for Table XI

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</table>

\[ M = \frac{56 \times 37 - 35 \times 3}{31} = 56.18 \]

\[ m = \frac{47 \times 48 - 23 \times 3}{31} = 47.24 \]

\[ \sigma = \sqrt{\frac{246 - 0.62 \times 3}{31}} = 8.25 \]

\[ \sigma = \sqrt{\frac{249 - 8.2 \times 3}{31}} = 8.16 \]

\[ \sigma_m = 8.25 = 1.48 \]

\[ \sigma_m = 8.16 = 1.46 \]

\[ AD = 56.18 - 47.24 = 8.94 \]

\[ \sigma_{diff} = \sqrt{1.482 \times 1.462} = 2.07 \]

8.94 divided by 2.07 equals 4.31 which shows that the difference is significant.
Table XII

Frequency Table for Table XII

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</table>

M = \frac{15 \times 30 - 19 \times 3}{31} = 16.05

\sigma = \sqrt{\frac{125 - 35^2 \times 3}{31}} = 5.91

\sigma_m = \frac{5.91}{\sqrt{31}} = 1.06

AD = 16.05 - 11.61 = 4.44

\sigma_{diff.} = \sqrt{1.06^2 + 0.99^2} = 1.45

4.44 divided by 1.45 equals 3.06 which shows that the difference is significant.
Table XIII

Frequency Table for Table XIII

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\[
\begin{align*}
M &= \frac{41 \times 56 - 45 \times 3}{31} = 42.05 \\
\sigma &= \sqrt{\frac{543 - 35^2 \times 3}{31}} = 12.51 \\
\sigma_m &= \frac{12.51}{31} = 0.25 \\
AD &= 42.05 - 41.23 = 0.82 \\
\sigma_{d.f.} &= \sqrt{2.25^2 + 2.28^2} = 3.23
\end{align*}
\]

.82 divided by 3.23 equals .25 which shows that the difference is not significant.
Table XIV

Frequency Table for Table XIV

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\[ M = \frac{26 \times 53 - 36 \times 3}{31} = 27.64 \]

\[ N = \frac{23 \times 27 - 38 \times 3}{31} = 21.94 \]

\[ \sigma = \sqrt{\frac{396 - .55^2 \times 3}{31}} = 10.59 \]

\[ \sigma = \sqrt{\frac{221 - .35^2 \times 3}{31}} = 7.8 \]

\[ \sigma_m = \frac{10.59}{\sqrt{31}} = 1.90 \]

\[ \sigma_n = \frac{7.8}{\sqrt{31}} = 1.31 \]

\[ AD = 27.64 - 21.94 = 5.70 \]

\[ \sigma_{\text{diff}} = \sqrt{1.90^2 + 1.31^2} = 2.36 \]

5.70 divided by 2.06 equals 2.42 which shows that the difference is significant.
Table XV

Frequency Table for Table XV

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\[
M = \frac{28 \times 38 - 23}{25} = 29.8
\]

\[
\sigma = \sqrt{\frac{225 - 0.62 \times 3}{25}} = 8.82
\]

\[
\sigma_m = \frac{8.82}{\sqrt{25}} = 1.76
\]

\[
AD = 29.8 - 24.76 = 5.04
\]

\[
\sigma_{AD} = \sqrt{1.76^2 + 1.43^2} = 2.26
\]

5.04 divided by 2.26 equals 2.23 which shows that the difference is significant.