A comparative study of sex differences in natural science achievement of the pupils of Lincoln memorial high school, Palmetto, Florida

Julia Osceola Webb
Atlanta University

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The writer is deeply grateful to Mr. Paul I. Clifford of Atlanta University, who during the planning and writing of this study made helpful suggestions. Gratitude is also expressed to Dr. O. W. Eagleson who served as co-chairman with Mr. Paul I. Clifford during the period of the study. Further acknowledgement is made to Mr. C.E. Hall, Principal of the school in which the study was made, and to Mr. Stevens, Supervisor of the same school for permitting the writer to make the study even though it sometimes caused the daily program to be altered. The writer is deeply indebted to Miss Nable Scott of Bradenton Elementary School, Bradenton, Florida, who assisted in checking and rechecking the test scores. Gratitude is also expressed to the 192 pupils of Lincoln Memorial High School who served as subjects and to Mr. Small who aided in various ways and Mrs. Brantley who typed the manuscript.
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A COMPARATIVE STUDY OF SEX DIFFERENCES IN
NATURAL SCIENCE ACHIEVEMENT OF THE
PUPILS OF LINCOLN MEMORIAL HIGH
SCHOOL, PALMETTO, FLORIDA

A THESIS
SUBMITTED TO THE FACULTY OF ATLANTA UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF ARTS

BY

JULIA OSCEOLA WEBB

SCHOOL OF EDUCATION

ATLANTA UNIVERSITY

JULY, 1950
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CHAPTER I
INTRODUCTION

Statement of Problem.— The problem involved in this study was to compare the achievement of male and female pupils of Lincoln Memorial High School, Palmetto, Florida, in general science, biology, chemistry, and physics.

Definition of Terms.— In this study achievement means the scores made on the following tests: Cooperative General Science Test, Form Y for grades 7, 8, and 9, published by the Educational Testing Service and edited by Paul Burke, University of Oregon; Cooperative Biology Test, Revised Series - Form Y originally published by the American Council on Education, but now by Cooperative Testing Service and edited by the editor-publisher named above; Cooperative Chemistry Test, and the Cooperative Physics Tests published and edited by the previously named editor and publishers.

Subjects.— The subjects were selected by stratification and selection from a population of 364 pupils of the school named above. Their ages ranged from 12 to 21 years. Their grade levels in school ranged from seventh through twelfth grades. The subjects were Negroes.

Location.— The study was made in Manatee County, Florida, a small county with approximately thirty thousand inhabitants. The educational status is very low. Parents are not well informed, for the most part, and do not value education. Even though there is an attendance assistant employed, the schools of the county have a great deal of absentees. One would be surprised at the enormous amount of superstition that exists in this locality.
Recently the county has improved the physical plants of the colored schools, however, the teaching aids are very inadequate. Bus transportation is furnished for all pupils living farther than a mile and one half from the school site. All schools in the county have witnessed a consolidation program, and at present there are only three colored schools in the county.

The economic conditions are average. Many people own their homes. The homes for the most part are well equipped with screens, electric lights, and other comforts that are found in the average home. Nevertheless, there are those who do not own their homes, many of which live in dilapidated shacks with outdoor toilets and other conditions that are conducive to ill health. The occupations of the people are mostly truck farming of fruits, vegetables and dairy products, domestic work, and a few small businesses such as grocery stores, pressing clubs, beer saloons, and bootblack stands. Even though this locality touches the Gulf of Mexico and has other bodies of water around it, the fishing industry is not well developed in this vicinity. Many people participate in the numbers racket and other forms of gambling depending almost solely upon it for their support. Because of their dependence upon such vice, they spend much money paying the "so-called" fortune teller to give them the lucky number.

The climate is mild all winter and as a result, it is quite attractive to tourists who come the latter part of September and remain until the last of March and the middle of April. As a result of their residing here during the winter, the demand for commodities is greatly increased, thus proving the climate to be an economic asset.

Near this vicinity are a "Reptile Farm", the Ringling Brothers Museum,
Ringling School of Art, Desoto Landing Site, and a Jungle Garden -- all within a radius of twenty-five miles. Not far away -- less than three hours driving is the famous Bok Tower. These places are quite informative to the many people who visit them. Movies, baseball, swimming, dancing, and dog races are the major forms of recreation. Football and basketball activities of the high school, are added features for amusement when they are in season.

All the teachers of the county have four years of college work or above except two, and they have more than ninety semester hours. All of the teachers of Lincoln Memorial High School are certified in their field. However, because of the science teaching load which is too heavy, a part of the seventh grade science is taught by the homemaking teachers. There are two full time science teachers in the school. Each is certified and fairly efficient in the science which he teaches. One has a B.S. degree in science from Florida State College for Segroes with a minor in physical education. The other holds a B.A. degree from Laime College, Augusta, Georgia with a first major in home economics and a second major in natural science, the latter has done six hours graduate work in science education at Atlanta University.

Each science teacher has a combination classroom and laboratory. The equipment is inadequate. The teacher in this phase is very limited in storage space for the apparatus and chemicals on hand.

The rooms are equipped with wall plugs for the use of electrical appliances. Alcohol lamps are the major heating devices. There are about fifteen Bunsen Burners, but in as much as there is no gas installed, they are useless. There are sufficient quantities of hard and soft glass test tubes, wide mouth bottles, flasks, watch glasses, test tube clamps, crucibles, petri dishes and glass and rubber tubing. There are many chemicals
including metals, non-metallic elements, various salts, acids, bases, and oxides. Among the acids are a few organic ones. There are shortages of ring stands, tripods, large beakers, and pneumatic troughs along with other equipment. In biology there are about eight dissecting sets, ten dissecting trays, eight culture dishes. There are among the chemicals those which are used in biology. The physics teacher has the most limited amount of supplies.

There is a small room that can be converted into a dark room for making pictures, an activity very much enjoyed by the students. Among the audio-visual aids are a movie projector, film strip, machine, lantern slide, bio-scope, microscope, recording machine, (wire) record player, radio, insects mounts, commercial and student made, small biological charts commercial posters, and those made by students, commercially and locally preserved specimens, charts of the metals, electro-motive series of metals, and non-metals, a periodic chart of the elements, and atomic weights.

Those students taking science are required to pay one dollar for consumption.

Procedure. -- In September, 1949, the writer secured permission from the principal and the advisor of secondary education to make the study in Lincoln Memorial High School, Manatee County, Palmetto, Florida. This was done because of the possibility of the necessity of interrupting the regular routine of work to administer the tests. The writer also feels that getting permission was necessary as a matter of courtesy and respect to those having greater authority.

In the early part of November after having been informed that the problem had been approved by the School of Education and that her thesis committee had been appointed, the writer attempted to secure her tests
from the American Council on Education. However, because that agency had sold most of its testing division to Testing Service, the order was forwarded to the other company.

Finally, the writer secured the tests and then upon advice of her thesis advisor came to Atlanta on February 4, 1950 to confer with her thesis advisor. At this time she received suggestions concerning the selection of her sample, the administering of the tests, the organization of materials, and other technicalities concerning the study. The advisor gave the writer the opportunity to freely ask questions about phases of the project which she did not clearly understand.

After returning to the location of the study the writer checked the assistant's attendance sheet to find the actual number of boys and girls enrolled in each class and in each class division, from grade seven through twelve. The writer checked the teachers' registers to find if there was a wide difference between ages of boys and girls in each section of the various classes.

In as much as there were veterans enrolled in some classes that differed widely from the group in age, it was necessary to control the age range. There were three sections of the seventh grade, three of the eighth, two of the ninth, tenth, eleventh, and twelfth grades. The sample was selected by stratification and selection of fifty per cent of the total enrollment of both boys and girls from each of the various grade sections as of the date the test was administered.

On February 14, 1950, between the hours of one and two o'clock with the permission of the principal, the researchist administered the Cooperative Biology Test to fifty per cent of the tenth grade girls and fifty per cent of the eleventh grade girls and fifty per cent of the tenth grade boys.
and fifty per cent of the eleventh-grade boys. The total number of eleventh and tenth-grade boys was thirty-six; the number to whom the test was administered was eighteen. The total number of eleventh and tenth-grade girls was fifty-six; the total number to whom the test was administered, twenty-eight. The writer adhered strictly to all rules as suggested by the manual which accompanied the tests. The test papers were carefully corrected and the scores arranged in frequency distribution tables. Statistics were calculated which included the mean, the standard deviation, the standard error of the mean, the difference between the means, the standard error of the difference between the means and t. From the equated scores and percentiles derived from the norms based on the scores made by 5,000 school children taken from eleven southern states, the writer constructed a percentile graph and constructed a line graph from the raw scores and frequencies of the sample.

On March 14, 1950 between the hours of 12:30 and 2:30 p.m. o'clock the Cooperative Science Test was administered to fifty per cent of seventh grade section two, fifty per cent of eighth grade section two, and fifty per cent of ninth grade sections one and two.

The test papers were corrected and scores equated and percentiles derived according to the norms of that particular grade. These norms were based on samples taken from school children from eleven southern states. Inasmuch as the seventh and eighth grades had the largest percentage of the enrollment, tests could not be administered to all of them at the same time. Therefore, the writer deferred the construction of frequency distribution tables, graphs, and the computation of statistics until students of these grades had been given the tests. However, the ninth grade scores were equated, percentiles determined, and statistics computed and graphs
constructed. The total number of ninth graders enrolled as of the date the test was given was 52. The total number of boys was 16, the number to whom the test was administered, 8; the total number of girls was thirty-six, the total number to whom the test was administered was 18.

On March 7, 1950 between the hours of 12:30 and 1:30 p.m. the writer administered the Cooperative Physics Test to fifty per cent of the total number of boys in the twelfth grade and fifty per cent of the total number of girls in the twelfth grade. The total number enrolled was 44; the total number of girls was twenty, the number to whom the test was administered was ten. The total number of boys enrolled in the twelfth grade was twenty-four; the number to whom the test was given was twelve. These pupils had been exposed to physics for one semester. The norms were based on 700 students selected from eleven southern states. The usual procedure followed with the computation of the scores of the above subjects.

On March 21, 1950 between the hours of 12:30 and 2:30 p.m. o'clock the writer administered the Cooperative Chemistry Test to the same eleventh grade subjects who had taken the biology and fifty per cent of the twelfth grade boys and fifty per cent of the twelfth grade girls. The total number of boys in class was twenty-four; the number to whom the test was administered was twelve. The total number of twelfth grade girls was twenty; the total to whom the test was administered, was ten. The total number of eleventh and twelfth grade girls was forty. The test was administered to twenty.

After having administered the test, these papers were corrected and the scores put into tables of frequency distribution and the necessary statistics were computed. A line graph of raw scores and frequencies was constructed, and a percentile graph of derived scores and percentiles was constructed. These equated scores and percentiles were based on the norms
derived from 500 school children taken from 11 southern states.

On May 16, 1950 between the hours of 12:30 and 2:30 p.m. o'clock the writer administered the Cooperative General Science Test to fifty per cent of the seventh grade sections one and two and fifty per cent of the eighth grade section one. The usual procedure was followed. The test scores of the seventh-grade section who took the test on March 14, 1950 were arranged with the test scores of the seventh graders who took the test during this sitting in a frequency distribution table. The necessary statistics were computed, equated scores were derived from the norms based on 5,000 school children taken from 11 southern states.

A percentile graph was constructed from the derived scores and percentiles and a line graph was constructed from the raw scores and the frequencies. The Cooperative General Science Test for grades 7, 8, and 9, was divided into three subdivisions; viz, "Informational Background", "Terms and Concepts", and "Comprehension and Interpretation". The scores for each section were tabulated the usual tables and graphs constructed and the necessary statistics computed.

The scores of the eighth-grade subjects, section 1 and 2, who had taken the test in a previous sitting were compiled with eighth graders of this sitting. The total number of eighth-grade girls enrolled was fifty and the total number of boys was forty. The total number of girls to whom the test was administered was twenty and the total number of eighth-grade boys to whom the test was administered was twenty-five. Class enrollment was ninety. The number of boys enrolled in the seventh grade was forty-six, the number to whom the test was administered was twenty-three. The total number of girls enrolled was sixty and the number to whom the test was administered was thirty. The total class enrollment was 106 and total
number to whom the test was administered was fifty-three.

In Chapter II the writer has compiled and interpreted the data that were obtained from the testing instruments.

The Period of Study.— This study was begun in August, 1949, and ended July, 1950. The method of research used was the normative survey and the techniques were testing and statistics.

Purpose of the Study.— The purpose of study was to test statistically the following null hypothesis: There is no sex difference in general science, biology, chemistry, and physics achievement.

Related Literature.— In reviewing the literature the writer found a limited number of studies dealing directly with the problem involved.

However, since sex difference in school achievement involves science achievement, and since science achievement is impossible in the absence of intelligence, the writer feels that literature in these areas are pertinent to the study. Many researchists have expressed their opinion as to the cause of sex differences. The writer will relate a few opinions in the study as well as give a brief historical sketch of sex difference as studied.

In this study the writer has divided the literature into five groups which are as follows:

1. Historical background
2. Sex difference in school achievement
3. Sex difference in intelligence
4. Sex difference in science studies
5. The causes of sex differences as are opinionated by various researchists.

For many years females have repeatedly admitted by ways and actions their subordination to males in many ways. Perhaps, such admittance has
been forced upon them by the culture in which they resided. The extent of subordination has varied with time and environment.

In achievement in the so-called "hard" subjects such as mathematics girls as a group usually allow boys to excel them. The belief of male superiority in intellect was confirmed for ages in the minds of the scientists and the general population. Anastasi and Foley write as follows:

The belief in hereditary sex differences in intellectual and emotional traits is an old and persistent one. It is only since the development of objective and quantitative testing methods that the notion of female inferiority has been expelled among scientists. In the general public this belief still prevails.¹

Little or no attention was given to the objective study of sex differences prior to the twentieth century. Objective study of sex differences in intellect and personality began after the mental testing program was begun. Among the first investigators in the realm of sex differences was Wooley, who listed in 1910 less than a dozen psychological studies in sex differences.² However, it seems from then on interest became greater and by 1935 there were over three hundred such studies listed and today we have over a thousand.³ The literature seems to reveal relatively few studies to date on sex differences in natural science.

It seems that the literature indicates that girls get better grades than boys in school in practically all subjects including science. It is held by some investigators that girls' getting better grades in school is

²Ibid.
³Ibid.
purely due to favoritism on the part of the teacher.

Most of the studies concerning achievement whether in science or other school work point to the fact that girls receive better grades than boys in school, but at the same time rate much lower than boys on standardized tests in achievement. Popular opinion among the writers is that boys do not get a fair deal in school marks. Among investigators supporting this view are Harold A. Doughlass and Newman E. Olson\(^1\), L. C. Day,\(^2\) Schinner\(^3\) and Dean Labough.\(^4\)

L. C. Day found in his studies in South Portland, Maine that girls had a three to one advantage over the boys in making the honor roll and that girls had one and one-half as much chance to make A as boys, and boys had two times as much chance to fail as girls. However, they excel girls on standardized tests and equaled them on intelligence tests.\(^5\)

Schinner found similar results in his study of twenty-one Junior High Schools in Cleveland, Ohio. He says that three times as many boys failed English as did girls, and twice as many boys failed as girls in mathematics, social studies and general science as girls. However, here again, the boys measured significantly higher on a standardized test.\(^6\) Thus the above writers conclude that boys deserve better grades in school than are re-

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1 Harold Doughlass, and Olson, "Relation of High School Mark to Sex in Four Minnesota High Schools", School Review, XLV (April, 1937), pp. 283-86.


Sol Whitman has a different viewpoint from the above writers. He feels that there should be no partiality shown, but inasmuch as the mark represents a total composite of the individual, that all factors in the composite should be reflected in the grade.¹

Studies seem to show no significant difference between boys and girls in intelligence when the test is either equally weighted with items in which males or females excel or when all such items have been eliminated.

In 1932 Robert Rusk who was at that time Director, Scottish Council for Research in Education, Edinburgh, Scotland, made a study of mental abilities of all children in Scotland born on the first day of June, 1921. The results gave a standard deviation of 17 for boys and 16 for girls, a mean of 103 for boys and 100 for girls. After completing statistical application, he concluded that there was no significant sex difference in mental ability among boys and girls.²

Paul Witty in a study of high schools in Illinois in the 1930's found results similar to Robert R. Rusk. Witty considered 27,642 tests in thirteen high schools and found similar intelligence scores for boys and girls. The slight difference, though insignificant, was in favor of the boys.³

In an article appearing in the New York Times it is said that men do better reasoning than do women, even though they have the same intelligence.


ratings.¹

Victor C. Smith made a study of sex differences in ninth grade general science to determine the sex differences in general in the difficulty of the course and the variations from one part to another. He secured a varied and random sampling of material including 748 statements, and surveyed ten textbooks to determine the frequency with which they occurred.

Subjects were obtained by the selected sampling method from six widely scattered states, all of which were in the north except Virginia. His sample included three hundred boys and three hundred girls. For the most part they were on the same age and grade levels. In each school the male and female subjects had the same instructor and had the same length class period. At the end of the year they were all given a review and then tested under normal conditions by the class teacher.²

Victor C. Smith had his test sub-divided into eighteen divisions, such as clothing, food, biology, light, astronomy, heat, geology, chemistry, biography, electricity, fluids, mechanics, etc.³

This investigator found only three sub-divisions of material in which there was not a revealing of significant differences in achievement. Of the eighteen sub-divisions, thirteen showed a significant difference in favor of the boys. Only fourteen questions were equally difficult for boys and girls. The following are typical questions in which girls excelled:

Artificial silk made from wood pulp is rayon.


³Ibid., p. 56.
Iodine mixed with starch gives a dark blue color. Smith found the boys to be significantly better in answering these.

Lamp cords are insulated with cloth and rubber.

A dry cell contains zinc.

An Airplane with two sets of wings is a bi-plane.\(^1\)

Even though the boys in this study show superior achievement in most of the sub-divisions, Smith concluded that the differences in a large measure may be contributed to environmental factors. He found that sitting in the same classes, reading the same books, and receiving instruction from the same teachers, does not operate effectively in eradicating sex differences.\(^2\)

He summarizes as follows:

1. Material generally covered in biology shows no sex difference, but sub-divisions show slight differences.

2. Physiography materials show no sex differences.

3. Chemistry materials show significant differences in favor of the boys.

4. Physics material is much easier for boys than girls.

5. The subject general science as a whole is much easier for boys than girls.

In 1931 Carl F. Hanske published a study which he did on sex differences in high school chemistry students in the Emmerich Manual Training High School, Indianapolis, Indiana. Before the study was made, the Terman Group Test of Mental Ability was administered to 230 pupils including 125 boys and 105 girls. Even though there was a wider range of variability among the boys than among the girls, the median I. Q. score was the

\(^{1}\text{Victor C. Smith, op. cit., p. 57}\)

\(^{2}\text{Tbid.}\)
same. The investigator in this study found that on an average the boys were about five months older than the girls and that approximately two-thirds of the boys had taken other courses in science; while only one-third of the girls had previously taken science.¹

After having obtained their I.Q.'s and average ages, a series of tests were administered throughout the term which included two inventory tests. One at the beginning of the first semester and the other at the beginning of the second semester. Rich's Gamma and Epsilon Test were administered at the end of the first semester and the above test for two semesters. Other tests were administered on the following phases of chemistry: (1) oxygen, (2) gas law problem, (3) water and solutions, (4) chemical arithmetic, (5) acids, etc. Valence, nomenclature, (6) chemical terms and formulae, (7) formulae and common names, (8) chemical terms and common names, (9) equation balancing, (10) baking powder, (11) soaps, (12) calcium compounds, (13) nitric acids and explosives, (14) periodic law and the electro-motive series.² On the above test the mean scores of the boys range from 1.9 to 9.0 higher than the girls on all tests except numbers 11, 12, 14, and 15. On these the girls scored insignificantly higher than the boys with averages excelling the boys by .9, .5, and 1.5 respectively the other 15 tests were in favor of the boys with critical ratios ranging from .26 to 6.7.³

Carl Hanske's investigation revealed the excellence of the boys over the girls in fifteen of the eighteen tests. However, he believed that the boys being older than the girls, and their having had more science than


²Ibid., p. 416.

³Ibid.
the girls were contributing factors in their favor.

A. W. Hurd made a study in 1932 of sex differences in physical science among high school boys and girls. The instructional unit in high school physics, "Electrical System," was used with 1326 pupils enrolled in 34 schools and fifty-three classes.¹

The subjects studied were matched according to age and grade. The members of each pair were under the same instructor for eighteen class periods of forty-five minutes each.²

Preliminary tests were given at the beginning of the study and a final test was administered at the end of the period of study. The results revealed that the boys excelled significantly in each test. In the preliminary test the mean for the boys was 10.28 and the standard error was 1.05, the critical ratio was 7.79.³

Even though the girls showed a significant percentage gain, the percentage gain in relation to the possible percentage was in favor of the boys, even though the critical ratio was insignificant.⁴

The Science Talent Test, which was conducted jointly by Science Clubs of America, Science Service and the Westinghouse Electric and Manufacturing Company, shows differences between the scores made by boys and girls each year on the Science Aptitude Examination. For example, the first year the contest was launched, twenty-two of the 2,460 boys who entered with complete entry materials made fewer than five errors, whereas, this was not true of

¹A. W. Hurd, op. cit., page 71.

²Ibid.

³Ibid.

⁴Ibid.
any of the 715 girls who entered.¹

In Edgerton and Britt's 1944 Summary of the scores made on the Science Talent Test for the first three years they found real sex differences in science achievement in favor of the boys each year.

The first year the critical ratio was 14.4, the second year it was 16.6, and the third year it was 18.2. Each of the above ratios favor the boys. From this information one readily notes a high statistically significant sex difference in favor of the boys.²

The problem of sex differences has, perhaps, claimed the attention of most of the sociologists, anthropologists, psychologists, and biologists of the twentieth century. It seems that they are becoming more cognizant of the infallible role of environment in determining these differences.

Starch, Stanton, and Koreth write as follows:

> Sex differences in science interest and achievement do not seem as great as popularly supposed. The slight preferences of boys for science studies and superiority in science subjects can be conditioned by custom, training, and environment.³

It appears to the writer that the above named writers re-emphasized the role of nurture in influencing sex differences, as they suggest that traditional social attitude toward women and girls may be an important factor in causing girls to exemplify less interest than boys in science and is possibly responsible for the lack of eminent women in science.⁴ However, as emphatically as the writers above admit their belief in the


²Ibid.


⁴Ibid.
forces of cultural and environmental factors influencing sex differences in science and other phases of individual group differences, they are not overlooking hereditary influences, and report a positive correlation between intelligence and science achievement.¹

Other writers who have expressed their belief, as a result of research in the influences of culture and the environment in determining sex differences are Head,² Terman and Miles,³ Anastasi and Foley,⁴ and Tyler.⁵

Margaret Head's study of the South Seas, is perhaps the most widely referred to study concerning the role of the environment upon sex differences. In her book, From the South Seas she concludes after having studied three primitive tribes that sex differences are culturally determined, and are evidences of the power of social control. She writes:

"Human nature is extremely malleable responding accurately and contrastingly to cultural conditions."⁶

In her more recent book, Male and Female, she reports having studied seven primitive tribes of the South Seas and again she reports the plasticity and relativity of sex differences.⁷ In her report this study more firmly substantiates her former conclusions - sex differences are culturally

²Margaret Head, From the South Seas, (New York, 1939), pp. 375.
³Terman and Miles, Sex and Personality (New York, 1936) pp. 460-5.
⁶Margaret Head, op. cit., pp. 375.
and environmentally determined.

Ward Reeder concludes as a result of various studies in which sex differences occur in varying conditions that the cause is more of a cultural and environmental nature than was previously conceived.¹

After having gathered and interpreted the data on the Science Talent Test, Harold Edgerton of Ohio State University, and Stewart Henderson Britt, Lieutenant, U.S.N.R. Navy Department, Washington, D. C. who conducted the tests concluded as follows:

Thus far the sex differences in scores on the examination have been consistent each year and they are statistically significant. They are probably due, however, to environmental and cultural factors rather than to inherent biological differences. This suggests, then, the desirability for greater attention in the primary and secondary schools to scientific training for American girls.²

In the writer's review of the literature, it appears that various reports of the researchists indicate a real sex difference in most of the areas of natural science achievement in favor of the boys. Even when the different sexes were equaled as to intelligence as measured by the Stanford Binet Scale or other similar instruments, it still held that the boys excelled significantly in natural science achievement. The literature reveals that the science in which girls most nearly equal boys is biology.

It seems that it is the popular belief of the more recent researchists in the study of sex difference in various cultures, that even though sex differences do occur statistically significant in some areas favoring the boys and in some areas favoring the girls, they are not fixed.

by the genes. But they are for the most part culturally determined and conditioned by the customs and mores of the society in which they live, and that sex differences are relative and plastic, and are strong exemplifying evidences of the power of social control. However, most of them agree that hereditary influences set the limits to which one potentialities can be developed in any area.

It is seen from the data above how the various writers have concluded as a result of their experiments and those of others concerning the factors affecting sex-differences. As has been pointed out they feel that the culture plays a potent role in determining sex differences.

However, the writer in this study makes no attempt to determine the cause of these differences. She merely presents her findings with statistical and graphic interpretations in the following chapters.
CHAPTER II

INTERPRETATION AND ANALYSIS OF DATA

Presentation, Interpretation and Analysis of Data.-- The data obtained from the administration of four tests and their sub-divisions to the 192 subjects, grouped according to their grade level, in this study are presented in graphic and tabular forms below. The data collected in this study are based upon statistical analysis of the scores obtained from the tests, and presented and discussed as an invalidation or substantiation of the null hypothesis stated in the purpose of this study.

In this chapter the writer has compared her findings with the results of other researchists and has the limitations of her study. In addition to the above, she has suggested the educational implications in theory and in practice as the study seemingly has suggested to her.

Scores on Cooperative Science Test, Part I, for Grade 7.-- Below are a line graph, a percentile graph, and a frequency distribution table of the data obtained by administering the Cooperative Science Test, Part I, "Informational Background", to thirty female and twenty-three male pupils of Lincoln Memorial High School to determine the sex difference, if any, in achievement of informational background in science as measured by the test.

The percentile graph below and each succeeding one in this study are based on the percentile of the norms of school children taken from eleven southern states. In no instance are the percentiles derived from the scores made by the subjects used in this study. The writer used percentiles of the norms in order to get a picture of how the students ranked with the southern norms as well as in relation to each other.
Fig. 1.- Line Graph of raw scores made by twenty-three seventh-grade boys and girls on the Cooperative Science Test, Part I, "Informational Background".
Fig. 2.- A Percentile Graph of the derived scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test, Part I, "Informational Background".
Figure 2 is a percentile graph of the derived scores made by twenty-three seventh grade boys and thirty seventh grade girls on Part I, "Informational Background", of the Cooperative Science Test.

The figure indicates a close parallel between the two groups. The girl who scored lowest ranked at the zero percentile. The boy scoring lowest deviated very slightly from zero. The two groups converge at the fiftieth percentile, and then it appears that the boys scored higher at the sixty-fifth percentile and they also scored higher at the forty-fifth percentile. They converge again at the seventy-fifth percentile which is the highest percentile rank of boys and girls. From the chart it seems that the highest scoring boy is no better than the highest scoring girl. A very slight difference does occur seemingly in favor of the seventh grade boys in achievement in informational background in natural science.

Table 1 shows information obtained from the frequency distribution of raw scores on Part I, "Informational Background" of the Cooperative Science Test administered to twenty-three boys and thirty girls of the previously named school seems to indicate the following: The mean for boys is 9.52, the standard deviation is 5.10 and the standard error of the mean is 1.09. The mean for girls is 8.67, the standard deviation is 5.02, and the standard error of the mean is .97. The difference between the means is .85, the standard error of the difference between the means is 1.44 and the critical ratio is .59. If the difference is significant, the critical ratio must be three or more times the standard error of the difference between the means. Therefore, it appears from the data that there is no real difference in natural science achievement in informational background between seventh grade boys and girls. The difference which occurs is probably due to errors in sampling.
TABLE 1

FREQUENCY DISTRIBUTIONS OF RAW SCORES OBTAINED BY TWENTY-THREE SEVENTH GRADE BOYS AND THIRTY SEVENTH GRADE GIRLS OF LINCOLN MEMORIAL HIGH SCHOOL, PALMETTO, FLORIDA, ON PART I, "INFORMATIONAL BACKGROUND" OF THE COOPERATIVE SCIENCE TEST FOR GRADES SEVEN, EIGHT, AND NINE LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND CRITICAL RATIO.

<table>
<thead>
<tr>
<th>Scores</th>
<th>Boys</th>
<th>Girls</th>
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<tbody>
<tr>
<td>16-18</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>14-16</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>12-14</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>10-12</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>8-10</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>6-8</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4-6</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>2-4</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0-2</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Totals</td>
<td>23</td>
<td>30</td>
</tr>
</tbody>
</table>

\[
\text{Scores} \quad \text{Boys} \quad \text{Girls}
\]

\[
\begin{align*}
\bar{x}_b &= 9.52 \\
\text{S.D.}_b &= 5.10 \\
\text{S.E.}_b &= 1.09 \\
\bar{x}_g &= 8.67 \\
\text{S.D.}_g &= 5.02 \\
\text{S.E.}_g &= 0.947
\end{align*}
\]

Scores on Cooperative Science Test, Part II, for Grade 7.-- Below are a line graph, percentile graph, and a frequency distribution table of the data obtained by administering part II, "Terms and Concepts", of the Cooperative Science Test, to twenty-three male, and thirty female pupils of Lincoln Memorial High School to determine the sex difference, if any, in achievement of the above phase of science as measured by the test.
Fig. 3.- Line Graph of the raw scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test, Part II, "Terms and Concepts".
Fig. 4.- A Percentile Graph of the derived scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test, Part II, "Terms and Concepts".
Figure 4 is a percentile graph of the derived scores obtained by twenty-three seventh grade boys and thirty seventh grade girls on Part II, "Terms and Concepts", of the Cooperative Science Test.

The figure shows that the two groups competed with each other rather closely at several percentiles. However, it does appear that the girl who scored lowest ranked at the nineteenth percentile and excelled the boy who scored lowest and ranked at the zero percentile. The boy who scored highest ranked at the eighty-fifth percentile and the girl who scored highest ranked at the seventy-eighth percentile. Again, the boys scored higher at the fiftieth percentile. After careful observation of the figure it seems that there might be a slight difference in the achievement of "Terms and Concepts" in science in favor of the boys. However, the figure does not show a great difference between the seventh grade boys and girls of the above school.

Table 2 shows information obtained from the frequency distribution of raw scores on Part II, "Terms and Concepts", of the Cooperative Science Test administered to twenty-three seventh grade boys and thirty seventh grade girls reveal the following information: The mean for girls is 4.8, the standard deviation is 3.72 and the standard error of the mean is .691. The mean for boys is 5.43, the standard deviation is 3.80, the standard error of the mean for boys is .825. The difference between the means is .63, the standard error of the difference between the means is 1.19 and the critical ratio is .55. According to the data collected as a result of the testing instrument used, the writer finds no significant difference between the achievement of seventh grade boys and girls in the above phase of science. Statistically speaking, the critical ratio must be three or more times the standard error of the difference between the means, to be
TABLE 2

FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY TWENTY-THREE SEVENTH GRADE BOYS AND THIRTY SEVENTH GRADE GIRLS OF LINCOLN MEMORIAL HIGH SCHOOL, PAJETTO, FLORIDA ON PART II "TERMS AND CONCEPTS" OF THE COOPERATIVE GENERAL SCIENCE TEST FOR GRADES SEVEN, EIGHT, AND NINE LISTING MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE, AND CRITICAL RATIO.

<table>
<thead>
<tr>
<th>Scores</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-14</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>10-12</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>8-10</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>6-8</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>4-6</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>2-4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>0-2</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Totals</td>
<td>23</td>
<td>30</td>
</tr>
</tbody>
</table>

\[ \bar{x}_b = 5.43 \quad \bar{x}_g = 4.8 \]
\[ s_\text{D} = 3.88 \quad s_\text{D} = 3.72 \]
\[ C. R. = .55 \quad S.E.\bar{x}_b = .925 \quad S.E.\bar{x}_g = .691 \]

Significant. In as much as the data on the above table reveals a critical ratio of .55, it holds that there is no real sex difference between the two groups in their achievement on Part II, the Cooperative Science Test, "Terms and Concepts". However, the difference occurring is in favor of the boys, but it is very likely due to errors in sampling or other chance factors.

Scores on Cooperative Science Test, Part III, for Grade 7.-- Below are a line graph, percentile graph, and frequency distribution table of the data obtained by administering the Cooperative Science Test, Part III, "Comprehension and Interpretation", to twenty-three male and thirty female
seventh grade pupils to determine the sex difference, if any, in science achievement as measured by the above phase of the test.

Figure 6 is a percentile graph of derived scores obtained by twenty-three male and thirty female pupils in the seventh grade, Lincoln Memorial High School, Palmetto Florida. It appears from the figure that the two groups parallel each other very closely. They seem to converge at the fifteenth, thirty-fifth, forty-ninth, and fifty-fifth percentile. The lowest scoring boy ranked at about the third percentile and the lowest scoring girl ranked at about the eighth percentile. The highest scoring boy ranked at the sixty-eighth percentile and the highest scoring girl ranked at about the sixty-fourth percentile. From the figure it appears that there is very little difference in achievement of the seventh grade male and female pupils of the Cooperative Science Test, Part III, "Comprehension and Interpretation".

From the above figure it seems that the male and female seventh grade pupils ranked very low on this phase of the test in comparison to the norms. Part III, "Comprehension and Interpretation" of the Cooperative Science Test is really a reading test in science, and it appears to the writer that the graph reveals a weakness in the students ability to read as well as a weakness in science. The seventh grade boys and girls of Lincoln Memorial High School ranked lower on this phase of the test than on any other subdivision of the test. This appears to the writer to be an important revelation, for if their ability to read and comprehend, is weak they are handicapped continuously in their ability to achieve. However, the graph seems to depict a definite weakness among the pupils although it is true that the pupils from whom the norms were derived had science one year, whereas the subjects of this study had science for only one semester.
Fig. 5.- Line Graph of raw scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test, Part III, "Comprehension and Interpretation".
Fig. 6.- A Percentile Graph of derived scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test, Part III, "Comprehension and Interpretation".
The data obtained from the frequency distribution of raw scores made on the Cooperative Science Test, Part III, "Comprehension and Interpretation", administered to twenty-three seventh grade boys and thirty seventh grade girls of Lincoln Memorial High School, Palmetto, Florida, seem to reveal the following: The mean for girls is 3.77, the standard deviation for girls is 2.47, and the standard error of the mean is .459. The mean for boys is 4.3, the standard deviation for boys is 2.92, and the standard deviation for boys is 2.92, and the standard error of the mean is .459.
error of the mean is \(0.644\). The difference between the means is \(0.53\) and the standard error of the mean is \(0.644\). The difference between the means is \(0.53\) and the standard error of the difference is \(0.791\). The critical ratio is \(0.67\). In as much as the critical ratio has to be three or more times the standard error of the mean in order to be statistically significant, it follows that there is no real sex difference in the achievement of Part III, "Comprehension and Interpretation" of seventh grade boys and girls of the school tested. Even though a slight difference did occur in favor of boys it is highly insignificant, and probably due to error in sampling.

**Total Scores on Cooperative Science Test, Grade 7.** Below are a line graph, percentile graph, and frequency distribution table of the data obtained by administering the total Cooperative Science Test to thirty seventh grade female pupils and twenty-three seventh grade male pupils to determine the sex difference, if any, in the total achievement of the above subjects in science as measured by the test.

Figure 6 is a percentile graph of the total derived scores obtained by twenty-three male and thirty female seventh grade pupils on the entire Cooperative Science Test.

The graph seems to indicate little difference in the total achievement of these two groups. They seem to parallel each other very closely. They converge at the twelfth percentile, and again at the twenty-fifth percentile. The girl who scored lowest had a zero percentile and the boy who scored lowest deviated only very slightly from zero. The highest scoring boy scored at the sixty-eighth percentile and the highest scoring girl also scored at the sixty-eighth percentile. This graph seems to indicate very little, if any, difference in the achievement of seventh grade boys.
Fig. 7. - Line Graph of Total Scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test.
Fig. 8.- A Percentile Graph of derived scores made by twenty-three seventh grade boys and thirty seventh grade girls on the Cooperative Science Test, Parts I, II, and III.
TABLE 4

FREQUENCY DISTRIBUTION OF THE TOTAL RAW SCORES OBTAINED BY TWENTY-THREE SEVENTH GRADE BOYS AND THIRTY SEVENTH GRADE GIRLS OF LINCOLN MEMORIAL HIGH SCHOOL, PALMETTO, FLORIDA LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND THE CRITICAL RATIO

<table>
<thead>
<tr>
<th>Scores</th>
<th>Boys</th>
<th>Girls</th>
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<tbody>
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<td>27-30</td>
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</tr>
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</tr>
<tr>
<td>18-21</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>15-18</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>12-15</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9-12</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>6-9</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3-6</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>0-3</td>
<td>1</td>
<td>2</td>
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</table>

<table>
<thead>
<tr>
<th>Totals</th>
<th>23</th>
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</tr>
</thead>
<tbody>
<tr>
<td>$M_b - M_g = 3$</td>
<td>$N_b = 19.5$</td>
<td>$M_g = 16.5$</td>
</tr>
<tr>
<td>$\Sigma D = 2.75$</td>
<td>$S.D. = 10.08$</td>
<td>$S.D. = 9.12$</td>
</tr>
<tr>
<td>C.R. $= 1.09$</td>
<td>$S.E. m_b = 2.17$</td>
<td>$S.E. m_g = 1.69$</td>
</tr>
</tbody>
</table>

and girls in general science.

At first glance it seems that both groups scored low in comparison to the norms, but when one considers the fact that these norms were based on pupils having had one year of science and the above pupils having had it only one semester, the writer feels that they compared favorably with the norms.

The data obtained from the frequency distribution of the total raw scores made on the Cooperative Science Test administered to twenty-three
seventh grade boys and thirty seventh grade girls indicate the following: The mean for girls is 16.5, the standard deviation is 9.12, the standard error of the mean is 1.69. The mean for boys is 19.5, the standard deviation is 10.08, and the standard error of the mean is 2.17. The difference between the means is 3, the standard error of the difference is 2.75, and the critical ratio is 1.09. In as much as the critical ratio must be three or more times the standard error of the difference between the means to be significant, the data reveal that there is no real sex difference in the total science achievement between seventh grade boys and girls of Lincoln Memorial High School. It seems that the slight difference which occurred in favor of the boys is probably due to errors in sampling or other chance factors.

Scores on Cooperative Science Test, Part I, for Grade 8.-- Below are a line graph, percentile graph, and frequency distribution table of the data obtained by administering the Cooperative Science Test, Part I, "Informational Background", to twenty-five female and twenty male eighth grade pupils to determine the sex difference, if any, in science achievement as measured by the above phase of the test.

Figure 10 is a percentile graph of the derived scores obtained by twenty eighth grade boys and twenty-five eighth grade girls on Part I, "Informational Background", of the Cooperative Science Test.

The figure shows the boy and girl who scored lowest ranked at about the same percentile. However, thereafter it appears from the figure that the boys ranked higher at practically every percentile. The girl who scored highest ranked at the sixty-ninth percentile, and the boy who scored highest ranked at the seventy-ninth percentile. Thus, it is indicated that the highest scoring boy excels the highest scoring girl.
Fig. 9.- Line Graph of the raw scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Part I, "Informational Background".
Fig. 10. - A Percentile Graph of the derived scores made by twenty-eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Part I, "Informational Background".
TABLE 5

FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY TWENTY-FIVE EIGHTH GRADE GIRLS AND TWENTY EIGHTH GRADE BOYS ON PART I, "INFORMATIONAL BACKGROUND", OF THE COOPERATIVE SCIENCE TEST LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND \( t \).

<table>
<thead>
<tr>
<th>Scores</th>
<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
</tr>
<tr>
<td>27-30</td>
<td>1</td>
</tr>
<tr>
<td>24-27</td>
<td>0</td>
</tr>
<tr>
<td>21-24</td>
<td>1</td>
</tr>
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<td>18-21</td>
<td>5</td>
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<tr>
<td>15-18</td>
<td>2</td>
</tr>
<tr>
<td>12-15</td>
<td>5</td>
</tr>
<tr>
<td>9-12</td>
<td>3</td>
</tr>
<tr>
<td>6-9</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>20</td>
</tr>
</tbody>
</table>

\[ M_b = 15.15, \quad M_g = 12.3 \]

\[ \text{S.D.} = 5.40, \quad \text{S.D.} = 3.51 \]

\[ \text{S.E.} = 1.24, \quad \text{S.E.} = 0.716 \]

A glance at this figure and one notes a difference in achievement in "Informational Background" in science in favor of the eighth grade boys of Lincoln Memorial High School.

The data secured from the frequency distribution of raw scores on Part I, "Informational Background" of the Cooperative Science Test for grades 7, 8, and 9 administered to twenty-five eighth grade girls and twenty eighth grade boys seem to indicate the following: the mean for the boys is 15.15, the mean for the girls is 12.3, the standard deviation for the boys is 5.40, the standard deviation for the girls is 3.51, the standard error of the mean for boys is 1.24, the standard error of the mean for girls is 0.716.
The difference between the means is 2.86, the standard error of the difference between the means is 1.43, and the critical ratio is 2. In as much as t must be 2.02 at the five per cent level of confidence in order to be statistically significant, it holds that there is no real sex difference in favor of the boys in natural science achievement in "Informational Background" between eighth grade girls and boys of Lincoln Memorial High School, Palmetto, Florida. From the information gathered the writer seems to find no real sex difference between male and female pupils of Lincoln Memorial High School, Palmetto, Florida, in the achievement of "Informational Background" in science.

The difference which occurs in favor of the boys is probably due to errors in sampling or other chance factors.

Scores on the Cooperative Science Test, Part II, for Grade 3.-- Below are a line graph, percentile graph, and frequency distribution table of the data obtained by administering the Cooperative Science Test, Part II "Terms and Concepts", to twenty male and twenty-five female eighth grade pupils of the above school to determine the sex difference, if any, in science achievement as measured by the above phase of the test.

Figure 12 is a percentile graph representing the derived scores made by twenty eighth grade boys and twenty-five eighth grade girls on Part II "Terms and Concepts" of the Cooperative Science Test.

The graph seems to indicate a decided difference in favor of the boys. Even though the lines parallel each other to some extent, it is shown that the girl who scores lowest ranked at the fourth percentile, while the boy who scored lowest ranked at the twelfth percentile. The highest scoring boy ranked at the eighty-fifth percentile and the highest scoring girl ranked at the sixty-seventh percentile. The boys seem to
Fig. 11.—A Line Graph of raw scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Part II, "Terms and Concepts".
Fig. 12.- A Percentile Graph of the derived scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Part II, "Terms and Concepts".
TABLE 6

FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY TWENTY-FIVE EIGHTH GRADE GIRLS AND TWENTY EIGHTH GRADE BOYS ON PART II, "TERMS AND CONCEPTS", OF THE COOPERATIVE SCIENCE TEST LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

<table>
<thead>
<tr>
<th>Scores</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
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<td>16-18</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>14-16</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>12-14</td>
<td>3</td>
<td>1</td>
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<tr>
<td>10-12</td>
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<td>8-10</td>
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<td>6-8</td>
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<td>4-6</td>
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<td>2-4</td>
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<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Totals</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

$M_b - M_g = 2.52$  $M_b = 9.6$  $M_g = 7.08$

$\sigma D = .98$  $S.D. = 3.52$  $S.D. = 2.74$

$t = 2.55$  $S.E. M_b = .808$  $S.E. M_g = .559$

compare favorably with the norms. However, the girls lag a bit more than the boys. This figure seems to indicate a difference in science achievement in favor of the eighth grade boys of Lincoln Memorial High School, Palmetto, Florida.

The data obtained from the frequency distribution of raw scores on Part II, "Terms and Concepts", of the Cooperative Science Test for grades 7, 8, and 9, administered to twenty-five eighth grade girls and twenty eighth grade boys of Lincoln Memorial High School of Palmetto, Florida, seem to indicate the following: The mean for girls is 7.08, the mean for
boys is 9.6; the standard deviation for girls is 2.74, and the standard deviation for boys is 3.52. The standard error of the mean for girls is .559 and the standard error of the mean for boys is .808. The difference between the means is 2.52 and the standard error of the difference between the mean is .93; t is 2.55. Inasmuch as t must be at least 2.02 at the five per cent level and 2.41 at the two per cent level of confidence in order to be statistically significant, it follows that there is a real sex difference in achievement of Part II, "Terms and Concepts", in favor of the boys in science at the five per cent and even at the two per cent levels of confidence. From the data obtained in this study, the writer seems to find that the eighth grade boys excel the eighth grade girls significantly in the achievement of "Terms and Concepts" in natural science at Lincoln Memorial High School, Palmetto, Florida.

Scores on Cooperative Science Test, Part III for Grade 8.-- Below are a line graph, percentile graph and frequency distribution table of the data obtained by administering the Cooperative Science Test, Part III, "Comprehension and Interpretation", to twenty male and twenty-five female pupils to determine the sex difference, if any, in science achievement as measured by the above phase of the test.

Figure 13 is a percentile graph of the derived scores made on the Cooperative Science Test by twenty eighth grade boys and twenty-five eighth grade girls on "Comprehension and Interpretation".

The graph shows that the scores made by the two groups parallel at various percentiles. The graph seems to indicate that the lowest scoring girl was better than the lowest scoring boy and that the highest scoring boy was better than the highest scoring girl. The highest scoring girl scored at the sixty-second percentile and the highest scoring boy scored at the sixty
Fig. 13.- A Line Graph of the raw scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Part III, "Comprehension and Interpretation".
Fig. 14. - A Percentile Graph of derived scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Part III, "Comprehension and Interpretation".
TABLE 7

FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY TWENTY-FIVE EIGHTH GRADE GIRLS AND TWENTY EIGHT GRADE BOYS ON PART III, "COMPREHENSION AND INTERPRETATION", OF THE COOPERATIVE SCIENCE TEST LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

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<th>Scores</th>
<th>Frequencies</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
</tr>
<tr>
<td>10-12</td>
<td>4</td>
</tr>
<tr>
<td>8-10</td>
<td></td>
</tr>
<tr>
<td>6-8</td>
<td>3</td>
</tr>
<tr>
<td>4-4</td>
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<tr>
<td>2-2</td>
<td>4</td>
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<td>0-2</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>20</td>
</tr>
</tbody>
</table>

\[ M_g - M_b = .22 \quad M_b = 5.5 \quad M_g = 5.28 \]

\[ \text{Sigma D} = .98 \quad \text{S.D.} = 3.53 \quad \text{S.D.} = 2.66 \]

\[ t = .23 \quad \text{S.E.m}_b = .007 \quad \text{S.E.m}_g = .547 \]

The graph does not indicate the extent to which the difference in the scores is significant, but it does indicate a difference seemingly in favor of the boys.

The data obtained from the frequency distribution of raw scores on Part III, "Comprehension and Interpretation" of the Cooperative Science Test for grades 7, 8, and 9, administered to twenty eighth grade boys and twenty-five eighth grade girls of Lincoln Memorial High School of Palmetto, Florida, seem to reveal the following: the mean for the girls is 5.28, the mean for girls is .547, the standard error of the mean for boys is .007. The difference between the means is .22 and the standard error of the dif-
ference between the means is .98. The t is .23.

The writer finds that there is no real sex difference between eighth grade boys and girls of Lincoln Memorial High School, Palmetto, Florida in science achievement on "Comprehension and Interpretation". The slight difference occurring in favor of the boys is highly insignificant even at the fifty per cent level of confidence and may be totally attributed to error in sampling.

Total Scores on Cooperative Science Test, for Grade 8.— Below are a line graph, percentile graph, and a frequency distribution table of the data gathered by administering the Cooperative Science Test to twenty-five female and twenty male pupils to determine the sex difference, if any, in science achievement as measured by the above test.

Figure 16 is a percentile graph of the total derived scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test.

This figure indicates that the boy who scored lowest on the scale is better than the girl who scored lowest. The two groups seem to parallel each other with the boys ranking higher at the seventh, thirtieth and fifty-fifth percentiles. It appears that they converge at the thirty-fifth and forty-fifth percentiles. The highest scoring girl ranked at the sixtieth percentile; while the highest scoring boy ranked at the seventy-fifth percentile. It seems to be indicated by this figure that there is a sex difference in science achievement between the eighth grade boys and girls of Lincoln Memorial High School, and that this difference occurs in favor of the boys.

The data in Table 8 obtained from the frequency distribution table of the total raw scores on the Cooperative Science Test administered to twenty
Fig. 15.- A Line Graph of the total raw scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test.
Fig. 16. - A Percentile Graph of the derived scores made by twenty eighth grade boys and twenty-five eighth grade girls on the Cooperative Science Test, Parts I, II, and III.
TABLE 8

FREQUENCY DISTRIBUTION TABLE OF TOTAL RAW SCORES OBTAINED BY TWENTY-FIVE EIGHTH GRADE GIRLS AND TWENTY EIGHT GRADE BOYS OF THE COOPERATIVE SCIENCE TEST LISTING MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

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<th></th>
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</tr>
<tr>
<td>Totals</td>
<td>20</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>

\[ M_b = 31.7 \quad M_g = 25.22 \]

\[ \text{S.D.} = 9.75 \quad \text{S.D.} = 7.29 \]

\[ t = 2.41 \quad S.E.m_b = 2.24 \quad S.E.m_g = 1.499 \text{ or } 1.50 \]

Eighth grade boys and twenty-five eighth grade girls, seem to indicate the following: The mean for girls is 25.22, the mean for boys 31.7; the standard deviation for girls is 7.29, the standard deviation for boys is 9.75; the standard error of the mean for girls is 1.50, the standard error of the mean for boys is 2.24. The difference between the means is 6.40, the standard error of the difference between the means is 2.69 and \( t \) is 2.41. In as much as \( t \) must be at least 2.02 at the five per cent level.
and 2.41 at the two per cent level, the data reveal that there is a real
sex difference in science achievement in favor of the boys at the five
per cent and two per cent levels of confidence. The writer finds from
the data obtained that the eighth grade boys of Lincoln Memorial High
School excel the girls significantly in science achievement and that the
difference occurring cannot be attributed to chance factors.

Scores on the Cooperative Science Test, Part I, for grade 9. Below
are a line graph, percentile graph, and frequency distribution table of
the data obtained by administering the Cooperative Science Test, Part I,
"Informational Background", to eight male and eighteen female pupils to
ascertain the sex difference, if any, in science achievement as measured
by the above phase of the test.

Figure 18 is a percentile graph representing the derived scores obtained
by eight ninth grade boys and eighteen ninth grade girls on Part I, "Infor-
mational Background" of the Cooperative Science Test.

The graph seems to indicate a marked difference in achievement in favor
of the boys. It appears that the boys score higher than the girls at
every percentile. It also shows that the lowest scoring for girls was at
the twelfth percentile, while the lowest scoring for boys was at the
twenty-third percentile. They paralleled each other at the fortieth and
at the fiftieth percentiles. The highest scoring girl was at the fiftieth
percentile while the highest scoring boy was at the seventy-first percent-
tile. This figure indicates very clearly that a difference occurs in
achievement in "Informational Background" in science in favor of the boys
of Lincoln Memorial High School.

Table 9 represents the data obtained from the frequency distribution
of raw scores on Part I, "Informational Background", of the Cooperative
Fig. 17.- A Line Graph of the raw scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part I, "Informational Background".
Fig. 18. - A Percentile Graph of the derived scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part I, "Informational Background".
TABLE 9

FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY EIGHT NINTH GRADE BOYS AND EIGHTEEN NINTH GRADE GIRLS OF LINCOLN MEMORIAL HIGH SCHOOL, PALMETTO, FLORIDA ON PART I, "INFORMATIONAL BACKGROUND", OF THE COOPERATIVE GENERAL SCIENCE TEST FOR GRADES SEVEN, EIGHT, AND NINE, LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

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</tr>
</thead>
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</tr>
<tr>
<td>24-26</td>
<td>-</td>
<td>-</td>
</tr>
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<td>22-24</td>
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<td>-</td>
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<tr>
<td>20-22</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18-20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16-18</td>
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<td>2</td>
</tr>
<tr>
<td>14-16</td>
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</tr>
<tr>
<td>12-14</td>
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<td>3</td>
</tr>
<tr>
<td>10-12</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>8-10</td>
<td>1</td>
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<td>6-8</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>4-6</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

| Totals | 8 | 18 |

\[ M_b = 16.25 \]
\[ M_g = 12.11 \]
\[ \sigma_D = 4.04 \]
\[ t = 2.45 \]

\[ \text{S.E.m}_b = 1.39 \]
\[ \text{S.E.m}_g = 0.955 \]

Science Test for grades 7, 8, and 9 reveal the following: The mean for the boys is 16.25, the standard deviation is 3.74, and the standard error of the mean is 1.39. The mean for the girls is 12.11, the standard deviation is 4.04 and the standard error of the mean is .955. The difference between the means is 4.14, the standard error of the difference between the means is 4.14, and t is 2.45. The t must be at least 2.07 at the five per cent level of confidence and 2.50 at the two per cent level of confidence in order to be statistically significant. Therefore, it appears from the
data revealed in the above table that a real sex difference occurs in favor of the boys at the five per cent level of confidence. From the data gathered the writer finds that there is a real difference between ninth grade boys and girls in achievement in "Informational Background" in science in favor of the boys of Lincoln Memorial High School, Palmetto, Florida.

Scores on Cooperative Science Test, Part II, for grade 9.-- Below are a line graph, percentile graph, and table of frequency distribution of data obtained by administering the Cooperative Science Test, Part II, "Terms and Concepts", to eight male and eighteen female ninth grade pupils to determine the sex difference, if any, in science achievement as measured by Part II of the above test.

Figure 20 is a percentile graph of the derived scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part II, "Terms and Concepts". The graph reveals that there is a close paralleling of scores made by the two groups with boys scoring a little higher than girls at every percentile. It appears from the indications of the graph that the lowest scoring boy is better than the lowest scoring girl, and that the highest scoring girl scores at the sixty-first percentile while the highest scoring boy scores at the sixty-ninth percentile. It appears from the graph that a difference in the achievement of "Terms and Concepts" in science occurs in favor of the boys.

The data obtained from the frequency distribution table of raw scores on Part II, "Terms and Concepts", of the Cooperative Science Test for grades 7, 8, and 9 administered to eight ninth grade boys and eighteen ninth grade girls of Lincoln Memorial High School, Palmetto, Florida, seem to indicate the following: the mean for the boys is 11.87, the mean for
Fig. 19.- A Line Graph of raw scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part II, "Terms and Concepts".
Fig. 20. - A Percentile Graph showing the derived scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part II, "Terms and Concepts".
TABLE 10

FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY EIGHT NINTH GRADE BOYS AND EIGHTEEN NINTH GRADE GIRLS OF LINCOLN MEMORIAL HIGH SCHOOL, PALMETTO FLORIDA ON PART II, "TERMS AND CONCEPTS", OF THE COOPERATIVE SCIENCE TEST FOR GRADES SEVEN, EIGHT, AND NINE, LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND \( t \)

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<td>2</td>
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<td>10-12</td>
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</tr>
<tr>
<td>8-10</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>6-8</td>
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<td>5</td>
</tr>
<tr>
<td>4-6</td>
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<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

\( M_g - M_b = 3.20 \)  
\( M_b = 11.87 \)  
\( M_g = 8.67 \)  
\( \sigma_D = 1.58 \)  
\( S.D. = 3.86 \)  
\( S.D. = 2.52 \)  
\( t = 2.03 \)  
\( \text{S.E.}_m_b = 1.46 \)  
\( \text{S.E.}_m_g = .611 \)

girls \( M_g = 8.67 \) the standard deviation for girls is 2.52, the standard deviation for boys is 3.86, the standard error of the mean for girls is .611, and the standard error of the mean for boys is 1.46. The difference between the means is 3.20, the standard error of the difference between the means is 1.58 and the \( t \) is 2.03. Inasmuch as \( t \) must be at least 2.06 at the five per cent level of confidence to be statistically significant, it follows that \( t \) in this data is insignificant.

From the data gathered the writer holds that the difference occurring in favor of the boys on Part II, "Terms and Concepts" of the Cooperative Science Test is probably due to chance factors. The difference is too small to be
Scores on Cooperative Science Test, Part III, for Grade 9. - Below are a line graph, percentile graph, and a frequency distribution table of data obtained by administering the Cooperative Science Test, Part III, "Comprehension and Interpretation", to eight male and eighteen female pupils to determine the sex difference, if any, in science achievement as measured by Part III of the above test.

Figure 22 is a percentile graph representing the derived scores made by eight ninth grade boys and eighteen ninth grade girls on Part III, "Comprehension and Interpretation" of the Cooperative Science Test. This figure seems to indicate a slight difference in favor of the girls. However both groups rank very low in comparison to the norms. The lowest scoring boy scored at about the fourth percentile and the lowest scoring girl scored at the sixth percentile. The highest scoring boy did not exceed the thirty-fifth percentile while the highest scoring girl reached the fifty-seventh percentile. There is a slight difference in science achievement seemingly in favor of the girls, of Lincoln Memorial High School, Palmetto, Florida.

Table 11 shows the frequency distribution of raw scores obtained on Part III, "Comprehension and Interpretation", of the Cooperative General Science Test for grades seven, eight, and nine, administered to eight ninth grade boys and eighteen ninth grade girls seem to indicate the following: the mean for boys is 5.03, the standard deviation for the boys is 3, and the standard error of the mean for boys is 1.06. The mean for girls is 5.11, the standard deviation is 3.44, and the standard error of the mean for girls is .83. The difference between the means is .11 and the standard error of the difference between the means is 1.40. The t
Fig. 21.- Line graph of the raw scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part III, "Comprehension and Interpretation".
Fig. 22. - A Percentile Graph of the derived scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test, Part III, "Comprehension and Interpretation".
is .079. From the data revealed by the above table it is readily seen that there is no real sex difference between ninth grade boys and girls in "Comprehension and Interpretation" in science. In as much as \( t \) must be 2.07 at the five per cent level of confidence, the data indicate no real difference between the achievement between these two groups. Nevertheless, the difference which does appear is in favor of the girls, but it is probably due to errors in sampling, for it is too small to be statistically reliable.

Total Scores on Cooperative Science Test for Grade 9. -- Below are a line graph, percentile graph, and a table of frequency distribution of data.
obtained by administering the entire Cooperative Science Test, to eight ninth grade male and eighteen ninth grade female pupils to determine the sex differences, if any, in the total science achievement as measured by the above test.

Figure 2k is a percentile graph of the total derived scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test.

This figure shows that the boy who scored lowest ranked at about the seventeenth percentile and the girl who scored lowest ranked at the fifth percentile. The boy who scored highest ranked at the fifty-fifth percentile, while the girl scoring highest ranked at the forty-eighth percentile. The figure reveals that the lowest scoring boy ranks above the lowest scoring girl and the highest scoring boy is better than the highest scoring girl. However, it seems that both groups rank low in comparison to the norms. It appears that there is a difference between the ninth grade boys and girls of Lincoln Memorial High School, and that the difference is in favor of the boys.

The data in table 12 obtained from the frequency distribution of raw scores made on the Cooperative Science Test administered to eight ninth grade boys and eighteen ninth grade girls on March 14, 1950, reveal the following: The mean for girls is 26.54 and the mean for boys is 33.13. The standard deviation for girls is 8.04 and for boys the standard deviation is 7.31. The standard error of the mean for girls is 1.95 and the standard error for boys is 2.65. The difference between the means is 6.29 and the standard error of this difference is 3.29. The t is 2.

In as much as t must be 2.06 to be significant at the five per cent level of confidence, it appears that there is no real sex difference in the
Fig. 23.- Line graph of the total raw scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test.
Fig. 24. - A Percentile Graph of the total derived scores made by eight ninth grade boys and eighteen ninth grade girls on the Cooperative Science Test.
TABLE 12

FREQUENCY DISTRIBUTION OF THE TOTAL RAW SCORES OBTAINED ON THE COOPERATIVE SCIENCE TEST ADMINISTERED TO EIGHT NINTH GRADE BOYS AND EIGHTEEN NINTH GRADE GIRLS SHOWING MEASURES OF CENTRAL TENDENCY, VARIABILITY AND SIGNIFICANCE AND t

<table>
<thead>
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<th>Frequencies</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
<td></td>
<td>Girls</td>
</tr>
<tr>
<td>50-53</td>
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<tr>
<td>47-50</td>
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<td>44-47</td>
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<td></td>
<td>-</td>
</tr>
<tr>
<td>41-44</td>
<td>-</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>38-41</td>
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<td></td>
<td>1</td>
</tr>
<tr>
<td>35-38</td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>32-35</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>29-32</td>
<td>1</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>26-29</td>
<td>2</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>23-26</td>
<td>-</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>20-23</td>
<td>-</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>17-20</td>
<td>1</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>14-17</td>
<td>-</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>11-14</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>8</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>$M_B - M_G = 6.29$</td>
<td>$M_B = 33.13$</td>
<td>$M_G = 26.84$</td>
<td>$\Sigma D = 3.29$</td>
</tr>
<tr>
<td>$t = 1.94$</td>
<td>$S.E.M_B = 2.65$</td>
<td>$S.E.M_G = 1.95$</td>
<td></td>
</tr>
</tbody>
</table>

The difference occurring is in favor of the boys. However, it is too small to be statistically significant and is probably due to chance factors.

Scores on Cooperative Biology Test, Grades 10 and 11. Below are listed a line graph, a percentile graph, and a frequency distribution of the total achievement in science between ninth grade male and female pupils according to the instrument used at the time the test was administered.
data obtained by administering the Cooperative Biology Test to eighteen tenth and eleventh grade boys and twenty-eight tenth and eleventh grade girls, to determine the sex difference, if any, in achievement in biology as measured by the test above.

Figure 26 shows a percentile graph representing derived scores made by twenty-eight girls and eighteen boys of the tenth grade at Lincoln Memorial High School at Palmetto, Florida, on the Cooperative Biology Test.

The graph shows that the two sets of scores made by the two groups parallel each other very closely at every interval. The graph indicates that the lowest score made by the boys was slightly higher than the lowest score made by the girls. The highest scoring boy and the highest scoring girl scored at the eighty-ninth percentile. This seems to indicate that the superior female equals the superior male in achievement in biology. However, the slight difference which occurs is seemingly in favor of the boys.

In Table 13 the data obtained from the frequency distribution of raw scores on the Cooperative Biology Test administered to twenty-eight tenth and eleventh grade girls and eighteen tenth and eleventh grade boys indicate the following: the mean for the girls is 8.57, the standard deviation for the girls is 4.67, the standard error of the mean for girls is .699. The mean for the boys is 9.67, the standard deviation for boys is 5.51, and the standard error of the mean for boys is 1.36. The difference between the means is 1.10. The standard error of the difference between the means is 1.66 and t is .66. In as much as t must be 2.02 at the ten per cent level of confidence, it follows that the slight difference occurring in favor of the boys is highly insignificant and that there is
Fig. 25. - A Line Graph of the raw scores made by twenty-eight tenth and eleventh grade girls and eighteen tenth and eleventh grade boys on the Cooperative Biology Test.
Fig. 26.- A Percentile Graph of scores made by eighteen tenth and eleventh grade boys and twenty-eight tenth and eleventh grade girls on the Cooperative Biology Test.
TABLE 13
FREQUENCY DISTRIBUTION OF RAW SCORES OBTAINED BY TWENTY-EIGHT TENTH AND ELEVENTH GRADE GIRLS AND EIGHTEEN TENTH AND ELEVENTH GRADE BOYS ON THE COOPERATIVE BIOLOGY TEST IN LINCOLN MEMORIAL HIGH SCHOOL, PALMETTO, FLORIDA, LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

<table>
<thead>
<tr>
<th>Scores</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>21-24</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18-21</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>15-18</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>12-15</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>9-12</td>
<td>3</td>
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<td>6-9</td>
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<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Totals</td>
<td>18</td>
<td>28</td>
</tr>
</tbody>
</table>

\[
M_b - M_g = 1.10 \quad M_b = 9.67 \quad M_g = 8.57
\]

\[
\Sigma D = 1.66 \quad S.D. = 5.51 \quad S.D. = 4.67
\]

\[
t = .66 \quad S.E.m_b = 1.36 \quad S.E.m_g = .699
\]

no real sex difference between boys and girls in science achievement in biology, in Lincoln Memorial High School, Palmetto, Florida. The difference that appears is probably due to chance factors.

Scores on the Cooperative Chemistry Test for Grades 11 and 12.-- Below are a line graph, a percentile graph, and a frequency distribution table of data obtained by administering the Cooperative Chemistry Test to twenty eleventh and twelfth grade girls and twenty-two eleventh and twelfth grade boys to determine the sex difference, if any, in science achievement in chemistry as measured by the test above.
Figure 28 is a percentile graph of the derived scores made by twenty
eleventh and twelfth grade girls and twenty-two eleventh and twelfth
grade boys on the Cooperative Chemistry Test.

The figure seems to reveal the following information: The boy and
the girl who scored lowest ranked about the fourth percentile. Then, it
seems that the girl or group of girls who scored lowest ranked at about
the eighteenth percentile; while there were boys ranking at the eighth
and twelfth percentiles. From then on the two groups seem to parallel
each other very closely until they reached the forty-eighth percentile.
It appears that the highest scoring girl reached the fifty-eighth percen-
tile and that there were boys scoring at the sixty-fifth and seventy-
ninth percentile and that the highest scoring boy ranked at the eighty-
fifth percentile. It is indicated by this graph that the boys had no
girls to compete with beyond the fifty-eighth percentile. Therefore
it is revealed that the best boys are better than the best girls in
chemistry, and that there is a difference in achievement between boys
and girls in chemistry in Lincoln Memorial High School. It is indicated
by this figure that the difference is in favor of the boys of Lincoln
Memorial High School, Palmetto, Florida.

Table 14 shows the data obtained from the frequency distribution
of raw scores on the Cooperative Chemistry Test administered to twenty
eleventh and twelfth grade girls and twenty-two eleventh and twelfth
grade boys reveal the following: the mean for the girls is 4.35, the
standard deviation is 3.21, the standard error of the mean is .739.
The mean for boys is 6.68, the standard error of the mean for boys
is .956. The difference between the means is 2.33, the standard error of
the difference is 1.206 and t is 1.92. In order to be significant at the
Fig. 27.- Line Graph of the raw scores made by twenty eleventh and twelfth grade girls and twenty-two eleventh and twelfth grade boys on the Cooperative Chemistry Test.
Fig. 28.- Percentile Graph of the derived scores made by twenty eleventh and twelfth grade girls and twenty-two eleventh and twelfth grade boys on the Cooperative Chemistry Test.
TABLE 14

FREQUENCY DISTRIBUTION TABLE OF RAW SCORES OBTAINED BY TWENTY ELEVENTH AND TWELFTH GRADE GIRLS AND TWENTY-TWO ELEVENTH AND TWELFTH GRADE BOYS ON THE COOPERATIVE CHEMISTRY TEST SHOWING MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

<table>
<thead>
<tr>
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<th>Frequencies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Boys</td>
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<tr>
<td>18-21</td>
<td>1</td>
</tr>
<tr>
<td>15-18</td>
<td>1</td>
</tr>
<tr>
<td>12-15</td>
<td>1</td>
</tr>
<tr>
<td>9-12</td>
<td>4</td>
</tr>
<tr>
<td>6-9</td>
<td>3</td>
</tr>
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<td>3-6</td>
<td>5</td>
</tr>
<tr>
<td>0-3</td>
<td>7</td>
</tr>
<tr>
<td>Totals</td>
<td>22</td>
</tr>
</tbody>
</table>

\[ M_b - M_g = 2.33 \]
\[ M_b = 6.63 \]
\[ M_g = 4.35 \]

\[ \text{Sigma } \bar{\text{X}} = 1.208 \]
\[ \text{S.D. } \bar{\text{X}} = 4.38 \]
\[ \text{S.D. } \bar{\text{X}} = 3.21 \]

\[ t = 1.92 \]
\[ \text{S.E.}\bar{\text{X}}_b = .956 \]
\[ \text{S.E.}\bar{\text{X}}_g = .739 \]

ten per cent level of confidence t must be 1.60, and to be significant at the five per cent level of confidence t must be 2.02. In as much as the data from the above table indicate t as 1.92, it appears that there is no real difference in favor of the boys. There is a numerical difference between the boys and girls of the sample studied, but it is too small to be of statistical significance. Therefore, it may be stated that the difference occurring may be attributed to chance factors. It seems to the writer from the data gathered that the boys of Lincoln Memorial High School achieved more than the girls in chemistry, but insignificantly so.

Figure 6 is a percentile graph of the total derived scores made by
twenty three male and thirty female seventh grade pupils of Lincoln Memorial High School, Palmetto, Florida. The figure seems to reveal that the two groups parallel each other very closely and the they converge.

Scores on Cooperative Physics Test for Grade 12.-- Below are a line graph, a percentile graph, and frequency distribution table of data obtained by administering the Cooperative Physics Test to ten twelfth grade girls and twelve twelfth grade boys to determine the sex difference, if any, in achievement in physics as measured by the above test.

Figure 30 is a percentile graph of derived scores made by ten twelfth grade girls and twelve twelfth grade boys on the Cooperative Physics Test. The figure seems to reveal that the girls scored at the zero percentile through intervals 23-26 and 26-29 and ranked at the eighth percentile at interval 37-39. The next percentile rank seems to be about the twenty-ninth. The highest scoring girl ranked at the fifty-first percentile. The highest scoring boy scored at the zero percentile and the next highest reached the third percentile and then there were those who ranked at the eighth, thirteenth, eighteenth, thirty-third and forty-fifth percentiles. The best boy ranked at the fiftieth percentile. These two groups paralleled each other closely at various percentiles. It appears that the best girl scored slightly higher than the best boy. However, it seems that the boys left the zero percentile before the girls and scored higher at most of the other intervals.

Table 15 represents the data revealed from the frequency distribution of raw scores on the Cooperative Physics Test administered to ten twelfth grade girls and twelve twelfth grade boys of the previously named high school and it appears that the following is true: the mean for the girls is 5.7, the standard deviation is 6.03 and the standard error of the mean
Fig. 29. - Line Graph of the raw scores made by ten twelfth grade girls and twelve twelfth grade boys on the Cooperative Physics Test.
Fig. 30.- A Percentile Graph of the derived scores made by ten twelfth grade girls and twelve twelfth grade boys on the Cooperative Physics Test.
TABLE 15

FREQUENCY DISTRIBUTION TABLE OF RAW SCORES OBTAINED BY TEN TWELFTH GRADE GIRLS AND TWELVE TWELFTH GRADE BOYS ON THE COOPERATIVE PHYSICS TEST LISTING CERTAIN MEASURES OF CENTRAL TENDENCY, VARIABILITY, SIGNIFICANCE AND t

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</tr>
<tr>
<td>18-21</td>
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<td>-</td>
</tr>
<tr>
<td>6-9</td>
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</tr>
<tr>
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<td>0-3</td>
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<td>6</td>
</tr>
<tr>
<td>Totals</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

\[
M_b = \bar{x}_b = 10.5, \quad M_g = \bar{x}_g = 5.7
\]

\[
\sigma_d = 2.59, \quad S.D. = 5.49, \quad S.D. = 6.03
\]

\[
t = 1.85, \quad S.E.m_b = 1.63, \quad S.E.m_g = 2.01
\]

is 2.01. The mean for the boys is 10.5, the standard deviation is 5.49, and the standard error of the mean is 1.63. The difference between the means is 4.8 and the standard error of the difference between the means is 2.59. The t is 1.85. The writer finds that t must be 2.08 in order to be significant at the five per cent level of confidence. According to the data obtained by the testing instrument there is no real sex difference in science achievement between boys and girls in physics in the situation studied. It does appear that the boys excel the girls in physics in Lincoln Memorial High School, Palmetto, Florida. However, the difference is too small to be statistically reliable.
It is very interesting to note from the data above that there is a numerical difference in science achievement in practically every phase of the test in favor of the boys. Of the fifteen t's computed, fourteen were in favor of the boys. Of the fourteen t's computed four were statistically significant.

In only one instance were the girls favored numerically, and that difference very slight. The difference between the means was only .23 in favor of the girls.

Comparison of the Writers Findings with the Literature.— From the various studies reviewed it appears that the girls are not as efficient in science as the boys. The science in which little or no sex difference occur is biology. The other science studies reveal a numerical, if not a significant difference on practically every phase. The writer of this study finds similar results. It does appear from this study that there is only a very slight numerical sex difference in favor of the boys in seventh grade general science, and a significant sex difference in the total achievement in eighth grade science. No studies were found in the literature below ninth grade, therefore, the writer cannot make comparisons of her study with the literature in the seventh and eighth grades. Neither has the writer found any other study in which Negro pupils were used as subjects in the study of sex difference in natural science achievement.

Since it appears from the literature and from the data in the writer's study that boys excel girls in science achievement even when they are equated, as to intelligence, age, and the same class room environment, that there are other factors playing an important role in causing this difference.

Educational Implications in Theory and Practice. -- It seems that this and other studies in sex differences in achievement might be indica-
tive of the need for more motivation of girls in science, that more emphasis should be placed upon inspiring girls to deepen their interest in this phase of academic achievement. Perhaps, this study will serve to motivate other researchists to study the cause of male excellency in science achievement as well as try to derive a means by which girls may be influenced to aspire for greater scientific achievement.

The writer suggests that educators and instructors in science should strive more religiously to depict science as a dynamic part of every individual's life experience applicable to both sexes alike. No longer should the pupil, whether male or female, look upon science as something difficult and far removed from their life activities.

If the girls are to visualize science even in the "so-called" distinctly feminine interests, then perhaps they would consider science studies as interesting activities rather than needless undesirable academic requirements which have no place in lives presently or in the future. Very seldom do girls see a real need for physics, and chemistry even though they are as practical as any other phase of their school experience.

Perhaps the educators should strive further to derive a plan to remove the social and cultural stigma which makes science predominantly a man's field.

The writer feels that the above educational implication may, if put into practice, awaken much latent talent that might lie undiscovered in female pupils. They may serve to change the seemingly present attitude of many girls toward science, and eliminate the paucity of eminent women that now exist in science.

Limitation. -- The writer admits the following limitations of this study: The subjects were not equated as to intelligence, and socio-
economic status. Achievement is based solely on the scores obtained by
the subjects on the tests used in this study. They were not equated as
to urban and rural residence of the subjects nor was the education and
achievement of their parents taken into consideration. As was mentioned
in Chapter I the average educational achievement in the location in which
this study was made is low. However, there is a wide range in the educa-
tional status of the community varying from the college graduate to the
individual who cannot write his name.
Summary.--- This study was concerned with determining the sex differences, if any, in science achievement between the male and female pupils of Lincoln Memorial High School, Palmetto, Florida. The subjects studied were tested in the following areas of natural science: (a) general science, (b) biology, (c) chemistry, and (d) physics.

The population consisted of 384 male and female pupils. The subjects were deleted by stratification and selection of 50 per cent of the total population of 384 pupils.

The study was begun in July, 1950 and ended in July, 1950. The normative survey method was used and the techniques were testing and statistics.

The tests listed below were used to gather the data.

1. Cooperative Science Test for grades 7, 8, and 9, Form Y.
2. Cooperative Biology Test - Revised Series, Form x.
3. Cooperative Chemistry Test - Revised Series, Form x.
4. Cooperative Physics Test - Revised Series, Form x.

The data derived from the administration of the tests to the subjects were tabulated, graphed, treated statistically, and interpreted. The findings are reported in Chapter II.

Critical ratios were computed for each sub-division of the test administered to the seventh grade, and for the total scores made on the test. Since all other groups were less than fifty, the writer computed Fishers' t to determine the significance of the difference, if any, between the sexes in science achievement for each sub-division, and for the total scores.
The critical ratios of Fishers' t are indicated below with the favored sex designated.

1. Seventh Grade.-- On the Cooperative Science Test, Part I, "Informational Background", the C.R. is .59 in favor of the boys, on Part II, "Terms and Concepts", the C.R. is .55 in favor of the seventh grade boys, on Part III, "Comprehension and Interpretation", the C.R. is .067 in favor of the seventh grade boys. On the total scores of the Cooperative Science Test, the C.R. is 1.09 in favor of the seventh grade boys.

2. Eighth Grade.-- The t's for the Cooperative Science Test and each sub-division were as follows: For Part I, "Information Background", t is 2 in favor of the eighth grade boys. On Part II, "Terms and Concepts" t is 2.55 in favor of the boys. On Part III, "Comprehension and Interpretation", t is .23 in favor of the boys and on the total scores of the Cooperative Science Test t is 2.41 in favor of the boys.

3. Ninth Grade.-- On Part I, "Informational Background" t is 2.45 in favor of the boys. On Part II, "Terms and Concepts" t is 2.03 in favor of the ninth grade boys. For Part III, "Comprehension and Interpretation", t is .079 in favor of the ninth grade girls. Total scores on the Cooperative Science Test is 1.94 in favor of the ninth grade boys.

4. Biology.-- For biology t is .66 in favor of the tenth and eleventh grade boys.

5. Chemistry.-- For chemistry t is 1.92 in favor of the eleventh and twelfth boys.

6. Physics.-- For physics t is 1.05 in favor of the twelfth grade boys.
These findings have been interpreted in Chapter II.

Conclusions.-- The following conclusions are drawn directly from the data revealed by the various tests administered to the subjects and indicate the extent to which the writer's null hypothesis has been substantiated or invalidated. The conclusions are as follows:

1. There is no sex difference in science achievement in achievement of "Informational Background" in general science between the seventh grade boys and girls in Lincoln Memorial High School, Palmetto, Florida. The slight difference which occurred for the boys, is probably due to errors in sampling or other chance factors.

2. There is no real sex difference in the achievement of "Terms and Concepts" in general science between the 7th grade male and female pupils of Lincoln Memorial High School, Palmetto, Florida. The slight difference favoring the boys is probably due to error in sampling or other chance factors.

3. There is no real difference in "Interpretation and Comprehension" in science achievement between the seventh grade boys and girls in Lincoln Memorial High School. The exceedingly slight difference again favor the boys. It is too small to be statistically reliable and probably due to errors in sampling.

4. There is no real sex difference in the total achievement in general science between the male and female pupils of Lincoln Memorial High School, Palmetto, Florida. Again, a slight difference favors the boys, but it is probably due to chance factors.

5. There is no real sex difference in achievement in "Informational Background" between the eighth grade male and female pupils of Lincoln Memorial High School, Palmetto, Florida.
6. There is a real sex difference in achievement in "Terms and Concepts" in science between eighth grade male and female pupils of Lincoln Memorial High School. The difference favors the boys and is significant at the two per cent levels of confidence.

7. There is no real sex difference in achievement in "Interpretation and Comprehension" between eighth grade male and female pupils in this study. However, the slight difference which occurs favors the boys, but probably is due to errors in sampling or other chance factors. It is highly insignificant at every level of confidence.

8. There is a real difference in the total achievement in general science between the eighth grade male and female pupils in Lincoln Memorial High School favoring the boys. The difference is significant at the five, and two per cent levels of confidence. The difference occurring is reliable and cannot be attributed to chance factors.

9. There is a real sex difference in the achievement of "Informational Background" in general science between the ninth grade pupils, male and female of Lincoln Memorial High School. The difference favors the boys and is significant at the five per cent levels of confidence.

10. There is a real sex difference in the achievement of "Terms and Concepts" between the ninth grade male and female pupils of Lincoln Memorial High School, Palmetto, Florida. The difference favors the boys and is significant at five per cent level of confidence or better. The difference occurring is too large to be attributed to chance factors.

11. There is no real sex difference in achievement in "Interpretation and Comprehension" in general science between ninth grade male and female pupils of Lincoln Memorial High School. However, the slight difference which does occur is in favor of the girls, but is highly insignificant, and is probably due to an error in sampling.
12. There is no real sex difference in the total achievement in general science between the ninth grade male and female pupils of Lincoln Memorial High School. The difference favoring the boys is probably due to errors in sampling.

13. There is no real difference in natural science achievement in biology between tenth and eleventh grade male and female pupils of Lincoln Memorial High School, Palmetto, Florida. The slight difference which occurred favored the boys, but is insignificant. This difference is probably due to chance factors.

14. There is no real sex difference in achievement in natural science in chemistry between eleventh and twelfth grade boys and girls of Lincoln Memorial High School, Palmetto, Florida. The difference occurring is in favor of the boys but is insignificant, and the difference may be attributed to chance factors.

15. There is no real sex difference in achievement in natural science in physics between twelfth grade male and female pupils of Lincoln Memorial High School, Palmetto, Florida. The difference occurring is in favor of the boys but is insignificant, and the difference may be attributed to chance factors.
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Smith, V.C., "Sex Differences in the Study of General Science,* Science.* LXXV (January 8, 1932) 55-57.

APPENDIX A

TEST USED IN THE STUDY
Please print:

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

Last First Middle

Grade or Class........................................Age...................................................

Yrs. Mos. Date of Birth

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

M. or F.

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

Number of years you have studied biology: (one semester = $\frac{1}{2}$ year; one quarter = $\frac{1}{2}$ 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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15 Amsterdam Avenue, New York 23, N. Y.
PART I
(20 minutes)

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 parenthesis at the right.

1. Which is a common source of trichina worm infection for human beings?
   1-1 Beef
   1-2 Pork
   1-3 Fish
   1-4 Mutton
   1-5 Chicken ............... 1 ( )

2. If an animal is covered with hair and bears its young alive, in which two groups does it belong?
   2-1 Mammal and bird
   2-2 Mammal and reptile
   2-3 Invertebrate and arthropod
   2-4 Vertebrate and reptile
   2-5 Vertebrate and mammal ........... 2 ( )

3. Which of the following best defines the environment of an organism?
   3-1 The land on which it lives
   3-2 The organisms and conditions which make its life possible
   3-3 The climate of the locality in which it lives
   3-4 The plants and animals which surround it
   3-5 The surroundings and conditions in which it lives ............... 3 ( )

4. Nurserymen commonly advertise trees that bear five different varieties of apples. What makes it possible to produce such trees?
   4-1 Mutations
   4-2 Cross pollination
   4-3 Special types of soil
   4-4 Selective breeding
   4-5 Budding or grafting ............... 4 ( )

5. Which of the following characteristics is of greatest value in distinguishing a seed-eating bird from an insect-eating bird?
   5-1 Flight movements
   5-2 Shape of beak
   5-3 Shape of feet
   5-4 Size of crop
   5-5 Length of alimentary canal ............... 5 ( )

6. What is the chief function of root hairs?
   6-1 The harboring of nitrogen-fixing bacteria
   6-2 The binding of soil particles
   6-3 Storage
   6-4 Anchorage
   6-5 Absorption ............... 6 ( )

7. Which of the following changes would best balance a meal consisting of bread and butter, mashed potatoes, tapioca pudding, and candy?
   7-1 Adding beef, eggs, or cheese
   7-2 Omitting the candy and adding milk, squash, and carrots
   7-3 Omitting the candy and adding fresh vegetables, beef, and milk
   7-4 Omitting the tapioca pudding and candy, and adding pork, boiled rice, and pineapple
   7-5 Adding mince pie and hot chocolate 7 ( )

8. Which is a direct result of the oxidation of simple sugar in a cell?
   8-1 Increase in cell size
   8-2 Decrease in cell size
   8-3 Loss of energy
   8-4 Release of energy
   8-5 Storage of food ............... 8 ( )

9. What factor that is essential for green plant growth is lacking at great depths in the ocean?
   9-1 Light
   9-2 Oxygen
   9-3 Carbon dioxide
   9-4 Minerals
   9-5 Nitrogen ............... 9 ( )

10. Which of the following elements is found in carbohydrates, fats, and proteins?
    10-1 Carbon
    10-2 Nitrogen
    10-3 Phosphorus
    10-4 Sulfur
    10-5 Potassium ............... 10 ( )

11. In an intestinal parasite, which of the following is usually most degenerate?
    11-1 Sensory system
    11-2 Circulatory system
    11-3 Reproductive system
    11-4 Respiratory system
    11-5 Digestive system ............... 11 ( )

12. In the human body, excess carbohydrates are normally stored in the
    12-1 blood stream.
    12-2 spleen.
    12-3 liver.
    12-4 muscles.
    12-5 pancreas ............... 12 ( )

Go on to the next page.
Leaves taken from green plants which have been kept in the dark for several days do not show any evidence of starch when tested with iodine. What does this indicate?

13-1 Plants grown in the dark do not use food.
13-2 Iodine does not affect starch that has been kept in the dark.
13-3 Plants do not manufacture food in the dark.
13-5 Light changes starch molecules into sugar.

Which of the following is the best evidence of division of labor among protozoans?

14-1 One-celled structure
14-2 Specialized tissues
14-3 Performance of different functions by certain cell parts
14-4 Absence of specialized tissues
14-5 Granular appearance of protoplasm

Which of the following biological principles is best illustrated by a balanced aquarium?

15-1 All living things respond to stimuli in their environment.
15-2 Plants and animals are dependent upon each other and upon their environment.
15-3 Food, oxygen, and certain optimal conditions of temperature, moisture, and light are essential to the life of most living things.
15-5 All plants and animals are engaged in a constant struggle for energy.

Which statement is part of Darwin's theory of evolution?

16-1 Individuals well adapted to their environment are more likely to live and reproduce.
16-3 Any organism quickly adapts itself to its environment.
16-5 The production of a new organ results from a new need.

Some scientists believe that wavy hair in human beings is the result of incomplete dominance of curly over straight hair. If this is correct, which of the following is most likely to be true if a wavy-haired couple has several children?

17-1 All have wavy hair.
17-2 All have curly hair.
17-3 All have straight hair.
17-5 All have either curly or wavy hair.

Which man is usually given credit for the discovery and proof that blood circulates in a vascular system?

18-1 Galen
18-2 Darwin
18-4 Harvey
18-5 Koch

A spike is driven into a thirty-foot tree at a height of five feet from the ground. The tree grows ten feet taller during the next fifteen years. How far above the ground is the same spike at the end of that period?

19-1 Five feet
19-2 Ten feet
19-3 Fifteen feet
19-4 Twenty feet
19-5 Thirty feet

Which of the following is an example of sexual reproduction?

20-1 Sprouting of tubers
20-2 Budding of yeast
20-4 Development of seeds
20-5 Grafting of fruit trees

A spike is driven into a thirty-foot tree at a height of five feet from the ground. The tree grows ten feet taller during the next fifteen years. How far above the ground is the same spike at the end of that period?

19-1 Five feet
19-2 Ten feet
19-3 Fifteen feet
19-4 Twenty feet
19-5 Thirty feet

Which of the following best explains the fact that the number of sperms produced by plants and animals is much larger than the number of eggs?

21-1 Eggs contain stored food.
21-2 Sperms contain nuclear material.
21-4 Sperms must find the stationary eggs.
21-5 Several sperms fertilize each egg.

Fossils are found in two different rock strata which lie as they were originally formed. In which of the following characteristics are the fossils taken from the lower stratum always different from those taken from the upper?

22-1 Age
22-3 Abundance
22-5 State of preservation

Two fundamental concerns of all organisms are (1) to obtain food, and (2) to keep from being destroyed. Which of the following is also a fundamental concern?

23-1 Growing larger and larger
23-2 Obtaining oxygen from the air
23-3 Maintaining proper body temperature
23-5 Adapting to the changing environment

What is the basic reason for the high body temperature of birds?

24-1 Rapid movement
24-2 Feather covering
24-3 Rapid oxidation
24-5 High protein consumption

Go on to the next page.
25. Which organ is responsible for the final digestion of most food?
   25-1 Stomach
   25-2 Small intestine
   25-3 Large intestine
   25-4 Liver
   25-5 Pancreas

26. Of what advantage is the slow movement of capillary blood?
   26-1 Pressure is decreased.
   26-2 Pressure is increased.
   26-3 There is more opportunity for osmosis.
   26-4 There is more opportunity for energy transformations.
   26-5 Less heart action is necessary.

27. What are the end-products of fermentation by yeast?
   27-1 Sugar and carbon dioxide
   27-2 Alcohol and carbon dioxide
   27-3 Starch and alcohol
   27-4 Water and carbon dioxide
   27-5 Alcohol and water

28. Which of the following is most often true of plants that have inconspicuous flowers?
   28-1 Few seeds will mature.
   28-2 Insects distribute the pollen.
   28-3 Few flowers grow on each plant.
   28-4 Large quantities of nectar are produced.
   28-5 Wind distributes the pollen.

29. Which of the following best explains the struggle for existence among all living things?
   29-1 Carnivorous species
   29-2 Natural antagonisms
   29-3 Instincts
   29-4 Evolution
   29-5 Over-production

30. Plants sometimes die when the soil is tamped too solidly around their roots. In such a case, which of the following is most responsible for the death of the plant?
   30-1 Rapid evaporation of soil water
   30-2 Insufficient mineral supply
   30-3 Insufficient air
   30-4 Crushed root hairs
   30-5 Inability of new roots to grow through hard soil

31. Which of the following is usually accepted as an explanation of sudden changes in lines of organic evolution?
   31-1 Mutations
   31-2 New needs
   31-3 New uses of organs
   31-4 Environmental changes
   31-5 Natural selection

32. With which of the following structures are root hairs most closely associated?
   32-1 Cortex
   32-2 Central cylinder
   32-3 Vascular bundles
   32-4 Root cap
   32-5 Epidermis

33. Why does washing the leaves of plants kept in the house often improve the health of the plant?
   33-1 Stomates are cleared.
   33-2 Water enters the stomates.
   33-3 Opaque materials are removed.
   33-4 Dust is removed from the upper surfaces of leaves.
   33-5 Impurities are removed.

34. Which of the following best accounts for the loss of weight by athletes during a hard game?
   34-1 Oxidation of food
   34-2 Excretion of water
   34-3 Liberation of energy
   34-4 Excretion of carbon dioxide
   34-5 Destruction of protoplasm

35. Which of the following is the best explanation for an ear of corn with many undeveloped kernels?
   35-1 Staminate flowers were not developed.
   35-2 A fungus disease attacked the ear.
   35-3 Essential minerals were lacking in the soil.
   35-4 Pistillate flowers were not developed.
   35-5 Pistillate flowers were not pollinated.

36. Some animals resemble objects in their environment. Which of the following statements concerning these animals is most nearly correct?
   36-1 They are benefited by the resemblance.
   36-2 They are insuring perpetuation of the species.
   36-3 They are seeking protection.
   36-4 They are not highly developed.
   36-5 They are inactive.

37. Which of the following is the most effective method for securing a culture of protozoans?
   37-1 Allowing pure distilled water to become stagnant
   37-2 Boiling river water and covering the container
   37-3 Adding river water to an open jar containing dried grass
   37-4 Distilling river water and allowing the residue to become stagnant
   37-5 Exposing a Petri-dish of agar-agar to the air for a few minutes

38. Which of the following statements is true of living green plants?
   38-1 They carry on respiration all the time and photosynthesis part of the time.
   38-2 They carry on photosynthesis all the time and respiration part of the time.
   38-3 They use oxygen and give off carbon dioxide during photosynthesis.
   38-4 They use carbon dioxide and give off oxygen during respiration.
   38-5 They carry on photosynthesis in place of respiration.
39. What is the chief function of the cells of the most recent wood rings in the stems of trees and shrubs?

39-1 Manufacture of food
39-2 Digestion
39-3 Support
39-4 Conduction
39-5 Storage

40. Which of the following does not illustrate the principle of osmosis?

40-1 Passage of water through stomates
40-2 Passage of water through root hairs
40-3 Entrance of oxygen into lung capillaries
40-4 The wilting of lettuce in vinegar
40-5 Absorption of food from the small intestine

41. Which of the following procedures would most quickly result in a "balance of nature" in a given region?

41-1 Introducing equal numbers of different species
41-2 Leaving the region unmolested
41-3 Allowing hunters to destroy predatory animals
41-4 Introducing natural enemies of insects
41-5 Reducing the number of herbivorous animals

42. Which tissue is lacking in a mature corn stem?

42-1 Xylem
42-2 Phloem
42-3 Cambium
42-4 Pith
42-5 Vascular tissue

43. What factor other than shade makes a forest relatively cool in hot weather?

43-1 Evaporation
43-2 Condensation of water vapor
43-3 Natural low temperature of trees
43-4 Absorption
43-5 High humidity

44. Information concerning the food habits of a mammal may be most readily obtained from the

44-1 teeth
44-2 tongue
44-3 large intestine
44-4 stomach
44-5 digestive glands

45. What factor in the life of forest trees reduces the number of knots in the lumber cut from their trunks?

45-1 Competition for light
45-2 Competition for soil minerals
45-3 Protection from wind damage
45-4 Abundant moisture
45-5 Rich soil

46. Drawing A in the figure above represents a plant root system in wet soil with a glass tube securely fastened to the cut stem at C. The tube contains mercury. Drawing B represents the same apparatus after a few hours have passed. What does the difference in the mercury levels in drawing B indicate?

46-1 Atmospheric pressure has increased.
46-2 Water has passed into the root from the soil.
46-3 The roots have manufactured food.
46-4 The roots have carried on transpiration.
46-5 The roots are using stored food.

47. Which of the following is usually associated with the ability of an animal to regenerate lost parts?

47-1 Small size
47-2 Large size
47-3 Little specialization
47-4 Great specialization
47-5 Presence of joints

48. Which of the following structures is similar in origin and structure to the wing of a bird?

48-1 Foreleg of a cat
48-2 Leg of a man
48-3 Wing of a grasshopper
48-4 Leg of a crayfish
48-5 Wing of a moth

49. What distinguishes most insects from all other animals?

49-1 Compound eyes
49-2 Segmented bodies
49-3 Number of appendages
49-4 Small size
49-5 Food habits

50. Which characteristic of an active snake is most responsible for the fact that food consumption per unit volume is typically much less than that of an active mammal such as a dog?

50-1 Long intestine
50-2 Efficient digestive system
50-3 Type of locomotion
50-4 Cold-blooded body
50-5 Hinged jaws which allow ingestion of whole animals as food

51. Which of the following best explains the large number of existing insects?

51-1 Freedom from competition
51-2 High degree of adaptation
51-3 Protective coloration
51-4 High degree of development
51-5 Unlimited food supply
52. Which of the following benefits derived from forests is the most important reason for forest conservation?
   52-1 Lumber
   52-2 Recreation areas
   52-3 Soil binding
   52-4 Regulation of water supply
   52-5 Homes for wildlife

53. Which of the following changes will usually result from changing the environment of a plant for several generations?
   53-1 A change in the number of chromosomes
   53-2 A non-heritable change in the vegetative parts
   53-3 A heritable change in the species
   53-4 A change in the sex cells
   53-5 A permanent change in the life cycle

54. In which structure does most digestion take place in a young potato plant which is being propagated from a piece of tuber?
   54-1 Leaf
   54-2 Stem
   54-3 Root
   54-4 Tuber
   54-5 Epidermis

55. What characteristic of fruits and vegetables makes it necessary for a person who lives chiefly on these substances to eat a larger volume of food than one who eats mainly animal products?
   55-1 High vitamin content
   55-2 Low vitamin content
   55-3 High proportion of cellulose
   55-4 Low proportion of cellulose
   55-5 Low carbohydrate content

PART II
(20 minutes)

Directions: This part consists of diagrams and passages, followed by several items concerning the diagram or passage. For each item, decide on the basis of the diagram or passage which one of the choices given below the incomplete statement or question best completes the meaning of the statement or answers the question. Put the number of your choice in the parentheses at the right of each item.

The development of every kind of living organism is influenced by the activities of other living organisms. There are intimate interrelations not only between various species of plants, but also between plants and animals.

A common biotic relationship is that found in competition. Plants compete with each other for water, for mineral nutrients, for space, and for light. In a forest, the plants which grow more slowly are shaded by more rapidly growing individuals, and often die as a result of their inability to obtain sufficient light. As a result of competition for moisture in the soil, those plants which absorb water most rapidly usually survive, whereas those which take up moisture more slowly are likely to succumb in the competition. Morphological features, such as depth of root systems and development of water-storage tissues, and physiological characteristics, such as rate of transpiration and of water absorption, and photosynthetic efficiency, are factors which determine what species will survive under given environmental conditions and what species will lose out.

Parasitism is another biotic relationship which influences strikingly the development and distribution of plants. Infections by fungal parasites may interfere seriously with photosynthetic activity, and thus indirectly reduce the numbers and quality of seeds produced.

Akin to parasitic relationships are symbiotic relationships. The term symbiosis (meaning "living together") is used to refer to an intimate biotic association in which the organisms involved live together more commonly than they live apart, and in which the relationship is often mutually beneficial. Lichens are regarded as symbiotic associations of algae and fungi, and the nitrogen-fixing bacteria which inhabit the nodules of leguminous roots live apparently in a symbiotic relationship of mutual benefit with their hosts.

Animals constitute an important biotic factor which influences the growth and distribution of plants, for all animals are dependent directly or indirectly upon plants for food. Overgrazing of grasslands and forests by animals produces marked vegetational changes. When leaves are continually cropped, the food-making machinery of plants is destroyed, and plants starve and die.

Flower-pollinating insects are an important factor in the distribution of plants, for most species of angiosperms are insect pollinated and are therefore dependent upon pollinating insects for their production of seed. Fluctuations of insect populations thus markedly influence the degree to which such plants may propagate themselves.

Items 1-9 on page 7 refer to the passage above.

Go on to the next page.
Forest trees often grow taller than trees of the same species growing in the open. This may be accounted for by competition for
1-1 water.
1-2 light.
1-3 food.
1-4 space.
1-5 mineral nutrients.

What effect of fungous parasites on green plants interferes most directly with photosynthetic activity?
2-1 Destruction of leaf tissue
2-2 Reduction of water supply
2-3 Depletion of storage products
2-4 Reduction in the number of seeds
2-5 Stimulation of abnormal growths

What is the chief contribution to legumes of the nitrogen-fixing bacteria which inhabit the nodules of their roots?
3-1 Free nitrogen
3-2 Nitrites
3-3 Nitrates
3-4 Minerals necessary for photosynthesis
3-5 Food for the roots

Which of the following is true of many symbiotic relationships, but is never true of parasite and host?
4-1 Two organisms live together in close association.
4-2 One organism provides food for another organism.
4-3 Each organism helps the other in one or more ways.
4-4 Each organism belongs to a different species.
4-5 One organism provides a place to live for another.

What is the chief contribution to the fungus of the alga which helps make up a lichen?
5-1 Water
5-2 Major portion of the plant body
5-3 Absorption of mineral nutrients
5-4 Protection
5-5 Food

What characteristic of bluegrass is most important in helping these plants survive the grazing of animals?
6-1 Succulent leaves
6-2 Growing region at the tip of the leaves
6-3 Growing region at the base of the leaves
6-4 Spreading root system
6-5 Vegetative reproduction

Which of the following groups of plants is most dependent upon insects for pollination?
7-1 Mosses
7-2 Ferns
7-3 Gymnosperms
7-4 Dicotyledons
7-5 Fungi

Which of the following insects has the greatest influence on the number of seeds produced by angiosperms?
8-1 Paper wasp
8-2 Butterfly
8-3 Lady bug
8-4 Bumblebee
8-5 Housefly

Which one of the following factors that Darwin used to account for the development of new species is not stated or implied in the second paragraph of this passage?
9-1 Over-production of individuals
9-2 Inheritance of favorable characteristics
9-3 Variation among individuals
9-4 Survival of the fittest
9-5 Struggle for existence
The basic experiment which underlies our modern ideas about photosynthesis was performed by Van Helmont about three hundred years ago. His simple but conclusive experiment proved that very little of the total substance of a plant comes from the soil. He planted a willow shoot weighing five pounds in a pot containing exactly 200 pounds of thoroughly dried earth. Then for five years he carefully watered it with rain-water. The earth in the pot was covered to prevent dust from blowing in. At the end of the five years the willow weighed 169 pounds. At the same time the earth in the pot, when again thoroughly dried, proved to have lost but two ounces. He concluded that the new substance of the willow was made of water.

We now know that green plants use water and carbon dioxide as raw materials in the manufacture of food, and that the end products are a carbohydrate and oxygen. Chlorophyll is in some way essential, and the process takes place only in the presence of light energy. The process can be summarized by the chemical equation

$$6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2.$$  

The chief organs of food manufacture in higher plants are the leaves. They are well adapted for the effective discharge of this function. The thin broad shape of typical leaves presents a large area to sunlight and allows a ready exchange of gases with the surrounding atmosphere. The tissues within a leaf are shown in the accompanying diagram. The cells between the upper and lower epidermis constitute the mesophyll. All mesophyll cells are richly supplied with chloroplasts. The intercellular spaces of the spongy mesophyll are connected with the external atmosphere through the stomates. This affords a passageway for CO$_2$ to reach the cells and O$_2$ to leave, and, during respiration, for the reverse process. There is usually a great deal of water vapor passing through the intercellular spaces and evaporating out through the stomates. Ramifying through the mesophyll are the supporting and transporting veins made up of fibro-vascular bundles.

Items 10–18 on page 9 refer to the passage and diagram above.
0. How much did the willow which Van Helmont planted gain in weight during the five year period?
10-1 200 lbs.
10-2 169 lbs.
10-3 164 lbs.
10-4 31 lbs.
10-5 5 lbs. . . . . . . . . . . . . 10(3)

1. What did Van Helmont attempt to control by covering the pot of soil in which he planted the willow twig?
11-1 Water loss by evaporation
11-2 Transpiration
11-3 Removal of soil by the wind
11-4 Introduction of additional soil into the pot
11-5 Amount of water used . . . . . . 11(5)

2. Why is oxygen considered a by-product of photosynthesis?
12-1 It is not part of the food manufactured.
12-2 It is present in carbon dioxide and water.
12-3 It is used by plants in respiration.
12-4 It is a useless gas.
12-5 It is released as a free gas. . . . . 12(5)

3. The chemical equation for photosynthesis, as given in the passage, could be improved by
13-1 balancing it.
13-2 indicating that energy is required.
13-3 indicating that energy is released.
13-4 identifying the waste products.
13-5 including the word photosynthesis. 13(1)

4. This discussion of photosynthesis provides the least information about
14-1 the steps in the process.
14-2 the raw materials.
14-3 the end products.
14-4 the source of energy.
14-5 the food manufactured. . . . . 14(5)

5. What adaptation for food manufacture is shown in the diagram but not mentioned in the passage?
15-1 Air spaces in spongy mesophyll
15-2 Large area for light reception
15-3 Fibro-vascular bundles
15-4 Concentration of chloroplasts in upper mesophyll cells
15-5 Openings in the lower epidermis . . . 15(5)

6. What is the chief function of the two epidermal layers of a leaf?
16-1 Food manufacture
16-2 Conduction
16-3 Light reception
16-4 Protection
16-5 Support . . . . . . . . . . . . . . . . 16(5)

7. During the daytime, what gas is present in the intercellular spaces of mesophyll cells in higher concentration than in the surrounding atmosphere?
17-1 Carbon dioxide
17-2 Nitrogen
17-3 Oxygen
17-4 Hydrogen
17-5 Carbon . . . . . . . . . . . . . . . . 17(5)

8. What structures are mentioned in the passage but not shown in the diagram?
18-1 Veins
18-2 Stomates
18-3 Chloroplasts
18-4 Epidermal cells
18-5 Intercellular spaces . . . . . . . . 18(5)

Go on to the next page.
When the left ventricle of the heart contracts, the blood it contains is forced out between valves into the largest blood vessel of the body, the aorta. This blood vessel branches, and blood is thus carried all over the body. By means of smaller divisions called capillaries, the blood is enabled to come close enough to cells to discharge food and oxygen to them, taking up wastes in return. It then flows into small veins leading back to the heart. During the systemic circulation, the blood passes through the kidneys, where it eliminates urea, and through the intestinal walls, where it gains a fresh supply of food.

The passage of venous blood from the stomach and the intestine through the liver requires special blood vessels comprised in the portal system. Passage of the blood through the liver keeps the carbohydrate content of the blood uniform.

When the venous blood reaches the heart it enters the right auricle, on the side opposite that from which it started out on the journey through the body. From the right auricle, it passes into the right ventricle. When this contracts, blood is forced through the pulmonary arteries to the lungs. It returns through the pulmonary veins to the left auricle and ventricle, from which it starts out again on a trip around the body.

The ventricles contract and expand together so that there are two waves of blood sent out at each beat, one to the lungs and one to the general circulation. While the ventricles are contracting and forcing out their blood, both auricles have been filling so there is no stop in the flow.

The general plan of circulation described above is summarized in the following diagram.

Items 19–26 refer to the passage and diagram above.

19. Which blood vessel shown on the diagram is the largest in the body?
   19–1 A  
   19–2 B  
   19–3 C  
   19–4 D  
   19–5 E . . . . . . . . . . . . . . 19( )

20. Which of the following best explains the greater thickness of the left ventricle walls as shown in the diagram?
   20–1 Contractions are more frequent.  
   20–2 Volume of blood pumped is greater.  
   20–3 Blood is pumped over greater distances.  
   20–4 There are more blood vessels leaving the left side.  
   20–5 There is a greater supply of "pure" blood. . . . . . . . . . . . . . . . . . . . . . . 20( )

21. The wastes of oxidation, picked up by the blood in the capillaries of all active tissues, consist of
   21–1 broken-down red corpuscles.  
   21–2 glycogen and oxygen.  
   21–3 amino acids and water.  
   21–4 urea and fibrinogen.  
   21–5 carbon dioxide and water. . . . . . . . . . . 21( )

22. When blood is leaving the right ventricle of the human heart, how is it moving in the other parts of the heart?
   22–1 It is entering the left ventricle and the two auricles.  
   22–2 It is entering the two auricles, and leaving the left ventricle.  
   22–3 It is neither entering nor leaving the auricles, and is leaving the left ventricle.  
   22–4 It is leaving all other parts.  
   22–5 It is leaving the left auricle, and entering the right auricle and ventricle. 22( )
3. Which of the following is the most accurate characterization of the blood carried by all arteries?
   23-1 Moving toward the heart
   23-2 Moving away from the heart
   23-3 Pure
   23-4 Impure
   23-5 Oxygenated

4. Which of the following procedures is used to determine the blood pressure in human beings?
   24-1 Counting the number of heart beats per minute
   24-2 Weighing a unit volume of blood taken from an artery
   24-3 Attaching a manometer to an artery
   24-4 Measuring the pressure necessary to stop the flow of blood through an artery
   24-5 Measuring the pressure in large veins

25. What is the chief advantage of a four-chambered-heart?
   25-1 Oxygenated blood and deoxygenated blood are kept completely separated.
   25-2 More blood is pumped per unit of time.
   25-3 One part rests while the other parts contract.
   25-4 Blood enters the heart at the same time it is pumped out.
   25-5 Higher capillary pressure is maintained.

26. What other animals have a heart similar to that shown in the diagram?
   26-1 Crayfish
   26-2 Adult frogs
   26-3 Fish
   26-4 Reptiles
   26-5 Birds

An exchange of gases is constantly taking place between plants, animals, and the air. This exchange is diagrammed in the figure above.

Items 27 and 28 refer to this diagram.

27. How should the diagram be changed if it is to represent the typical exchanges taking place under cold winter conditions?
   27-1 Remove lines B and C
   27-2 Reverse the arrows on lines A and B
   27-3 Remove lines A, B, and E
   27-4 Remove line E
   27-5 Reverse the arrows on lines A and D

28. Under normal growing conditions, what gas is represented by line B in the figure?
   28-1 Water vapor
   28-2 Hydrogen
   28-3 Nitrogen
   28-4 Oxygen
   28-5 Carbon dioxide

The figure above illustrates the life history of a mosquito. Items 29 and 30 refer to this figure.

29. What characteristic of the adult shown in the figure indicates that the drawing represents a member of the genus Culex rather than Anopheles?
   29-1 Comparative size
   29-2 Position
   29-3 Number of legs
   29-4 Length of abdomen
   29-5 Length of wings

30. Which of the following life processes is directly benefited by the structure shown at E?
   30-1 Circulation
   30-2 Sensation
   30-3 Excretion
   30-4 Locomotion
   30-5 Respiration

If you finish before the time is up, you may go back and work on either part.
AMERICAN COUNCIL ON EDUCATION

COOPERATIVE CHEMISTRY TEST

REVISED SERIES FORM X

by

PAUL J. BURKE, Cooperative Test Service

with the editorial assistance of

THEODORE A. ASHFORD, University of Chicago

Please print:

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Last First Middle

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

Yrs. Mos.

School..................................................................................................................City.....................................Sex.......................M. or F.

Title of chemistry course you are now taking.......................................................Instructor

Number of semesters you have studied chemistry..............................................

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.

<table>
<thead>
<tr>
<th>Part</th>
<th>I</th>
<th>II</th>
<th>Total</th>
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<tbody>
<tr>
<td>Minutes</td>
<td>25</td>
<td>15</td>
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15 Amsterdam Avenue, New York 23, N. Y.
Directions: Each of the following incomplete statements or questions is followed by five possible answers. For each one, select the answer which best completes the statement or answers the question, and put its number in the parentheses at the right.

1. Which of the following is used in order to make city water safe to drink?
   1-1 Sulfur  1-2 Iodine  1-3 Hydrogen  1-4 Bromine  1-5 Chlorine  ( )

2. The characteristic odor of rotten eggs is due to
   2-1 H₂S  2-2 HBr  2-3 HCl  2-4 SO₂  2-5 HOBr  ( )

3. Which of the following lists the halogens in correct order according to their chemical activity (most active element first)?
   3-1 Fluorine, chlorine, bromine, iodine  3-2 Iodine, bromine, chlorine, fluorine  3-3 Chlorine, fluorine, bromine, iodine  3-4 Iodine, bromine, chlorine  3-5 Chlorine, bromine, fluorine  ( )

4. The gas which causes bread to rise is
   4-1 carbon dioxide  4-2 hydrogen  4-3 helium  4-4 sulfur dioxide  4-5 oxygen  ( )

5. “Hard” water is water that
   5-1 has a drying effect on the skin  5-2 has sand particles in suspension  5-3 contains substances that precipitate soap  5-4 contains no dissolved gases  5-5 contains acid in solution  ( )

6. The construction of transcontinental railroads, skyscrapers, and large bridges was made possible by the development of
   6-1 the chamber and contact processes  6-2 the Bessemer and open-hearth processes  6-3 the electric furnace  6-4 the electrolytic process  6-5 the fractionating tower  ( )

7. Which of the following is used to etch glass?
   7-1 HI  7-2 HCl  7-3 HF  7-4 H₂SO₄  7-5 HNO₃  ( )

8. Which one of the following metals lies below hydrogen in the activity or electromotive series? (Most active metals are highest in the series.)
   8-1 Magnesium  8-2 Iron  8-3 Aluminum  8-4 Zinc  8-5 Platinum  ( )

9. Starch can be identified in food by a test with
   9-1 bromine  9-2 Fehling’s solution  9-3 Tollen’s reagent  9-4 iodine  9-5 hydrochloric acid  ( )

10. What is the valence of argon?
    10-1 0  10-2 +1 and −1, −3, −5, −7  10-3 +3  10-4 +4 and −4  10-5 +2 and +4  ( )

11. Which of the following pairs of compounds illustrates the law of multiple proportions?
    11-1 CO and CO₂  11-2 H₂CO₃ and CCl₄  11-3 HCl and HBr  11-4 H₂SO₄ and NaOH  11-5 CH₄ and CS₂  ( )

12. What is an important use of the substance Ca(H₂PO₄)₂?
    12-1 As a pigment  12-2 As a dentifrice  12-3 In metallurgy  12-4 As a medicine  12-5 In fertilizers  ( )

13. The element that is found in all organic compounds is
    13-1 hydrogen  13-2 nitrogen  13-3 oxygen  13-4 carbon  13-5 sulfur  ( )

Go on to the next page.
14. Which of the following best describes how soap and water remove dirt?
   14-1 By neutralizing the acid in the dirt
   14-2 By bringing the dirt particles into colloidal suspension
   14-3 By rendering the dirt soluble through a chemical change
   14-4 By removing the top layer of dead skin just beneath the dirt and lifting the dirt off with it
   14-5 By neutralizing the alkali in the dirt

15. The cyanamide process and the Haber process are both methods for the
   15-1 manufacture of phosphates.
   15-2 refining of gold.
   15-3 synthesis of ammonia.
   15-4 hardening of steel.
   15-5 manufacture of illuminating gas.

16. What base is used in mortar?
   16-1 NaOH
   16-2 KOH
   16-3 Mg(OH)₂
   16-4 Al₂(OH)₃
   16-5 Ca(OH)₂

17. A solution of a metal in mercury is called
   17-1 a mercurate.
   17-2 a hydrargentite.
   17-3 spiegeleisen.
   17-4 an amalgam.
   17-5 carbaloy.

18. Mercury is used as a solvent in the refining of
   18-1 iron.
   18-2 aluminum.
   18-3 calcium.
   18-4 silver.
   18-5 potassium.

19. Which of the following is made of an alloy?
   19-1 A gold ring
   19-2 A copper wire
   19-3 Tin coating on a can
   19-4 A tungsten filament
   19-5 A lead plate in a battery

20. The reason why helium is used in balloons instead of hydrogen is that helium
   20-1 provides more lifting force per unit volume.
   20-2 is cheaper.
   20-3 does not burn.
   20-4 is liquefied with more difficulty.
   20-5 diffuses less readily.

21. How are edible liquid oils changed into solid fats?
   21-1 By heating under high pressure
   21-2 By heating to drive off the liquid parts
   21-3 By a reaction with potassium hydroxide
   21-4 By a reaction with hydrogen in the presence of a catalyst
   21-5 By a reaction with sodium chloride

22. An alloy of bismuth, lead, tin, and cadmium is used for its
   22-1 great tensile strength.
   22-2 low melting point.
   22-3 great elasticity.
   22-4 low coefficient of thermal expansion.
   22-5 high coefficient of thermal expansion.

23. How is neon produced commercially?
   23-1 From natural deposits of the free gas
   23-2 By the liquefaction of air
   23-3 By liberation from its compounds
   23-4 By synthesis
   23-5 By electrolysis

24. The large number of existing organic compounds is explained by
   24-1 the large number of the valence states of carbon.
   24-2 the large number of elements that commonly enter into organic compounds.
   24-3 the wide variety of temperatures and pressures that exist in nature.
   24-4 the ability of carbon atoms to link together in chains and rings.
   24-5 the ease with which one organic compound may be converted into another.

25. An element that is found in all proteins but is not found in carbohydrates is
   25-1 nitrogen.
   25-2 phosphorus.
   25-3 oxygen.
   25-4 sodium.
   25-5 sulfur.
5. Which one of the following elements has chemical properties most similar to those of carbon?
   - Silicon
   - Argon
   - Iron
   - Boron
   - Nitrogen

6. One of the stable valences of chlorine is — 1.
   - The atom loses an electron very easily.
   - The nucleus contains one proton.
   - The nucleus contains seven protons.
   - There is one electron in the outer shell.
   - There are seven electrons in the outer shell.

7. How are the elements arranged in the periodic table?
   - In sequence according to their atomic numbers
   - In sequence according to the number of electrons in the nucleus
   - In sequence according to the number of electrons in their outer orbits
   - In groups according to their atomic weights
   - In groups according to their physical properties.

8. What is the explanation for the unreactive nature of the noble gases?
   - They cannot be ionized.
   - They have even atomic numbers.
   - They have a stable configuration of electrons in their outer shells.
   - Their nuclei are extremely stable.
   - Their atoms are bound together strongly.

9. Carbon monoxide is a dangerous poison because it
   - renders the walls of the air-sacs impermeable.
   - reduces the solubility of oxygen in the blood.
   - combines chemically with hemoglobin.
   - combines chemically with oxygen.
   - dissolves the red blood corpuscles.

10. Which of the following is an extremely poisonous substance often used for fumigation?
    - HCl
    - HCN
    - KMnO₄
    - P₂O₅
    - H₂S

11. What chemical process is important in the development of photographic film?
    - The liberation of sulfur from sodium thiosulfate
    - The reduction of silver halides to metallic silver
    - The oxidation of silver to silver oxide
    - The oxidation of gelatin to urea
    - The neutralization of free alkali.

12. The essential difference between the "ic" and "ous" valence states in the case of ferric and ferrous, is that in the "ferric" state the iron atom
    - has lost fewer electrons.
    - has combined with more atoms of oxygen.
    - has lost more electrons.
    - has gained more electrons.
    - has gained fewer electrons.

13. Which one of the following best explains the fact that the volumes of gases that combine chemically with each other are to each other as small whole numbers?
    - All gases have molecules which contain a small integral number of atoms.
    - Equal masses of gas have volumes which are to each other as small whole numbers at the same temperature and pressure.
    - Equal volumes of all gases contain the same number of molecules at the same temperature and pressure.
    - Equal volumes of all gases have the same mass at the same temperature and pressure.
    - Equal masses of all gases contain the same number of molecules at the same temperature and pressure.
35. Which of the following is used as a water softener?
   35-1 Sodium tetraborate
   35-2 Sodium chloride
   35-3 Calcium carbonate
   35-4 Ferric chloride
   35-5 Calcium silicate

36. How does “heavy water” differ from ordinary water?
   36-1 Its molecules contain two atoms of oxygen.
   36-2 Its molecules contain three atoms of hydrogen.
   36-3 It consists of ordinary water whose molecules have joined together.
   36-4 It contains hydrogen of atomic weight 2.
   36-5 It contains oxygen of atomic weight 17.

37. In the reaction:
   \[ \text{SnCl}_2 + 2\text{FeCl}_3 \rightarrow \text{SnCl}_4 + 2\text{FeCl}_2 \]
   what change, if any, occurs in the valence of the chlorine?
   37-1 It is increased.
   37-2 It is reduced.
   37-3 It is increased in one molecule and reduced in the other.
   37-4 None.

38. In the reaction \( \text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl} \), the hydrogen is
   38-1 reduced.
   38-2 neutralized.
   38-3 hydrated.
   38-4 oxidized.
   38-5 displaced.

39. Sodium bicarbonate is sometimes used to relieve stomach distress. Which of the following summarizes the reaction that occurs when sodium bicarbonate acts in the stomach?
   39-1 \( \text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow \text{H}_2\text{CO}_3 + 2\text{NaCl} \)
   39-2 \( \text{NaHCO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{CO}_3 + \text{NaHSO}_4 \)
   39-3 \( \text{Na}_2\text{CO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{CO}_3 + \text{Na}_2\text{SO}_4 \)
   39-4 \( \text{NaHCO}_3 + \text{HCl} \rightarrow \text{H}_2\text{CO}_3 + \text{NaCl} \)
   39-5 \( \text{NaHCO}_3 \rightarrow \text{CO}_2 \uparrow + \text{NaOH} \)

40. A reducing agent that is also used to identify heavy metal ions is
   40-1 \( \text{H}_2\text{S} \)
   40-2 \( \text{H}_2\text{SO}_3 \)
   40-3 \( \text{H}_2 \)
   40-4 \( \text{HCl} \)
   40-5 \( \text{NaH} \)

41. The atomic number of an element depends on
   41-1 the number of neutrons in the nucleus.
   41-2 the number of protons in the nucleus.
   41-3 the sum of the number of protons and the number of neutrons in the nucleus.
   41-4 the number of protons in the nucleus and the number of electrons in the outer shell.
   41-5 the total number of particles of which the atom is composed.

42. Which of the following is a colloidal dispersion?
   42-1 Protoplasm
   42-2 Mineral oil
   42-3 Water
   42-4 Whiskey
   42-5 Sodium thiosulfate

43. The contact process for the large scale manufacture of sulfuric acid depends on which of the following reactions?
   43-1 \( \text{SO} + \text{O}_2 \rightarrow \text{SO}_3 \)
   43-2 \( 2\text{HCl} + \text{Na}_2\text{SO}_4 \rightarrow \text{H}_2\text{SO}_4 + 2\text{NaCl} \)
   43-3 \( 2\text{SO}_3 + \text{O}_2 \rightarrow 2\text{SO}_3 \)
   43-4 \( 2\text{HNO}_3 + \text{CaSO}_4 \rightarrow \text{H}_2\text{SO}_4 + \text{Ca(NO}_3)_2 \)
   43-5 \( \text{H}_2\text{S} + 2\text{O}_2 \rightarrow \text{H}_2\text{O} + \text{SO}_3 \)

44. Which one of the following most readily replaces the oxygen in water?
   44-1 Chlorine
   44-2 Fluorine
   44-3 Bromine
   44-4 Iodine
   44-5 Benzene

45. An element which is used in certain types of photoelectric cells is
   45-1 molybdenum.
   45-2 iridium.
   45-3 phosphorus.
   45-4 sulfur.
   45-5 selenium.
6. What substances are formed when H₂S and H₂O₂ are mixed?
46-1 SO₂ and H₂
46-2 H₂OS and H₂O
46-3 S and H₂O
46-4 S, H₂, and O₂
46-5 There is no reaction

47. How many grams of CaCO₃ are produced from 76 grams of Ca(OH)₂ and unlimited CO₂ gas in the reaction Ca(OH)₂ + CO₂ → CaCO₃ + H₂O?
(Atomic weights: Ca = 40, O = 16, H = 1, C = 12)
47-1 50 grams
47-2 100 grams
47-3 144 grams
47-4 150 grams
47-5 200 grams

48. How many liters of oxygen are required for the complete combustion of 100 liters of CH₄?
48-1 100 liters
48-2 200 liters
48-3 300 liters
48-4 400 liters
48-5 250 liters

49. How many molecules of H₂O appear in the balanced equation for the following reaction: PH₃ + O₂ → P₂O₅ + H₂O?
49-1 1
49-2 2
49-3 3
49-4 4
49-5 5

50. Which reaction takes place when milk of magnesia is ingested into the stomach?
50-1 Mg(OH)₂ + 2HCl → MgCl₂ + 2H₂O
50-2 MgSO₄ + 2HCl → MgCl₂ + H₂SO₄
50-3 MgO + H₂O → Mg(OH)₂
50-4 MgCO₃ + 2HCl → MgCl₂ + CO₂ + H₂O
50-5 Mg(HCO₃)₂ + H₂SO₄ → MgSO₄ + CO₂ + 2H₂O

51. How many grams of NaOH are necessary to neutralize 98 grams of H₃PO₄?
(Atomic weights: P = 31, O = 16, H = 1, Na = 23)
51-1 32.6 grams
51-2 40 grams
51-3 80 grams
51-4 98 grams
51-5 120 grams

52. Which of the following is the most reactive?
52-1 Lithium
52-2 Sodium
52-3 Potassium
52-4 Rubidium
52-5 Caesium

Go on to the next part.
Directions: Continue as in the preceding part.

Items 53 through 55: The above diagram shows how the solubilities in water of 5 substances change with temperature.

53. How many grams of sodium sulfate may be dissolved in 100 grams of water at a temperature of 75°C?
   53-1 38 grams
   53-2 40 grams
   53-3 41 grams
   53-4 43 grams
   53-5 46 grams

54. Suppose we had a mixture of five grams of each of the five substances dissolved in 100 grams of water. Which substance could be separated out by cooling down to 0°C?
   54-1 Ca(C₂H₃O₂)₂·2H₂O
   54-2 KNO₃
   54-3 Na₂SO₄
   54-4 NaCl
   54-5 K₂Cr₂O₇

55. Which substance has a minimum solubility between 60°C and 70°C?
   55-1 Ca(C₂H₃O₂)₂·2H₂O
   55-2 NaCl
   55-3 K₂Cr₂O₇
   55-4 Na₂SO₄
   55-5 KNO₃

56. Which of the following substances could best be prepared and collected with this apparatus?
   56-1 Carbon dioxide
   56-2 Bromine
   56-3 Chlorine
   56-4 Hydrogen sulfide
   56-5 Helium

57. Suppose the apparatus were used to prepare and collect hydrogen. Which of the following might appear in the balanced equation for the reaction?
   57-1 SO₂
   57-2 2H₂SO₄
   57-3 HCl
   57-4 2ZnCl₂
   57-5 ZnCl₂

58. This apparatus should not be used to prepare gases which are
   58-1 very poisonous.
   58-2 highly soluble in water.
   58-3 explosive when mixed with oxygen.
   58-4 lighter than air.
   58-5 heavier than air.

Go on to the next page
Equal weights of anhydrous sodium hydroxide and sand are placed on the pans of a balance as shown in A. After some time, the balance has the appearance shown in B. What has happened to cause this?

59-1 The sodium hydroxide has undergone molecular rearrangement.
59-2 The sodium hydroxide has combined with the oxygen of the air.
59-3 The sodium hydroxide has absorbed water from the air.
59-4 The sand has lost moisture.
59-5 Either more sodium hydroxide must have been added or some sand must have been taken away.

Items 60 through 66 refer to the diagram above.

60. What is the name of the phenomenon illustrated above?

60-1 Efflorescence
60-2 Condensation
60-3 Sublimation
60-4 Deliquescence
60-5 Regelation

61. Suppose hydrated copper sulfate had been substituted for the sodium hydroxide. What would have been the appearance of the balance in B?

61-1 The same as that shown in B.
61-2 Opposite to that shown in B.
61-3 Evenly balanced.
61-4 It is impossible to tell.

Items 62 through 66 refer to the diagram above.

62. Which one of the following may be in the battery jar when the bulbs are lit?

62-1 Ethyl alcohol and water
62-2 Distilled water
62-3 Sodium sulfate in aqueous solution
62-4 Glucose in aqueous solution
62-5 None of the above is possible

63. Suppose the substance in the battery jar is a solution of sulfuric acid. What particles in the solution are chiefly responsible for carrying the electric current?

63-1 Electrons
63-2 Positrons
63-3 Neutrons
63-4 Protons
63-5 Mesotrons

64. What substance is given off at A when the solution in the battery jar is sulfuric acid and the bulbs are lit?

64-1 Oxygen
64-2 Hydrogen
64-3 Sulfur
64-4 Hydrogen sulfide
64-5 Nitrogen

65. The chemical changes in the solution produced at the electrodes by the passage of the electric current are referred to as

65-1 Catalysis
65-2 Electromagnetic induction
65-3 Electrophoresis
65-4 Electrolysis
65-5 Single displacement

66. Why are platinum electrodes used in apparatus of this type?

66-1 Platinum forms a protective oxide coating.
66-2 Platinum is hard.
66-3 Platinum is easily prepared in pure form.
66-4 Platinum combines good electrical conductivity with malleability.
66-5 Platinum is unreactive.
Items 67 to 71: The above apparatus is to be used to produce sulfurous acid.

67. What are the substances in flask A?
   - Na₂SO₄ + HCl
   - Na₂SO₄ + HNO₃
   - Na₂SO₃ + H₂SO₄
   - H₂SO₃ + H₂O
   - K₂SO₃ + NaOI

68. What gas collects in flask B?
   - SO
   - SO₂
   - SO₃
   - SO₄
   - S₂O

69. What might be added at X in order to protect the laboratory air from unpleasant fumes?
   - A bottle of concentrated H₂SO₄ solution
   - A bottle of concentrated NaOH solution
   - A bottle of dilute HCl solution
   - A flask of saturated NaCl solution
   - A flask of formaldehyde solution

70. Which numbered part or connection has been made or placed incorrectly?
   - 1
   - 2
   - 3
   - 4
   - 5

71. The gas that collects in bottle B is called
   - an anhydride.
   - a monatomic gas.
   - a perfect gas.
   - a sulfide.
   - an oxidizing agent.
The following group of items (74 through 79) consists of three pairs of questions. In the first question of each pair, you are to indicate the answer to the problem. In the second question of each pair, you are to indicate which principle or principles (of those listed below) you used in solving the problem.

**Principles:**
- **Charles' Law:** The volume of a gas at constant pressure varies directly as the absolute temperature.
- **Boyle's Law:** The volume of a gas at constant temperature varies inversely as the pressure.
- **Avogadro's Principle:** Equal volumes of all gases under the same conditions of temperature and pressure contain equal numbers of molecules.
- **Law of Multiple Proportions:** When two or more compounds contain the same elements, the weights of one element which are combined with a fixed weight of the others are to each other as small whole numbers.
- **Law of Definite Composition:** Equal quantities of a compound always contain the same amounts of each of the elements of which it is composed.

1. About how much water is there in 27 grams of sodium carbonate, \( \text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O} \)?
   Atomic weights: \( \text{Na} = 23, \text{C} = 12, \text{O} = 16, \text{H} = 1 \)
   - 74-1 11 grams
   - 74-2 13 grams
   - 74-3 15 grams
   - 74-4 17 grams
   - 74-5 19 grams

2. Principle or principles used in solving item 74:
   - 75-1 A and E
   - 75-2 B and D
   - 75-3 C
   - 75-4 D
   - 75-5 E

3. 10 liters of oxygen at 0°C and 15 lb per square inch pressure are subjected to 150 lb per square inch pressure at the same temperature. What is the new volume of the oxygen?
   - 76-1 1 liter
   - 76-2 2 liters
   - 76-3 3 liters
   - 76-4 10 liter
   - 76-5 1.1 liters

4. Principle or principles used in solving item 76:
   - 77-1 A, B, and D
   - 77-2 B
   - 77-3 C and D
   - 77-4 B, C, and D
   - 77-5 A, C, and E

5. How many liters of hydrogen gas, under standard conditions, react with oxygen to form 18 cc of liquid water?
   (Atomic weights: \( \text{H} = 1, \text{O} = 16 \))
   - 78-1 9
   - 78-2 2
   - 78-3 22.4
   - 78-4 8.6
   - 78-5 2.4

6. Principle or principles used in solving item 78:
   - 79-1 D
   - 79-2 A and C
   - 79-3 B and E
   - 79-4 C and D
   - 79-5 C and E

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Raw Score = Difference
Scaled Score

Number right
Subtract (See table above)

(See table on key)
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M. or F.

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

Number of semesters you have studied physics........................................

General Directions: Do not turn this page until the examiner tells you to do so. This examination requires 40 minutes of working time. The directions are printed at the beginning of the test. 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.
PART I

Directions: Each of the following incomplete statements or questions is followed by five possible answers. Select the one that is most appropriate and put its number in the parentheses at the right.

1. A lubricant acts by
   1-1 increasing mechanical advantage.
   1-2 eliminating "knock."
   1-3 increasing the efficiency of heat-radiation.
   1-4 keeping gear-teeth sharp.
   1-5 reducing friction.  1(  )

2. The efficiency of a simple machine is always less than one because of
   2-1 inertia.
   2-2 gravity.
   2-3 friction.
   2-4 tension.
   2-5 leverage.  2(  )

3. A compass needle may be used to show the direction of the current in a wire because it
   3-1 becomes magnetized by contact.
   3-2 conducts electricity in one direction only.
   3-3 always points in the same direction.
   3-4 lines up along the direction of the lines of force.
   3-5 has a low permeability.  3(  )

4. In order to avoid the danger of an accidental spark starting a fire in a truck which is transporting gasoline, it is best to
   4-1 use a Diesel instead of a gasoline engine.
   4-2 diminish friction between the moving parts of the truck.
   4-3 make the tires out of a material which is a good insulator.
   4-4 insulate the tank from the rest of the metallic parts of the truck.
   4-5 establish a connection through a conductor between the tank and ground.  4(  )

5. The height to which a column of liquid may be raised by atmospheric pressure alone depends most upon its
   5-1 density.
   5-2 mass.
   5-3 volume.
   5-4 surface tension.
   5-5 viscosity.  5(  )

6. An altimeter is a kind of
   6-1 barometer.
   6-2 hydrometer.
   6-3 thermometer.
   6-4 calorimeter.
   6-5 potentiometer.  6(  )

7. In order for two forces to produce the greatest possible acceleration of a body, they must act on the body
   7-1 in opposite directions.
   7-2 at right angles.
   7-3 as close together as possible.
   7-4 as far apart as possible.
   7-5 in the same direction.  7(  )

8. The bar shown above is made of two strips of metal, A and B; and A has a larger coefficient of linear expansion than B. When the temperature of the bar is raised it will
   8-1 bend with A on the outside.
   8-2 bend with B on the outside.
   8-3 lengthen without bending.
   8-4 shorten without bending.
   8-5 remain the same size.  8(  )

9. How many calories are necessary to raise the temperature of 100 gm of water from 10°C to 20°C?
   9-1 50
   9-2 200
   9-3 500
   9-4 1000
   9-5 2000  9(  )

10. The liter is a measure of
   10-1 density.
   10-2 weight.
   10-3 mass.
   10-4 energy.
   10-5 volume.  10(  )

11. Convection is an important method of heat transfer in
   11-1 wood.
   11-2 interplanetary space.
   11-3 iron.
   11-4 salt.
   11-5 air.  11(  )

12. What is the average power needed to raise a 1000-lb weight a distance of 55 ft in 10 seconds?
    (1 hp = 550 ft lb per sec)
    12-1 5 hp
    12-2 10 hp
    12-3 55 hp
    12-4 90 hp
    12-5 900 hp  12(  )

Go on to the next page.
13. When a stone is put into 100 cc of water in a graduated cylinder, the level of the water rises to the 140 cc mark. If the weight of the stone is known to be 100 gms, what is its specific gravity?

13-1 40
13-2 100
13-3 $2\frac{1}{2}$
13-4 $3\frac{1}{2}$
13-5 $4\frac{1}{2}$...

14. The note one octave above a note of 512 vibrations per second is of

14-1 4096 vibrations per second.
14-2 3584 vibrations per second.
14-3 2048 vibrations per second.
14-4 1024 vibrations per second.
14-5 576 vibrations per second...

15. A narrow beam of light goes from air into a glass prism at X, as shown in the diagram above. It will emerge at

15-1 A
15-2 B
15-3 C
15-4 D
15-5 E...

16. Normal body temperature is 98.6°F on the Fahrenheit scale. What is it on the centigrade scale?

16-1 20°C
16-2 28°C
16-3 37°C
16-4 47°C
16-5 58°C...

17. When a pendulum is at the highest point in its swing, its energy is

17-1 all kinetic.
17-2 evenly divided between potential and kinetic.
17-3 mostly potential.
17-4 mostly kinetic.
17-5 all potential...

18. An automobile starting from rest attains a speed of 20 miles per hour in 10 seconds. What is its average acceleration?

18-1 2 miles per second per second
18-2 2 miles per hour per second
18-3 200 miles per hour per hour
18-4 $3\frac{1}{3}$ miles per second per second
18-5 $3\frac{1}{3}$ miles per hour per second...

19. Which is the best conductor of heat?

19-1 Copper sulfate
19-2 Copper
19-3 Water
19-4 Air
19-5 Alcohol...

20. In which of the following containers of water, if any, is the pressure at the bottom greatest?

20-1

20-2

20-3

20-4

20-5 All have the same pressure on the bottom...

21. It is desirable to use only the portion of a lens near its center in order to reduce

21-1 spherical aberration.
21-2 definition.
21-3 astigmatism.
21-4 diffraction.
21-5 refraction...

22. What force is necessary to keep a 240-lb barrel from rolling down an inclined plane that is 12 ft long and 4 ft high? (Ignore friction.)

22-1 20 lb
22-2 40 lb
22-3 60 lb
22-4 80 lb
22-5 120 lb...

23. A wire carrying a current is passed perpendicularly through a piece of paper. Iron filings sprinkled on the paper will be arranged into

23-1 curved lines radiating out from the wire.
23-2 straight lines radiating out from the wire.
23-3 circles with the wire at the center.
23-4 the same sort of lines that are given by two like poles.
23-5 the same sort of lines that are given by two unlike poles...

Go on to the next page.
24. As the air temperature increases, the speed of sound in air
   24-1 increases.
   24-2 decreases.
   24-3 first increases and then decreases.
   24-4 first decreases and then increases.
   24-5 remains the same.

25. What is the largest weight that can be lifted by a 100-lb force using the pulley system shown above?
   25-1 200 lb
   25-2 300 lb
   25-3 350 lb
   25-4 400 lb
   25-5 600 lb

26. What condition must exist for Boyle's law, PV = R, to hold?
   26-1 Constant pressure
   26-2 Constant volume
   26-3 Constant density
   26-4 Constant rate of expansion
   26-5 Constant temperature

27. When the absolute temperature of a gas is doubled and the pressure remains the same, the volume is multiplied by
   27-1 1
   27-2 2
   27-3 \( \frac{1}{2} \)
   27-4 4
   27-5 \( \frac{1}{4} \)

28. An object that weighs 500 grams weighs about
   28-1 1 lb
   28-2 2 lb
   28-3 3 lb
   28-4 4 lb
   28-5 5 lb

29. The gas which makes up the greatest part by weight of the atmosphere is
   29-1 oxygen.
   29-2 carbon dioxide.
   29-3 nitrogen.
   29-4 water vapor.
   29-5 argon.

30. An object 1 cm tall is 30 cm from a lens and its image is 10 cm from the lens. How tall is the image?
   30-1 1 cm
   30-2 3 cm
   30-3 .11 cm
   30-4 .33 cm
   30-5 .9 cm

31. A piece of metal in a cold room feels colder than a piece of wood in the same room because the metal
   31-1 has a lower specific heat.
   31-2 has a higher specific heat.
   31-3 is at a higher temperature.
   31-4 is a better radiator of heat.
   31-5 is a better conductor of heat.

32. The time taken by a pendulum for one complete vibration is called its
   32-1 amplitude.
   32-2 frequency.
   32-3 period.
   32-4 fundamental.
   32-5 time-constant.

33. As the armature of an electric motor rotates, it develops
   33-1 a steady current.
   33-2 an emf which opposes the applied emf.
   33-3 a constantly increasing resistance.
   33-4 an emf which aids the applied emf.
   33-5 a current in the same direction as the applied current.

34. The focal length of a convex lens is 15 cm. An object is 15 cm from the lens. The image of the object is
   34-1 at infinity.
   34-2 15 cm from the lens.
   34-3 7.5 cm from the lens.
   34-4 30 cm from the lens.
   34-5 60 cm from the lens.

35. When an automobile travels 30 miles an hour, the shortest distance in which it can be brought to a stop is 40 ft. What is the shortest distance in which it can be stopped when it travels 60 miles per hour?
   35-1 160 ft
   35-2 130 ft
   35-3 100 ft
   35-4 80 ft
   35-5 70 ft

36. Which is the most fundamental difference between a voltmeter and an ammeter?
   36-1 An ammeter responds only to current; a voltmeter, to voltage.
   36-2 A voltmeter has a shunt; an ammeter, a series resistance.
   36-3 An ammeter has a shunt; a voltmeter, a series resistance.
   36-4 An ammeter is a kind of galvanometer; a voltmeter, a potentiometer.
   36-5 A voltmeter is a kind of galvanometer; an ammeter, a potentiometer.

Go on to the next page.
37. A piece of ice at $-100^\circ$C is heated until it exists as steam at $+200^\circ$C. Most of the heat used is needed to
37-1 raise the temperature of the ice to $0^\circ$C.
37-2 melt the ice.
37-3 raise the temperature of the water to $100^\circ$C.
37-4 boil the water.
37-5 raise the temperature of the steam to $200^\circ$C. ....... 37

38. Two copper wires are the same length but one is twice the diameter of the other. The resistance of the thicker wire is to that of the thinner as
38-1 1:2
38-2 1:4
38-3 1:1
38-4 2:1
38-5 4:1 ......... 38

39. At which temperature will a quantity of air with a fixed weight of water vapor in it have the lowest relative humidity?
39-1 $0^\circ$C
39-2 $10^\circ$C
39-3 $20^\circ$C
39-4 $30^\circ$C
39-5 The relative humidity will be the same at all temperatures. 39

40. A man weighing 250 lb climbed on a raft 8 ft by 6 ft by 1 ft which was half submerged in fresh water. How much deeper did the raft sink because of the man's weight? (Density of water equals 62.4 lb/ft$^3$)
40-1 1 inch
40-2 2 inches
40-3 3 inches
40-4 4 inches
40-5 5 inches. ......... 40

PART II

Directions: Continue as in the preceding part.

41. The rate of evaporation of a liquid may be increased by
41-1 increasing the pressure over it.
41-2 increasing the concentration of its vapor.
41-3 raising its temperature.
41-4 decreasing its surface area.
41-5 dissolving a salt in it. ..... 41

42. Alcohol is used in thermometers which measure low temperatures because alcohol has a low
42-1 freezing point.
42-2 density.
42-3 viscosity.
42-4 boiling point.
42-5 coefficient of thermal expansion. 42

43. The sound of a tuning fork is amplified by holding it near a closed pipe of proper length. The name given to this phenomenon is
43-1 resonance.
43-2 beats.
43-3 vibration.
43-4 attenuation.
43-5 harmony. ......... 43

44. When the temperature of a confined gas is raised, the molecules show
44-1 an increase in mass.
44-2 an increase in speed.
44-3 an increase in density.
44-4 a decrease in density.
44-5 a decrease in the average distance between them. .... 44

45. The secondary of an induction coil has one hundred times as many turns as the primary. The voltage across the secondary is to the voltage across the primary approximately as
45-1 1:1
45-2 10:1
45-3 100:1
45-4 10,000:1
45-5 1:10. ......... 45

46. A pillow weighing 2 lb, when dropped from a tower, will fall more slowly than a stone weighing 4 lb because
46-1 the pull of gravity is twice as great on the stone.
46-2 the force of gravity is concentrated over a smaller area on the stone.
46-3 the pillow has a smaller mass.
46-4 the pillow is retarded more by air resistance.
46-5 the pillow has a smaller density. 46

47. Which one of the following is an instrument used to detect static electricity?
47-1 A galvanometer
47-2 An electrophorus
47-3 An ammeter
47-4 An electroscope
47-5 A dipping needle. .... 47

Go on to the next page.
48. A flat iron passes a current of 6 amperes on a 100-volt line. The power consumed in the flat iron is
48-1 260 watts
48-2 300 watts
48-3 600 watts
48-4 3600 watts
48-5 6 watts 48( )

49. In a sound wave, the number of wave fronts that pass a given point in one second is called the
49-1 amplitude.
49-2 frequency.
49-3 period.
49-4 wave-length.
49-5 velocity 49( )

50. White light is dispersed into colors when it passes through a glass prism because light waves
50-1 are transverse waves.
50-2 are longitudinal waves.
50-3 of different frequencies travel at different speeds in glass.
50-4 are reflected according to the law of reflection.
50-5 in the visible region are poorly absorbed by glass. 50( )

51. Both the lift pump and the force pump depend, for their operation, mainly on
51-1 atmospheric pressure.
51-2 the surface tension of water.
51-3 the tenacity of water.
51-4 Pascal's principle.
51-5 Archimedes' principle. 51( )

52. A stone weighing 2 lb is thrown straight up with a kinetic energy of 32 ft lb. How high will it rise?
52-1 8 ft
52-2 16 ft
52-3 32 ft
52-4 64 ft
52-5 128 ft 52( )

Questions 53 through 57 refer to the figure above, which represents the electric circuit in a small apartment. Assume that the resistance of the wires and fuse is negligible.

53. Which of the following devices draws the largest total current when in operation?
53-1 Lamp L1
53-2 Lamp L2
53-3 Lamp L3
53-4 The toaster 53( )

54. The current through lamp L1 is
54-1 \( \frac{11}{3} \) amperes
54-2 \( \frac{11}{9} \) amperes
54-3 \( \frac{9}{11} \) amperes
54-4 \( \frac{3}{11} \) amperes
54-5 \( \frac{11}{27} \) amperes 54( )

55. Wire AB is probably made of
55-1 aluminum.
55-2 nickel.
55-3 iron.
55-4 lead.
55-5 copper. 55( )

56. When the current through CD becomes too great for safety, it is important that the fuse
56-1 melt.
56-2 decrease its resistance.
56-3 be replaced by a copper coin.
56-4 harden.
56-5 spark. 56( )

57. A substance of very low heat conductivity is used in the
57-1 lamp filaments.
57-2 refrigerator walls.
57-3 toaster coils.
57-4 connecting wires.
57-5 contacts. 57( )

Go on to the next page.
58. As a sound wave travels out from its source, which of the following is most likely to diminish?
   58-1 Its period
   58-2 Its fundamental frequency
   58-3 Its amplitude
   58-4 The frequencies of its harmonics
   58-5 Its velocity

59. Which of the following substances, all at the same volume at 0°C, will occupy the largest volume at 50°C, assuming constant pressure?
   59-1 Water
   59-2 Steel
   59-3 Glass
   59-4 Air
   59-5 Kerosene

60. The image formed by the lens of the human eye is
   60-1 virtual and erect.
   60-2 real and erect.
   60-3 virtual and inverted.
   60-4 real and inverted.

61. What are the units in which specific gravity may be expressed?
   61-1 Pounds per cubic foot
   61-2 Pounds per square foot
   61-3 Foot pounds per second per second
   61-4 Feet per second per second
   61-5 No units

62. The automobile carburetor is used to change a
   62-1 vapor to a gas.
   62-2 vapor to a liquid.
   62-3 liquid to a vapor.
   62-4 gas to a liquid.
   62-5 gas to a vapor.

63. When a note of 50 cycles per second and another of 52 cycles per second are sounded simultaneously, the number of beats per second is
   63-1 1
   63-2 2
   63-3 4
   63-4 51
   63-5 102

64. A sound is heard 5 seconds after it is produced. The distance between the observer and the source is about
   64-1 1 mile
   64-2 2 miles
   64-3 1 1/2 miles
   64-4 1 1/2 miles
   64-5 2 1/2 miles

65. When the distance of a lamp from a surface is changed from 2 feet to 8 feet, the intensity of illumination at the surface due to the lamp is multiplied by
   65-1 1/16
   65-2 1/12
   65-3 1/8
   65-4 1/4
   65-5 1/5

66. What does a moment of force have in common with work?
   66-1 They both involve the use of energy.
   66-2 They are both expressed in the same units.
   66-3 They are both products of force and distance.
   66-4 Neither concept enters into the calculation of rotational acceleration.
   66-5 Both involve the idea of mass.

67. A rheostat is a
   67-1 tuning condenser.
   67-2 high resistance.
   67-3 kind of transformer.
   67-4 voltage divider.
   67-5 variable resistance.

68. The operation of a dynamo depends on the principle that a conductor
   68-1 placed in a magnetic field moves toward the north pole.
   68-2 moving parallel to a magnetic field has a current developed through it.
   68-3 moves back and forth in a magnetic field.
   68-4 placed in a magnetic field, changes magnetic energy into electrical energy.
   68-5 moving at right angles to a magnetic field has an emf developed across it.

69. A fluorescent lamp is more efficient than an incandescent lamp because the fluorescent lamp
   69-1 changes less electrical energy to heat energy.
   69-2 gives a brighter light.
   69-3 gives a whiter light.
   69-4 concentrates its radiation in the infra-red.
   69-5 has a continuous spectrum.

Go on to the next page.
70. Heat is extracted in a mechanical refrigerator by
   70-1 compression of a vapor.
   70-2 vaporization of a liquid.
   70-3 condensation of a gas.
   70-4 melting of a solid.
   70-5 freezing of a liquid. . . . . . . 70(  )

71. An important difference between a Diesel engine and a gasoline engine is that the Diesel engine
   71-1 uses alcohol as fuel.
   71-2 can operate as a two-cycle engine only.
   71-3 has no carburetor.
   71-4 is air-cooled.
   71-5 is more powerful. . . . . . . . 71(  )

72. A dyne is a unit of
   72-1 work.
   72-2 pressure.
   72-3 acceleration.
   72-4 force.
   72-5 length. . . . . . . . . . . . 72(  )

73. About how many ounces are there in a kilogram?
   73-1 35
   73-2 32
   73-3 30
   73-4 27
   73-5 25 . . . . . . . . . . . . . . . . 73(  )

74. Which of the following gives a bright-line spectrum?
   74-1 An incandescent liquid
   74-2 An incandescent solid
   74-3 A cool gas which absorbs part of a continuous spectrum
   74-4 A luminous gas
   74-5 An incandescent mixture . . . 74(  )

75. Why is it that a hydrometer can be used to test the condition of a lead-acid storage cell?
   75-1 Water combines with lead as the battery is used.
   75-2 Water evaporates as the battery is used.
   75-3 Sulfuric acid enters the solution as the battery is used.
   75-4 Sulfuric acid combines with water as the battery is used.
   75-5 Sulfuric acid combines with lead as the battery is used. . . . . . . . . . 75(  )

76. With which one of the levers shown below could a 100-lb weight be lifted with the smallest effort force?
   76-1
   76-2
   76-3
   76-4
   76-5 . . . . . . . . . . . . . . . . . 76(  )

77. A shell is fired from a gun at an angle of 45° with the horizontal. What is the direction of the acceleration of the shell after it leaves the gun? (Ignore air resistance.)
   77-1 In the direction of flight of the shell
   77-2 Vertically downward
   77-3 Opposite to the direction of the flight of the shell
   77-4 Horizontally forward
   77-5 Horizontally backward . . . . 77(  )

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School........................................ City........................ Sex .... M. or F.
Title of the science course you are now taking (for example: General Science) ....................... 

Teacher........................................

General Directions: Do not turn this page until the examiner tells you to do so. This examination consists of three parts, and requires 80 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 a part when the time is up, stop work on that part and proceed at once to the next part. If you finish the last part before the time is up, you may go back and work on any part. No questions may be asked after the examination has begun.

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15 Amsterdam Avenue, New York 23, N. Y.
PART I
INFORMATIONAL BACKGROUND  
(40 minutes)

Directions: Each of the questions or incomplete statements below is followed by five choices. Select the one that best completes the statement or answers the question, and put its number in the parentheses at the right.

1. A man watching the stars notices that stars which were just rising six hours ago are now directly overhead. This effect is caused by the
   1-1 rotation of the earth on its axis.
   1-2 vast speed of the stars in distant space.
   1-3 revolution of the moon about the earth.
   1-4 motion of the sun among the stars.
   1-5 turning of the stars around the sun as a center. 1( )

2. Discoveries that are announced by scientists are likely to be true because
   2-1 scientists are educated people.
   2-2 the discoveries are usually based on careful experiments.
   2-3 the discoveries are based on natural laws.
   2-4 scientists rarely make mistakes.
   2-5 scientists know what they are trying to discover 2( )

3. It is believed that dinosaurs lost out in their struggle for existence chiefly because
   3-1 they were killed by man for food.
   3-2 man could not tame them.
   3-3 they were not adapted to changes that took place in the earth's surface and climate.
   3-4 they were not fitted to eat plant food.
   3-5 they had no brains. 3( )

4. Which of the following would tend to increase in number most rapidly if all owls in a locality were killed?
   4-1 Field mice
   4-2 Robins
   4-3 Groundhogs
   4-4 Wild ducks
   4-5 Quail 4( )

5. Which one of the following animals can most easily change his surroundings to fit his needs?
   5-1 A whale
   5-2 A gorilla
   5-3 An elephant
   5-4 A man
   5-5 A horse 5( )

6. The moon exerts a very important influence on
   6-1 the tides.
   6-2 changes in weather.
   6-3 crops.
   6-4 the relative lengths of day and night.
   6-5 climate. 6( )

7. The caloric rating of food refers specifically to the
   7-1 vitamin content.
   7-2 mineral content.
   7-3 heat energy released by burning the food.
   7-4 dry weight.
   7-5 amount of protoplasm it will build. 7( )

8. Most of the energy used by power plants at Niagara Falls is obtained from water by
   8-1 evaporating the water.
   8-2 distilling the water.
   8-3 changing the water chemically.
   8-4 making use of the force the water exerts in falling.
   8-5 taking electricity from the water. 8( )

9. Soft coal heated to a high temperature in the absence of air will yield
   9-1 coke.
   9-2 petroleum.
   9-3 marble.
   9-4 lime.
   9-5 sodium bicarbonate. 9( )

10. A blast furnace is used to
    10-1 extract aluminum from its ore.
    10-2 extract iron from its ore.
    10-3 extract gasoline from petroleum.
    10-4 produce natural gas.
    10-5 produce coal gas. 10( )

11. The planet which takes the longest time to revolve around the sun is
    11-1 the earth.
    11-2 Mercury.
    11-3 Venus.
    11-4 Mars.
    11-5 Pluto 11( )

12. Through the entire atmosphere, as one gets farther away from the surface of the earth, the atmosphere
    12-1 becomes denser.
    12-2 becomes less dense.
    12-3 changes continuously in chemical composition.
    12-4 becomes bluer in color.
    12-5 increases steadily in temperature. 12( )

13. Fresh water will boil at about
    13-1 32° Fahrenheit.
    13-2 68° Fahrenheit.
    13-3 132° Fahrenheit.
    13-4 150° Fahrenheit.
    13-5 212° Fahrenheit. 13( )

Go on to the next page.
1. What may cause the bulging and breaking of a concrete highway on a hot summer day?
   14-1 Contraction of the concrete
   14-2 Expansion of the roadbed
   14-3 Chemical changes in the concrete
   14-4 Expansion of the concrete
   14-5 Contraction of the roadbed

2. Which of these characteristics is probably least determined by heredity in normal human beings?
   15-1 Hair color
   15-2 Skin color
   15-3 Blood type
   15-4 Eye color
   15-5 Intelligence

3. In going from Seattle, Washington, to Miami, Florida, a traveler crosses
   16-1 lines of latitude only.
   16-2 lines of longitude only.
   16-3 lines of latitude and longitude.
   16-4 the prime meridian.
   16-5 the International Date Line

4. Which of these recommendations should not be followed if a patient has symptoms of appendicitis?
   17-1 Apply a cold application to the abdomen.
   17-2 Administer laxatives.
   17-3 Call a doctor.
   17-4 Give the patient a drink of water.
   17-5 Keep the patient inactive

5. It is impossible to hear a bell ringing in a vacuum because
   18-1 there is no material in the vacuum in which sound waves can exist.
   18-2 the vacuum acts as a sound conductor.
   18-3 the clapper gives up kinetic energy to the vacuum.
   18-4 the vacuum decreases the pitch of the bell.
   18-5 the vacuum increases the pitch of the bell

6. Which of the following move through a wire when a current of electricity flows in the wire?
   19-1 Atoms
   19-2 Neutrons
   19-3 Protons
   19-4 Electrons
   19-5 Molecules

7. How many high tides are there at a point on the ocean shore during a 24-hour period?
   20-1 One
   20-2 Two
   20-3 Three
   20-4 Four
   20-5 The correct answer is not given

21. A certain machine is said to be 50 per cent efficient. What does this mean?
   21-1 The machine is not adequate for the task performed.
   21-2 The machine operates at maximum efficiency only 50 per cent of the time.
   21-3 Only half of the work put into the machine is used up.
   21-4 Half of the energy put into the machine is destroyed.
   21-5 Only half of the work put into the machine is returned as useful work done

22. Which of the following gases makes up a higher percentage of the atmosphere around industrial cities than in rural areas?
   22-1 Oxygen
   22-2 Helium
   22-3 Nitrogen
   22-4 Argon
   22-5 Carbon dioxide

23. Which of the following fish may be affected most by the further development of large dams in the rivers of northwestern states?
   23-1 Brook trout
   23-2 Tuna
   23-3 Salmon
   23-4 Sea bass
   23-5 Black bass

24. The most practical method used so far to conserve the coal and oil supplies of the country is the
   24-1 building of engines run by the sun's rays.
   24-2 harnessing of the tides to make electricity.
   24-3 substitution of lumber for coal and oil.
   24-4 construction of dams for the production of hydroelectric power.
   24-5 production of energy by atom smashers

25. When saturated air is cooled, it
   25-1 takes up more moisture.
   25-2 loses moisture.
   25-3 loses weight.
   25-4 increases in volume.
   25-5 rises to a higher level

26. In the motor of an automobile, the gasoline in the cylinders is ignited by
   26-1 a tiny gas flame.
   26-2 spontaneous combustion.
   26-3 an electric spark.
   26-4 the heat of the engine.
   26-5 the pressure in the cylinder

27. During which two phases of the moon does the sun help to cause unusually high tides?
   27-1 New moon and full moon
   27-2 New moon and third quarter
   27-3 First quarter and second quarter
   27-4 First quarter and full moon
   27-5 Second quarter and half-moon

Go on to the next page.
28. The gypsy moth and the Japanese beetle are especially destructive to
   28-1 clothes.
   28-2 ragweed.
   28-3 cotton plants.
   28-4 wooden buildings.
   28-5 trees.

29. The approximate pressure of air at sea level, expressed in inches of mercury, is
   29-1 10
   29-2 20
   29-3 30
   29-4 40
   29-5 50.

30. The chief difference between the highest note and the lowest note on a piano is that
    the high note
    30-1 is always a louder sound.
    30-2 is always a softer sound.
    30-3 has more vibrations per second.
    30-4 has fewer vibrations per second.
    30-5 is a sound that travels faster.

31. Molecules of steam differ from those of ice in that the molecules of steam
    31-1 move more slowly.
    31-2 are smaller.
    31-3 contain less energy.
    31-4 are closer together.
    31-5 are farther apart.

32. Which of the following men is famous for his work in plant breeding?
   32-1 Burbank
   32-2 Harvey
   32-3 Darwin
   32-4 Pasteur
   32-5 Morgan

33. The planet Mercury differs from the earth in that Mercury
    33-1 is larger.
    33-2 revolves around the sun.
    33-3 rotates on its axis.
    33-4 is smaller.
    33-5 reflects light.

34. Many insects have a series of tiny openings around the sides of the abdomen. These
    are used for
    34-1 seeing.
    34-2 hearing.
    34-3 smelling.
    34-4 breathing.
    34-5 laying eggs.

35. Topsoil is changing in most farming regions by
    35-1 becoming shallower.
    35-2 becoming deeper.
    35-3 increasing in mineral content.
    35-4 increasing in water-holding capacity.
    35-5 increasing in humus content.

36. The fact that a man has a low-pitched voice indicates that his vocal cords
    36-1 are short and thin.
    36-2 are tightly stretched.
    36-3 do not vibrate rapidly.
    36-4 vibrate rapidly.
    36-5 vibrate uniformly.

37. The immediate source of the water which forms dew on grass during some summer
    evenings is
    37-1 the air.
    37-2 the soil.
    37-3 the grass.
    37-4 low fog.
    37-5 clouds.

38. Which of the following substances has the highest boiling point?
   38-1 Ether
   38-2 Alcohol
   38-3 Gasoline
   38-4 Water
   38-5 Mercury

39. The white chalk cliffs at Dover, England, are made of
   39-1 granite.
   39-2 sandstone.
   39-3 shale.
   39-4 limestone.
   39-5 slate.

40. When samples of wool and cotton are boiled in lye solution, it is observed that the wool
    dissolves and the cotton is unaffected. This experiment is important because it
    40-1 shows that cotton will not be injured if lye is spilled on it.
    40-2 shows that cotton is stronger than wool.
    40-3 enables one to determine whether a given sample of cloth is cotton or wool.
    40-4 shows that wool is obtained from animals.
    40-5 shows that wool is warmer than cotton.

41. Which of the following statements about the color of ordinary sunlight is true?
   41-1 It is yellow in color.
   41-2 It is orange in color.
   41-3 Nothing is known about its color.
   41-4 It has no color.
   41-5 It contains all the colors.

42. One important function of man's skin is to aid in the
    42-1 digestion of food.
    42-2 storage of food.
    42-3 absorption of air into the body.
    42-4 regulation of body temperature.
    42-5 elimination of bacteria from the blood.
1. Why do cavities in teeth enlarge rapidly when bacteria act on sugar which is lodged in the cavities?
   43-1 Acids formed by bacteria dissolve calcium salts.
   43-2 Toxins formed by bacteria soften teeth.
   43-3 Bacteria also digest calcium salts.
   43-4 Enzymes formed by bacteria dissolve calcium salts.
   43-5 Alcohol formed during sugar digestion dissolves calcium salts.

2. What happens to a lighted match when it is thrust into a bottle of pure oxygen?
   44-1 It explodes.
   44-2 It goes out.
   44-3 It ignites the oxygen.
   44-4 It burns very slowly.
   44-5 It burns more rapidly.

3. Fair weather clouds that have flat bases and rounded tops are called
   45-1 stratus.
   45-2 nimbus.
   45-3 cumulo-nimbus.
   45-4 cumulus.
   45-5 cirrus.

4. Capillaries connect large vessels of the
   46-1 circulatory system.
   46-2 excretory system.
   46-3 muscular system.
   46-4 nervous system.
   46-5 digestive system.

5. The energy in coal originally came from
   47-1 the air.
   47-2 the sun.
   47-3 boiling water.
   47-4 petroleum.
   47-5 the interior of the earth.

6. A boat is to be pulled out of the water onto the beach on a set of rollers. Before the amount of work required for this operation can be determined, it is necessary to know
   48-1 only the distance the boat is to be moved along the beach.
   48-2 the volume of the boat and the distance it is to be moved.
   48-3 the force required to move the boat and the distance it is to be moved.
   48-4 the shape and size of the boat.
   48-5 the weight of the boat and the diameter of the rollers.

7. A magnet will lose its magnetism if it is
   49-1 dipped in water.
   49-2 pointed toward the north pole of the earth.
   49-3 hammered.
   49-4 brought near a compass.
   49-5 brought near a piece of metal.

8. Which one of the following is operated by air under high pressure?
   50-1 Gasoline engine
   50-2 Typewriter
   50-3 Pneumatic drill
   50-4 Fountain pen
   50-5 Medicine dropper

9. The function of the valves in wind musical instruments is to
   51-1 control the loudness of the sounds produced.
   51-2 keep the length of air columns from changing.
   51-3 keep air columns from vibrating.
   51-4 make air columns vibrate.
   51-5 change the length of vibrating air columns.

10. One reason why air rises over a midwestern lake on summer evenings is that the air
    52-1 contains little water vapor.
    52-2 contains much water vapor.
    52-3 is colder than surrounding air.
    52-4 is warmer than surrounding air.
    52-5 does not change in temperature as rapidly as the water.

11. Lean meat is important in the diet of people who engage in strenuous physical labor because it
    53-1 contains much protein.
    53-2 releases more heat energy than fats.
    53-3 releases more heat energy than carbohydrates.
    53-4 contains essential vitamins.
    53-5 contains bone-building minerals.

12. Many of the small motors used in refrigerators and washing machines are rated at one-fourth horsepower. How many footpounds of work can such a motor do in one minute?
    54-1 550
    54-2 8,250
    54-3 11,500
    54-4 22,250
    54-5 33,000

13. Which of the following is most important in determining the amount of silt a river can carry?
    55-1 Rate of water flow
    55-2 Depth of the river
    55-3 Width of the river
    55-4 Length of the river
    55-5 Volume of water

14. Which of the following has the greatest density?
    56-1 Water
    56-2 Gasoline
    56-3 Cork
    56-4 Aluminum
    56-5 Mercury

Go on to the next page.
57. A reddish-brown deposit left in a container from which water has evaporated indicates that the water most likely contained dissolved
57-1 sodium chloride.
57-2 limestone.
57-3 iron compounds.
57-4 phosphorus compounds.
57-5 nitrates. 57( )

58. Planets differ from stars in that the planets are
58-1 visible because of incandescent solids.
58-2 fixed in space.
58-3 visible because of reflected light.
58-4 larger.
58-5 visible because of hot gases. 58( )

59. Limestone is made up of calcium carbonate which will not dissolve in alkaline water. The fact that ground water does dissolve some calcium carbonate indicates that ground water contains some
59-1 alkali.
59-2 minerals.
59-3 enzymes.
59-4 acid.
59-5 salts. 59( )

60. When it is 10:00 p.m. in Portland, Oregon, what time is it in New York City? (Assume standard time in both cities.)
60-1 1 a.m.
60-2 2 a.m.
60-3 7 p.m.
60-4 8 p.m.
60-5 12 p.m. 60( )

61. It does not get dark immediately after the sun sets in the evening because
61-1 some light is absorbed by the earth.
61-2 light is reflected from dust in the atmosphere.
61-3 light is reflected from parts of the earth on which the sun is shining.
61-4 luminous bodies on the earth give off light.
61-5 light rays are bent by the clouds. 61( )

62. A warm air current, saturated with moisture, rising into a cold level of air would be likely to form
62-1 dew.
62-2 frost.
62-3 a cloud.
62-4 clear weather conditions.
62-5 an area of high visibility. 62( )

63. In the United States, days and nights are of approximately equal length on
63-1 March 21 and December 21.
63-2 March 21 and June 21.
63-3 June 21 and September 21.
63-4 March 21 and September 21.
63-5 September 21 and December 21. 63( )

64. Which of the following planets has its orbit within the orbit of the earth?
64-1 Saturn
64-2 Jupiter
64-3 Uranus
64-4 Neptune
64-5 Venus. 64( )

65. The body temperature of cold-blooded animals is
65-1 always lower than that of their surroundings.
65-2 nearly the same as that of their surroundings.
65-3 constant.
65-4 always lower than that of warm-blooded animals.
65-5 dependent upon the amount of food they obtain. 65( )

66. A molecule of water may be separated into its elements by
66-1 violent boiling.
66-2 evaporation.
66-3 a magnetic field.
66-4 freezing temperatures.
66-5 a direct current of electricity. 66( )

67. When light rays pass from air into water, they are
67-1 bent.
67-2 stopped.
67-3 speeded up.
67-4 not affected.
67-5 made stronger. 67( )

68. Deciduous trees should be transplanted in early spring or in the fall because at these times
68-1 trees need very little water.
68-2 it is not necessary to be very careful about packing the roots or trimming the branches.
68-3 the sap is found mostly in the main trunk or larger roots.
68-4 there is little demand on the tree for growth.
68-5 the cool weather prevents the tree from dying. 68( )

69. The raw materials used by green plants in the manufacture of carbohydrates are
69-1 minerals and water.
69-2 sunlight and water.
69-3 oxygen and water.
69-4 carbon dioxide and water.
69-5 sunlight and carbon dioxide. 69( )

70. Birds that catch insects in flight have beaks that are
70-1 curved and sharp.
70-2 long and narrow.
70-3 long and thick.
70-4 short and thick.
70-5 short and wide. 70( )

Go on to the next page.
1. What gas makes up the major part of the earth's atmosphere?
   71-1 Water vapor
   71-2 Oxygen
   71-3 Carbon dioxide
   71-4 Nitrogen
   71-5 Hydrogen

2. Which of the following would be true if the earth’s axis were perpendicular to the plane of the earth’s orbit?
   72-1 Seasonal changes in temperature would be greater.
   72-2 Seasonal changes in temperature would be less.
   72-3 Days and nights would vary more widely in length during different seasons.
   72-4 Winters would be longer in all regions.
   72-5 Summers would be longer in all regions.

73. The material used in fuses must
   73-1 contain copper.
   73-2 have a high melting point.
   73-3 have a low melting point.
   73-4 have high electrical resistance.
   73-5 contain silver.

74. Food often seems tasteless when one has a cold because the
   74-1 saliva does not flow easily.
   74-2 sense of smell is impaired.
   74-3 flow of saliva is increased.
   74-4 Eustachian tube is clogged.
   74-5 tongue is coated with a white substance.

75. Which one of the following men first worked with microscopes?
   75-1 Leeuwenhoek
   75-2 Audubon
   75-3 Hooke
   75-4 Jenner
   75-5 Linnaeus

Go on to the next part.
PART H

TERMS AND CONCEPTS

(15 minutes)

Directions: Continue as in the preceding part.

1. At certain times the moon comes in front of the sun and cuts off the sunlight. This effect is called
   1-1 a transit.
   1-2 an eclipse.
   1-3 a penumbra.
   1-4 a sunspot.
   1-5 a solar prominence. 

2. The instrument used to look at and study the surface of the moon and the planets is the
   2-1 galvanoscope.
   2-2 microscope.
   2-3 telescope.
   2-4 electroscope.
   2-5 radiometer. 

3. Desert land lacks the moisture necessary for the growth of crops. Such areas could be made productive by
   3-1 cultivation.
   3-2 fertilization.
   3-3 erosion.
   3-4 irrigation.
   3-5 flood control. 

4. Which of the following instruments shows wind direction?
   4-1 An anemometer
   4-2 A weather vane
   4-3 A thermograph
   4-4 A barometer
   4-5 A hygrometer 

5. A man who claims to be able to cure all diseases with a single medicine is evidently a
   5-1 druggist.
   5-2 reputable physician.
   5-3 quack.
   5-4 research scientist.
   5-5 surgeon. 

6. The path of a planet, moon, or comet is also known as its
   6-1 diameter.
   6-2 radius.
   6-3 circumference.
   6-4 orbit.
   6-5 speed. 

7. When the E string on a violin is tightened, the
   7-1 pitch is raised.
   7-2 pitch is lowered.
   7-3 intensity is increased.
   7-4 intensity is decreased.
   7-5 overtones are improved. 

8. The most destructive type of local storm is usually
   8-1 a cyclone.
   8-2 an anti-cyclone.
   8-3 a whirlwind.
   8-4 a thunderstorm.
   8-5 a tornado. 

9. Fuels will not begin to burn unless they are heated to the
   9-1 critical temperature.
   9-2 kindling temperature.
   9-3 melting point.
   9-4 reduction temperature.
   9-5 boiling point. 

10. One end of a magnetized soft-iron rod is definitely known to be a north pole. How many other magnetic poles are there on the same rod?
    10-1 One
    10-2 Two
    10-3 Three
    10-4 Four
    10-5 Five 

11. An instrument which measures changes in atmospheric pressure is called a
    11-1 thermometer.
    11-2 calorimeter.
    11-3 pressure gauge.
    11-4 hygrometer.
    11-5 barometer. 

12. Pasteurizing milk is a process which kills
    12-1 the bacteria that cause souring.
    12-2 certain bacteria that may cause disease.
    12-3 all the bacteria present.
    12-4 the bacterial spores.
    12-5 all the organisms present. 

13. If two plants of the same species but of different varieties are mated, the offspring are called
    13-1 mongrels.
    13-2 sports.
    13-3 biennials.
    13-4 lentils.
    13-5 hybrids. 

14. The thyroid is a gland located in the
    14-1 skull.
    14-2 neck.
    14-3 chest.
    14-4 abdomen.
    14-5 pelvis. 

Go on to the next page.
5. One way of removing impurities from water is by passing it through sand. This process is called
   15-1 aeration.
   15-2 sedimentation.
   15-3 centrifugation.
   15-4 filtration.
   15-5 sanding.  

6. What are vertebrae?
   16-1 Bones that compose the spinal column
   16-2 Nervous systems of higher animals
   16-3 Animals having a backbone
   16-4 The lower ribs
   16-5 Worm-like animals  

7. The energy necessary for photosynthesis in green plants comes from the
   17-1 cells.
   17-2 air.
   17-3 soil.
   17-4 chlorophyll.
   17-5 sun.  

8. A liquid in which the molecules of one substance are uniformly distributed among the molecules of another substance is called a
   18-1 suspension.
   18-2 sediment.
   18-3 solution.
   18-4 solute.
   18-5 solvent.  

9. Lines on a daily weather map that are drawn through the locations of the weather stations reporting the same atmospheric pressure for the day are called
   19-1 graph lines.
   19-2 isotherms.
   19-3 isobars.
   19-4 barographs.
   19-5 thermographs.  

10. What is the gas with which so-called “soft drinks” are charged?
    20-1 Carbon monoxide
    20-2 Carbon dioxide
    20-3 Nitrogen
    20-4 Water vapor
    20-5 Hydrogen  

11. An artery is most accurately defined as a blood vessel carrying
    21-1 blood away from the heart.
    21-2 blood to the heart.
    21-3 pure blood.
    21-4 impure blood.
    21-5 red blood.  

12. A door knob is an example of a simple machine known as
    22-1 a pulley.
    22-2 a screw.
    22-3 an inclined plane.
    22-4 a wheel and axle.
    22-5 a Pelton wheel.  

13. Heat energy is changed to the energy of motion by
    23-1 a flywheel.
    23-2 a water turbine.
    23-3 a storage battery.
    23-4 an electric motor.
    23-5 a steam engine.  

14. Which of the following is a form of organic matter?
    24-1 Wood
    24-2 Iron
    24-3 Water
    24-4 Limestone
    24-5 Cement  

15. An opaque body is one which
    25-1 is colored.
    25-2 is colorless.
    25-3 allows no light to pass through.
    25-4 allows some light to pass through.
    25-5 allows all light to pass through.  

16. Which of the following foods is most likely to contain large numbers of disease-causing bacteria?
    26-1 Raw milk
    26-2 Potato
    26-3 Lettuce
    26-4 Poultry
    26-5 Uncooked pork  

17. A bonfire warms people that are near it because heat
    27-1 sets up convection currents.
    27-2 diffuses.
    27-3 flows.
    27-4 travels through air by conduction.
    27-5 is radiated.  

18. The north pole is 90° north of the
    28-1 prime meridian.
    28-2 tropic of Cancer.
    28-3 equator.
    28-4 tropic of Capricorn.
    28-5 south pole.  

19. All matter is made up of
    29-1 atoms.
    29-2 cells.
    29-3 compounds.
    29-4 mixtures.
    29-5 solids.  

20. When a liquid is distilled, it is always
    30-1 boiled for a long time.
    30-2 fermented.
    30-3 heated without boiling.
    30-4 changed into a vapor and then back to a liquid.
    30-5 frozen and then melted again.  

21. Which of the following is a characteristic of all bacteria?
    31-1 They cause disease.
    31-2 They are harmful.
    31-3 They are made up of one cell.
    31-4 They live in animals.
    31-5 They give off poisonous compounds.  

Go on to the next page.
32. The force exerted by air upon the earth's surface is called
   32-1 cohesion.
   32-2 density.
   32-3 centrifugal force.
   32-4 capillary attraction.
   32-5 atmospheric pressure. 32( )

33. The outer layer of cells on a young tree twig is called the
   33-1 epidermis.
   33-2 cambium.
   33-3 phloem.
   33-4 xylem.
   33-5 pith. 33( )

34. A drone is a
   34-1 female bee.
   34-2 worker bee.
   34-3 male bee.
   34-4 soldier ant.
   34-5 female ant. 34( )

35. Which of the following elements burns brightly in air and extremely brightly in pure oxygen?
   35-1 Magnesium
   35-2 Iodine
   35-3 Fluorine
   35-4 Argon
   35-5 Hydrogen. 35( )

36. Oxygen unites chemically with other substances in muscle cells in the process called
   36-1 excretion.
   36-2 respiration.
   36-3 digestion.
   36-4 secretion.
   36-5 circulation. 36( )

37. The process which changes rock to soil is called
   37-1 precipitation.
   37-2 fission.
   37-3 condensation.
   37-4 weathering.
   37-5 erosion. 37( )

38. Which of the following substances is an element?
   38-1 Water
   38-2 Salt
   38-3 Vinegar
   38-4 Carbon dioxide
   38-5 Oxygen. 38( )

39. In order to operate successfully, an electric motor does not need
   39-1 an armature.
   39-2 an electromagnet.
   39-3 a coil.
   39-4 a transformer.
   39-5 a source of current. 39( )

40. Heat moves along a metal rod by
   40-1 convection.
   40-2 conduction.
   40-3 radiation.
   40-4 induction.
   40-5 osmosis. 40( )

41. Which of the following is an example of a stratified rock?
   41-1 Feldspar
   41-2 Granite
   41-3 Marble
   41-4 Mica
   41-5 Shale. 41( )

42. Phosphorus is used in some match heads because it
   42-1 has a low kindling point.
   42-2 has a high kindling point.
   42-3 is not poisonous.
   42-4 will burn without oxygen.
   42-5 can be heated by friction. 42( )

43. All telegraph sounders contain
   43-1 vacuum tubes.
   43-2 loud-speakers.
   43-3 electromagnets.
   43-4 push buttons.
   43-5 dry cells. 43( )

44. Which of the following contains an enzyme that acts on starches?
   44-1 Gastric juice
   44-2 Bile
   44-3 Lymph
   44-4 Blood
   44-5 Pancreatic juice. 44( )

45. In man, most carbohydrate digestion takes place in the
   45-1 liver.
   45-2 small intestine.
   45-3 mouth.
   45-4 large intestine.
   45-5 stomach. 45( )

Go on to the next part.

| Number wrong | 0 | 3 | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Amount to be subtracted | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |

Number right

Subtract (See table at left)

Raw Score on Part II = Difference
PART III

COMPREHENSION AND INTERPRETATION

(25 minutes)

Directions: This part consists of passages and tables. Following each selection are several items concerning it. Read the passage or examine the table carefully first; then decide which one of the choices given after each item completes the statement or answers the question. If you cannot decide, you may go back to the selection. After you have decided on the answer to an item, put its number in the parentheses at the right as you did in Parts I and II.

### SOME COMMON COMMUNICABLE DISEASES

<table>
<thead>
<tr>
<th>Disease</th>
<th>Means of Communication</th>
<th>Early Symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken Pox</td>
<td>Discharges from nose or throat of patient.</td>
<td>Rash.</td>
</tr>
<tr>
<td>Diphtheria</td>
<td>Nose or throat discharges; sometimes infected milk.</td>
<td>Begins like a cold. Reddish spots appear on the third day.</td>
</tr>
<tr>
<td>Measles</td>
<td>Nose or throat discharges.</td>
<td>Pain in salivary glands.</td>
</tr>
<tr>
<td>Mumps</td>
<td>Nose or throat discharges.</td>
<td>Begins like a cold. In 24 hours evenly diffused bright red spots appear under skin.</td>
</tr>
<tr>
<td>Scarlet Fever</td>
<td>Discharges from nose, mouth, ears; infected milk.</td>
<td>Cough worse at night. “Whooping” develops in about 2 weeks.</td>
</tr>
<tr>
<td>Whooping Cough</td>
<td>Discharges from nose or mouth.</td>
<td></td>
</tr>
</tbody>
</table>

1. According to the table above, impure milk is most likely to carry germs of
   1-1 measles.
   1-2 mumps.
   1-3 scarlet fever.
   1-4 chicken pox.
   1-5 whooping cough. 1( )

2. Mary was sent home from school with what seemed like a cold accompanied by a rash. One would be justified in concluding that she probably had
   2-1 diphtheria.
   2-2 whooping cough.
   2-3 mumps.
   2-4 tuberculosis.
   2-5 some communicable disease; it is impossible to tell which one from the information given. 2( )

3. The diseases listed in the table, taken as a whole, are most likely to be spread by
   3-1 spoiled food.
   3-2 polluted water.
   3-3 air-borne germs.
   3-4 unpasteurized milk.
   3-5 household pets. 3( )

4. One of the most practicable ways to avoid getting these diseases is to
   4-1 stay away from crowds in poorly ventilated rooms.
   4-2 eliminate milk from one’s diet.
   4-3 boil all drinking water.
   4-4 pasteurize all milk.
   4-5 screen all windows and doors. 4( )
In 1941 the United States shipped some 150,000 tons of water to Great Britain. This represents the water content (75 to 95%) of the fruits and vegetables that were transported during that year. Removal of this water by dehydration before shipping will make it possible for this tonnage to be used for the transportation of other materials.

Modern scientific dehydration preserves the flavor and some 90% of the vitamins of fresh food. In one process the fruits and vegetables are cooked, cooled, pulped, and then sprayed in a thin film on revolving drums, where heat drives off 96% of their water in from ten to twenty seconds. Steam rising rapidly from the food prevents oxidation, as when apples turn brown. The foods most successfully dried in this way are apples, bananas, peaches, peas, squash, and pumpkin; and in the dried state these foods will store well for years. When water is added and the food warmed up (it need not be cooked again), it is ready to be served.

5. The process described by the writer removes most of the water from the food by
   5-1 oxidation.
   5-2 preservation.
   5-3 evaporation.
   5-4 transportation.
   5-5 cooling.

6. The writer of the passage believes that
   6-1 many foods should be dehydrated before shipping.
   6-2 less food should be transported to Great Britain.
   6-3 dehydrated foods contain more vitamins than untreated foods.
   6-4 the transportation of other materials is more important than the transportation of food.
   6-5 dehydration of foods improves their flavor.

7. According to the passage, an important reason for drying foods before shipment is to
   7-1 increase the amount of water shipped to Great Britain.
   7-2 permit greater shipments of other materials.
   7-3 prevent apples from turning brown.
   7-4 conserve fuel by making it unnecessary to cook foods.
   7-5 make the foods more convenient to serve.
When air masses are active, storms occur. To a meteorologist a storm does not necessarily mean rain or snow. It is merely an active field of combat where warm air has made a dent in the cold front. This forms a round, oval low-pressure storm area, anywhere from 300 to 7000 miles in diameter, with the winds revolving around the center counterclockwise and spiraling slowly towards the center.

Rains sometimes fall along the fronts in this “low” and are carried across the country by the prevailing westerly winds. Along the warm front, the onrushing warm air climbs over and pushes back the wedge of cold air, as is shown in Figure 1. As it rises, it cools and gives up its moisture. Clouds form as billions of tiny water droplets, only about four ten-thousandths of an inch across, condense out of the air, and cling to microscopic bits of dust. Then, as the droplets grow in size, they fall and we have rain—or if they freeze on the way down, we have sleet; or if they form crystals of ice while they are still in the cloud, we have snow.

Along the cold front, shown in Figure 2, changes are usually sharper. The warm air is pushed upward suddenly, and huge quantities of water, often thousands of tons, condense out of it to form towering thunderheads.

8. A storm may best be defined as
   8-1 a low-pressure area.
   8-2 a high-pressure area.
   8-3 an area in which the winds are revolving clockwise.
   8-4 an area in which the winds are spiraling out from the center.
   8-5 an area in which there are violent and destructive winds.

9. Rains usually move across the United States from
   9-1 east to west.
   9-2 west to east.
   9-3 north to south.
   9-4 south to north.
   9-5 southeast to northwest.

10. Which of the following characteristics of the warm air mass is responsible for its position as shown in Figure 1?
    10-1 Rapid motion
    10-2 Counterclockwise motion
    10-3 Large volume
    10-4 Light weight
    10-5 Relatively heavy weight

11. Sleet particles are most accurately described as
    11-1 frozen rain drops.
    11-2 large hailstones.
    11-3 frozen water vapor.
    11-4 small bits of dust.
    11-5 a kind of snow.

12. Rains are caused by
    12-1 cold fronts being pushed upward.
    12-2 cold fronts being pushed downward.
    12-3 warm fronts rising over cold fronts.
    12-4 warm fronts going under cold fronts.
    12-5 warm fronts mixing with cold fronts.

13. The center of every raindrop is
    13-1 a molecule of water.
    13-2 an atom of water.
    13-3 a tiny particle of ice.
    13-4 a tiny particle of dust.
    13-5 an electron.

14. A person who predicts weather on the basis of accurate information is technically called
    14-1 a weather forecaster.
    14-2 a geologist.
    14-3 a meteorologist.
    14-4 an anemometer.
    14-5 an astrologist.

15. What is the approximate diameter in inches of a water droplet in a cloud?
    15-1 .4
    15-2 .04
    15-3 .004
    15-4 .0004
    15-5 .00004

Go on to the next page.
The work you do in walking is, for the greater part, work in lifting your body. To find how high you lift your body at each step, hold a piece of crayon touching the blackboard when you stand with your side to it. Walk along at your natural gait, keeping the arm rigid with the body. The crayon makes a rising and falling curved line. Find the number of inches from the average of the lowest points on the curve to the average of the highest points on the curve. This is the distance you lift your body at each step. Measure this distance in inches and change to a fraction of a foot. This number multiplied by your weight is the work you do at each step; multiply by the number of steps you take in walking from home to school to get the foot-pounds of work you do.

The work you do in taking one step is found by multiplying your weight by

16-1 12.
16-2 your height.
16-3 the distance, in feet, that your body is lifted in taking a step.
16-4 the length, in feet, of the curved line in the experiment.
16-5 the number of inches in one step.

Even without the use of the crayon and blackboard, one could calculate that the work done by a 200-pound man going up a step 9 inches high would be

19-1 150 foot-pounds.
19-2 175 foot-pounds.
19-3 200 foot-pounds.
19-4 267 foot-pounds.
19-5 1,500 foot-pounds.

In calculating the amount of work you do in walking from home to school by the method described above, it is not necessary to know

17-1 your weight.
17-2 the number of inches in one foot.
17-3 the number of inches in one step.
17-4 the number of steps from home to school.
17-5 the speed with which you walk.

To make the change indicated in lines 12 and 13 of the passage, it is necessary to

20-1 multiply by your weight.
20-2 multiply by the number of steps from home to school.
20-3 multiply by 12.
20-4 divide by 12.
20-5 divide by your height.

This method for measuring the work you do in walking would be least accurate if you

18-1 weighed a great deal.
18-2 were going uphill.
18-3 walked in a straight line.
18-4 walked in a circle.
18-5 walked very slowly.

If your weight is 120 pounds, and the distance you lift your body at each step is one inch, how much work will you do in taking 1,000 steps?

21-1 1,000 foot-pounds
21-2 1,200 foot-pounds
21-3 10,000 foot-pounds
21-4 12,000 foot-pounds
21-5 120,000 foot-pounds

Go on to the next page.
Often the instinctive actions of insects seem so complicated that it is difficult to think of them as being purely mechanical reactions, as they are. The actions of a certain larva that is a parasite of one of the wild solitary bees illustrate this statement. Following their inherited instincts, these tiny larvae lie in wait for this certain kind of bee at the mouth of the underground tunnel in which she builds her nest. As she approaches, several of the larvae leap upon her back and bury themselves in her hair. Here they remain motionless while the bee, following her instincts, makes the necessary journeys to the flowers for materials with which to construct her cells and to store them with food for her young. But the instant she lays an egg in a cell, the egg somehow serves as a stimulus to the little parasites. Immediately they leap upon it, for it is the bee's egg that they use for food. The bee seals the cell in her customary mechanical way—the only way that her inherited nerve structure permits. She has no way of knowing that her egg will be eaten, nor can she alter her behavior in the slightest degree.

2. The larva mentioned in the passage above is
22-1 not harmful to bees in general.
22-2 really of benefit to bees.
22-3 harmful to many insects.
22-4 a parasite.
22-5 a nest-builder.

23. The food of the larvae consists of
23-1 honey.
23-2 part of a beehive.
23-3 bees' eggs.
23-4 bees' hair.
23-5 parasites.

24. According to the writer, the actions of both the bee and the larva depend on
24-1 past experience.
24-2 the need for food.
24-3 parental instruction.
24-4 intelligent planning.
24-5 inherited nerve structure.

25. The author feels that
25-1 some bees are very intelligent.
25-2 seemingly intelligent behavior in insects is merely instinctive.
25-3 parasites are among the most intelligent of insects.
25-4 parasites as well as insects are important in pollinating flowers.
25-5 domestic bees have more highly developed nerve structures than wild solitary bees.

26. From the passage, one could justifiably conclude that
26-1 most parasites eat bees' eggs.
26-2 this larva has a well-developed sense of smell.
26-3 the disappearance of this kind of bee might also cause the disappearance of these larvae.
26-4 the bees who know that their eggs are under attack can drive parasites away.
26-5 this larva would be found in all beehives.
The first stroke of the four-stroke cycle Diesel engine is the intake of a charge of fresh air. With the inlet valve open, the piston, moving downward, pumps in air to fill the cylinder. When the piston passes the bottom of its stroke, the inlet valve closes.

The second stroke compresses the air to between 500 and 600 pounds per square inch. When air is compressed, its temperature rises. In the Diesel engine the temperature of the compressed air may reach as high as 1,000 degrees Fahrenheit.

The fuel is injected into this hot air. Since the oil is in a fine, fog-like spray, it starts to burn immediately. The injector continues to spray fuel oil into the cylinder until all of the charge is injected. The pressure in the cylinder rises to between 800 and 850 pounds per square inch.

The third stroke is the power stroke. The hot gases expand and force the piston downward. The chemical energy of the fuel is converted into mechanical energy to move the piston.

The fourth stroke is the exhaust stroke. The exhaust valve opens and the piston, moving upward, forces the burned gases out to make room for a new charge of air.

27. The pressure which injects oil into a Diesel cylinder must be at least
   - 15 pounds per square inch.
   - 30 pounds per square inch.
   - 100 pounds per square inch.
   - 400 pounds per square inch.
   - 800 pounds per square inch.

29. What causes the fuel to ignite in a Diesel cylinder?
   - Hot fuel
   - A spark
   - Hot air
   - Heat of friction
   - A fuel pump

28. Which of the following processes is most important during the third stroke of the piston?
   - Chemical changes occur.
   - Air is compressed.
   - Heat is absorbed.
   - Energy is stored.
   - Energy is destroyed.

30. In what position are the valves during the compression stroke?
   - Both are open.
   - Both are closed.
   - The inlet valve is open and the exhaust valve is closed.
   - The inlet valve is closed and the exhaust valve is open.

If you finish this part before the time is up, you may go back and work on any part.

<table>
<thead>
<tr>
<th>Number wrong</th>
<th>0</th>
<th>3</th>
<th>7</th>
<th>11</th>
<th>15</th>
<th>19</th>
<th>23</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount to be subtracted</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Subtract (See table at left)

Raw Score on Part III = Difference
DIRECTIONS FOR ADMINISTERING THE COOPERATIVE TESTS

The cover page of each Cooperative test contains the essential information needed in administering the test, but there are certain general rules that should always be followed, as well as special directions for certain tests and for particular conditions of administration. The examiner should study the General Directions in the first section, and then follow exactly the procedure described in the appropriate set of instructions below.

GENERAL DIRECTIONS

The Examiner’s Preparation. The examiner should thoroughly familiarize himself with all parts of each test that he is to administer. Perhaps the best way for him to do this is by taking each test himself in a bona fide manner. By doing so, he can anticipate many of the questions that examinees will ask, and also foresee problems of organization and prepare for them.

When a large group is to be tested, proctors are needed to help administer the tests. There should be one proctor for every thirty examinees. The proctors should understand in advance exactly what they are to do, so that the booklets may be quickly distributed and collected without confusion.

The examiner should see that the used and unused booklets are carefully counted, classified, and labeled at the end of the examination.

Announcing the Examination. The preliminary announcement of the examination should name the place, day, and hour at which it will be given. Allow from 5 to 10 minutes for seating and preliminary arrangements in the examination room. The time allowances printed on the booklets are for actual work on the test questions, exclusive of time taken for preliminaries. Examinees should be told to bring two well sharpened No. 2 (or B) pencils with good erasers unless tests are to be machine scored, in which case examiner will provide special mechanical pencils (see page 3). The use of fountain pens or ink in any form should be specifically forbidden. Examiners should have a supply of pencils on hand, and should provide scratch paper for all mathematics and science tests.

Directions in the Examination Room. The seating order in the examination room should be carefully arranged in advance. In taking objective examinations it is comparatively easy for students to observe the answers of their neighbors and to be influenced or disturbed by such observations. The students should always be seated as far apart as possible, never closer than in alternate seats. If it seems necessary, the disturbing character of such observation may be explained to the students.

Directions for taking the tests are printed on the test booklets. The examiner must see that the examinees understand the essential points in the directions before they begin work on the test. This can be done by allowing sufficient time at the beginning of the examination for the students to read the directions on the cover page carefully, by emphasizing points that seem to need emphasis, and by answering any legitimate questions that may be asked. In testing large groups, the carrying power of the examiner’s voice is an important factor in avoiding confusion and in creating good morale.

Fidelity to Printed Directions. In answering questions and in orally emphasizing the directions, it is essential that the examiner stay within the meaning, and, so far as possible, use the vocabulary of the directions printed on the test booklet. Any deviation from these directions may destroy the comparability and impair the meaning of the test results. The directions concerning guessing are especially susceptible to distortion; questions by examinees on this point should invariably be answered by reading the directions verbatim.

Order and Discipline in the Test Situation. Once a test is under way, the chief function of the examiner and proctors is to keep everyone seriously at work all the time, without producing an atmosphere of nervous tension. Disturbances are to be avoided at all cost. It is just as bad for the examiner to disturb the group in enforcing order as it is for the examinee to create a disturbance.

Cooperative Test Service.
15 Amsterdam Avenue, New York 23, N. Y.
DIRECTIONS FOR ADMINISTERING WHEN ANSWERS ARE RECORDED IN BOOKLETS

Standard Procedure for Administering Tests
Not Divided into Parts

1. When all are seated, the examiner should say:

"We shall now pass out the test booklets. Do not open them now. As soon as you get the booklet, fill in your name and the other items of information called for on the cover page. Print your name. When you have finished filling in the blanks, read carefully the directions on the cover page; then wait for further directions. Do not open the booklet until I tell you to do so."

2. Allow sufficient time for filling in the spaces on the cover page and reading the directions. When each student has done this, the examiner may orally emphasize any points that need emphasis, and say:

"Are there any questions? No questions may be asked after the examination begins."

3. Answer all legitimate questions, and then say:

"When I say 'Begin,' turn to the first page of questions, read the directions at the top of the page, and start work. Work as fast as you can without making mistakes. Ask no questions. Read the directions again if you do not understand. You are not expected to answer all the questions in the time limit. Begin."

4. Note the exact time when you say "Begin" and write it down. Allow exactly the number of minutes specified for the test, counting from the moment you say "Begin." Do not allow extra time for reading the specific directions inside the booklet. At the end of the allotted time, say:

"Stop! Even if you have not finished, close your booklets. See that you have clearly printed your name and that you have given all the other information asked for."

5. Have the booklets collected at once. In doing so, make sure that all the information necessary for identification and classification has been entered. Supply any necessary missing items of information.

Standard Procedure for Administering Tests
Having Two or More Parts

Including the Cooperative English Tests, Forms Q Through T

1. When all are seated, the examiner should say:

"We shall now pass out the test booklets. Do not open them now. As soon as you get the booklet, fill in your name and the other items of information called for on the cover page. Print your name. When you have finished filling in the blanks, read carefully the directions on the cover page; then wait for further directions. Do not open the booklet until I tell you to do so."

2. Allow sufficient time for filling in the spaces on the cover page and reading the directions. When each student has done this, the examiner may orally emphasize any points that need emphasis, and say:

"Are there any questions? No questions may be asked after the examination begins."

3. Answer all legitimate questions, and then say:

"When I say 'Begin,' turn to the first page of questions, read the directions carefully, and start work. Work as fast as you can without making mistakes. Ask no questions. Read the directions again if you do not understand. You are not expected to answer all the questions in any part in the time limit, but if you should finish before time is called, go on to the next part. If you finish the last part before time is called, you may go back and work on any earlier part. Begin."

4. Note the exact time when you say "Begin" and write it down. Allow exactly the number of minutes specified for the part of the test which you are administering, counting from the moment you say "Begin." Do not allow extra time for reading the specific directions at the beginning of the part.

At the end of the allotted time for Part I, say:

"Stop! Even if you have not finished Part I, begin Part II. Read the directions for Part II carefully. If you finish Part II before the time is up, you may go back and work on Part I again, or you may go on to the next part."

5. The examiner should see that all students begin Part II promptly. Allow exactly the specified number of minutes, then say (if there is a Part III):

"Stop! Even if you have not finished Part II, begin Part III. Read the directions for Part III carefully."

6. Thus each part of the test is administered until all parts have been given. Then say:

"Stop! Even if you have not finished, close your booklets. See that you have clearly printed your name and that you have given all the other information asked for."

7. Have the booklets collected at once. Make sure that all the information necessary for identification and classification has been entered. Supply any necessary missing items of information.
Most of the Cooperative tests can be given with separate answer sheets. Forms OM and PM of the Cooperative English Test can be given only with answer sheets. The other Cooperative English Tests may be given either with separate answer sheets or by having answers recorded in the booklets. These tests and many others have special answer sheets designed for the particular test. Other tests are set up so that the standard Cooperative Answer Sheet may be used with them.

The marking of the answer sheet requires a soft pencil with which a clear black line can be quickly made. When the answer sheets are to be scored by machine, it is imperative to use very soft pencils of good quality, which will make a smooth, glossy black line. Mechanical pencils with a special electrographic lead may be obtained from the Cooperative Test Service.

If the examination period is not long enough to allow ample time for making the necessary explanations and answering all questions before the beginning of the allotted time for actual work on the test, it is desirable to explain the use of the answer sheets prior to the examination period.

Standard Procedure for Administering Tests with Separate Answer Sheets

1. When all are seated, the examiner should say:

"We shall now pass out the test booklets and answer sheets. In this test, you are to mark your answers on a separate answer sheet instead of on the pages of the test booklet. Do not write anything at all in the booklet. Your name and your answers to the questions on the test are to be put on the separate answer sheet."

When the booklets and answer sheets have been passed out, the examiner should show the students an answer sheet to illustrate the different points, and say:

"Print your name on the line at the left side of the answer sheet, fill in the other items of information called for, and read the directions on both the answer sheet and the cover of the booklet. Do not write on the booklet, and do not open the booklet until I tell you to do so."

2. Allow sufficient time for filling in the spaces and reading the directions; then say:

"In taking this test, you are to mark your answer on the answer sheet by making a black pencil mark between the pair of dotted lines numbered the same as the answer you think is correct. You are not to write the answer in the test booklet."

At this point, the two paragraphs printed in small type should be read to the examinees if the answer sheets are to be scored by machine. The two paragraphs should not be read if the answer sheets are to be scored by hand.

"The answer sheet will be scored by an electrical test scoring machine. This machine will score the test accurately if each answer is indicated with a solid black pencil mark. Solid black marks are made by using a soft pencil, by going over each mark two or three times, and by pressing firmly on the pencil. The answer sheet should be marked on a hard surface.

"The scoring machine cannot distinguish between intended answers and stray pencil marks. If you are careless in erasing or leave unnecessary marks on or near the short dotted lines, such marks may be counted by the machine as wrong answers, and your score will be lower than it should be. If you keep your place on the answer sheet with your pencil, it will help to avoid stray marks if you rest the pencil on the large item number at the left while you are reading the question, and do not let the pencil touch any of the answer spaces until you are ready to mark your answer for that item."

The examiner then continues:

"Are there any questions about how you are to take the test? No questions may be asked after the examination begins."

Answer all legitimate questions and make sure that all pupils understand how to mark the answer sheets. During the examination, examiners should check occasionally, especially at the beginning of new parts, to see that the students are recording their answers properly on the answer sheets.

From this point on, use the appropriate section below, according to the test being administered. The first section is for tests not divided into parts; the second section is for tests having two or more parts.

Directions (Continued) for Administering Tests Not Divided into Parts, with Separate Answer Sheets

3. After answering all legitimate questions, the examiner should say:

"When I say 'Begin,' open the booklet and fold the page over. Keep the booklet folded back so you will have only one page at a time in front of you. Read the directions at the top of the page and start work. Work as fast as you can without making mistakes. Ask no questions. Read the directions again if you do not understand. You are not expected to answer all the questions in the time limit. Begin."

4. Note the exact time when you say "Begin" and write it down. Allow exactly the number of minutes specified for the test, counting from the moment you say "Begin." Do not allow extra time for reading the specific directions inside the booklet. At the end of the allotted time, say:

"Stop! Even if you have not finished, close your booklets. See that you have filled in all the blanks at the side of the answer sheet, and that you have clearly printed your name."

5. Have the students put their answer sheets inside the booklets, and collect the booklets and answer sheets at once. Make sure that all booklets are returned.
Directions (Continued) for Administering Tests

Having Two or More Parts, with Separate Answer Sheets

3. After answering all legitimate questions, the examiner should say:

"When I say 'Begin,' open the booklet and fold the page over. Keep the booklet folded back so you will have only one page at a time in front of you. Read the directions at the top of the page and start work. Work as fast as you can without making mistakes. Ask no questions. Read the directions again if you do not understand. You are not expected to answer all the questions in any part in the time limit, but if you should finish before time is called, go on to the next part. If you finish the last part before time is called, you may go back and work on any earlier part. Begin."

4. Note the exact time when you say "Begin" and write it down. Allow exactly the number of minutes specified for the part of the test which you are administering, counting from the moment you say "Begin." Do not allow extra time for reading the specific directions at the beginning of the part. At the end of the allotted time for Part I, say:

"Stop! Even if you have not finished Part I, begin Part II. Read the directions for Part II carefully. If you finish Part II before the time is up, you may go back and work on Part I again, or you may go on to the next part."

5. The examiner should see that all students begin Part II promptly. Allow exactly the specified number of minutes, then say (if there is a Part III):

"Stop! Even if you have not finished Part II, begin Part III. Read the directions for Part III carefully."

6. Thus each part of the test is administered until all parts have been given. Then say:

"Stop! Even if you have not finished, close your booklets. See that you have filled in all the blanks at the side of the answer sheet, and that you have clearly printed your name."

7. When the entire test has been administered, have the students put their answer sheets inside the booklets, and collect the booklets and answer sheets at once. Make sure that all booklets are returned.

DIRECTIONS FOR SCORING THE COOPERATIVE TESTS

DIRECTIONS FOR SCORING WHEN ANSWERS ARERecorded IN BOOKLETS

The essential information needed in scoring the Cooperative tests is printed on the scoring keys. For almost all the tests, the scoring is entirely objective, and can be done by clerks or dependable high-school pupils, if they are adequately trained and supervised and if their work is systematically checked.

Organization of Scoring Procedure. The entire scoring procedure should be arranged in advance, and each worker should have a general understanding of the whole scheme. A certain amount of division of labor adds to the efficiency and accuracy of scoring. For example, marking and counting should usually be separate operations, since most of the Cooperative tests require the marking and counting of both correct and incorrect answers. It should be possible to trace each error unmistakably to the scorer who made it. For this reason each scorer should initial each task completed, and a record should be kept of each scorer's "error count."

Experience has shown that accuracy of scoring is as difficult to secure as it is necessary for good test results. A systematic routine is indispensable in even the smallest scoring projects, as many errors can be prevented by careful organization of the scoring work. However, some errors will be made in spite of the most careful arrangements. It is therefore essential that adequate provision be made for finding and correcting the errors which do occur. This means that checking and rechecking must be a regular part of the routine of the scoring procedure.

Preparation of Scoring Keys. The scoring keys for nearly all the Cooperative tests are printed on sheets which, when folded back along the heavy vertical lines, become "fan" or "accordion" type keys. The answers for the test pages appear on successive folds of the "fan" in the same sequence as the pages of the test. The successive folds are numbered at the top to correspond with the successive pages of the test. The folding of the key sheets must be done carefully with the heavy line on the outside of the fold, so that the sequence of folds will
Fidelity to the Key Is Essential. If there is an obvious error or misprint in the key or in the test, the error should be corrected and the fact reported to the Cooperative Test Service. Any such correction should be made on all copies of the key which are in use. Mere differences of opinion should never lead to deviations from the key. Unless the key is strictly followed, test results will not be comparable.

Marking and Counting Right and Wrong Answers. When using "fan" keys, scorers must compare the page number on the key fold with the number of the page that is being scored. This comparison must be made for each successive page of each test scored.

The answers given on the key are compared with the student's answers, and the right and wrong answers neatly marked.

The following rules will be useful to all scorers, and will be indispensable in large scoring centers:

a. All original scoring should be done with pencils of the same color, and rescoring should be done with a second color.

b. All correct answers in all tests should be marked at the right with a short horizontal line, and these short lines should be in a straight vertical column. The short lines should never pass through any part of the examinee's answers, or otherwise impair their legibility.

c. Wrong answers in all true-false, multiple-choice, and matching sections of all tests (unless specifically excepted on the scoring keys) should be marked at the right with a small neat x, and these x's should be in a vertical column slightly to the right of the short horizontal lines marking the right answers. It is important that each error be marked with a small x, and not with a plus sign, +. If a scorer errs, and wishes to change a − to an x, or vice versa, he should scratch out (never erase) the erroneous mark thus X, or X, and write the correct mark at one side of the scratched-out mark, in the proper column.

Erasures take more time, and involve the risk of erasing part of the student's answers. Corrections should never be superimposed on incorrect marks, thus X; nor should any attempt be made to blot out incorrect marks, thus X or X.

d. Omissions, if marked at all, should be marked with a small neat o. Illegible answers should be marked and counted as omissions, never as wrong answers. When two answers are given for any item, the item should be marked as an omission, provided that one of the answers given is the correct answer; but if both answers are wrong, the item should be marked and counted as a wrong answer.

Checking and Rechecking. Neatness and uniformity not only tend to prevent errors, but are essential to the certain detection of errors that are not prevented. The checking schedule below represents a minimum for acceptably accurate test results. All checking should be done by trained and accurate scorers, and no scorer should check his own work.

a. The initial scoring of all new clerks should be completely checked until the results indicate acceptable accuracy.

b. A sampling of about 10 per cent of all tests scored should be rescored. The sampling should be selected to represent every scorer, and a record of the number and kinds of errors of each scorer should be kept.

It has been found that more than half of all significant errors are errors of addition, subtraction, or division; about 15 per cent are transfer errors; and about 10 or 15 per cent are errors of counting, such as dropping or adding 10's, omitting (or counting twice) whole pages, etc. Thus it is obvious that c. and d. above are indispensable to good results.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3)</td>
<td>(3)</td>
</tr>
<tr>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>(5)</td>
<td>(5)</td>
</tr>
<tr>
<td>(4)</td>
<td>(4)</td>
</tr>
<tr>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>(4)</td>
<td>(4)</td>
</tr>
<tr>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
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<td>(5)</td>
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<tr>
<td>(2)</td>
<td>(2)</td>
</tr>
<tr>
<td>(1)</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>158</td>
</tr>
</tbody>
</table>

Many of the most troublesome errors in scoring are directly due to lack of neatness and uniformity in the marks and figures which scorers put on the test blanks. The common checking mark (v) is the source of many costly errors and should never be used in scoring tests. The facsimile of the work of Scorer A, reproduced at the left, illustrates the desirable neatness and uniformity with which scoring should be done. Work such as that of Scorer B will certainly lead to errors.

Computing Raw Scores. The scoring keys give directions for computing raw scores on each part of the tests. These directions must be followed exactly. Spaces are provided at the end of each test (or part of test) for entering the necessary figures for computing the raw scores. Count the number of right answers and enter in the appropriate space. The amount to be subtracted depends on the number of wrong answers and can be read for most of the tests from the little table which is to be found directly above or at the left of the spaces. The amount to be subtracted is always a whole number. Fractions of ½ or less are dropped and fractions greater than ½ increase the amount to be subtracted to the next higher integer. If the resulting difference is negative, the raw score is zero.
Obtaining the Scaled Scores. After the raw scores are computed, the Scaled Scores are obtained by referring to the conversion tables provided on the scoring key (except for some tests for which there are no Scaled Scores).

For the English and foreign language tests, there are Scaled Scores for the parts as well as for the total. The raw score on each part is converted into a Scaled Score by referring to the appropriate table on the scoring key. This Scaled Score is entered in the test booklet in the space provided at the end of each part.

The Scaled Scores for the parts are transferred to the cover page and added. This total is converted to a Scaled Score by referring to the table for totals on the scoring key. Note that on the English and foreign language tests only Scaled Scores appear on the cover page. The Scaled Score for the total test in these subjects must be obtained by converting the sum of the Scaled Scores for the parts by the use of the table for totals on the scoring key. (See illustration below.)

Illustration of the Method of Securing the Scaled Score for the Total of the Cooperative French Test, Revised Series—Advanced Form O:

<table>
<thead>
<tr>
<th>PART I:</th>
<th>Raw Score</th>
<th>Scaled Score</th>
<th>(From Table on Key)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Score</td>
<td>17</td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PART II:</th>
<th>Raw Score</th>
<th>Scaled Score</th>
<th>(From Table on Key)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Score</td>
<td>12</td>
<td>62</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PART III:</th>
<th>Raw Score</th>
<th>Scaled Score</th>
<th>(From Table on Key)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Score</td>
<td>18</td>
<td>64</td>
<td></td>
</tr>
</tbody>
</table>

(Sum of Scaled Scores for Parts: 179)

<table>
<thead>
<tr>
<th>Part</th>
<th>Minutes</th>
<th>Scaled Score</th>
<th>Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Reading</td>
<td>15</td>
<td>53</td>
</tr>
<tr>
<td>II</td>
<td>Vocabulary</td>
<td>10</td>
<td>62</td>
</tr>
<tr>
<td>III</td>
<td>Grammar</td>
<td>15</td>
<td>64</td>
</tr>
</tbody>
</table>

DIRECTIONS FOR SCORING SEPARATE ANSWER SHEETS

Experiments have shown that the use of separate answer sheets introduces a factor of clerical facility into the test scores. In general, for tests in which speed is not an important factor, this has only a slight effect on group achievement. Allowance is made for this factor, in the case of those tests which have Scaled Scores, in the special tables for converting raw scores into Scaled Scores. These special tables are printed on the answer sheets and differ from the corresponding tables printed on the fan keys. A particular Scaled Score usually corresponds to a slightly lower raw score when the test is given with answer sheets than when given in the usual way. How much effect the use of separate answer sheets may have on the score of any particular pupil has not been determined.

For those tests which do not have Scaled Scores, it should be remembered that the norms provided by the Cooperative Test Service are based on scores made by students marking their answers in the booklets, not on separate answer sheets, and should be interpreted accordingly.

Scoring Procedure

For many of the Cooperative tests, scoring stencils are available. For other tests it is necessary to make a stencil key by punching out the answers as given on the fan key.

Do not obtain part scores unless they are necessary (as in the case of the languages) or unless there is a difference in the scoring formulas. For example, the scoring formula for Part I of the Plane and Solid Geometry Tests is Rights minus Wrongs, while for Parts II and III it is Rights minus one-fourth of the Wrongs. Here it is necessary to get separate scores for Part I, but Parts II and III should be scored as a unit. These scores are then added to give the total raw score.

If the students tested are not accustomed to this method of taking tests, an occasional student may put his answers in the booklet, despite all directions to the contrary. Such booklets should be watched for when the answer sheets are taken out of the booklets. If the booklets are to be used more than once, they must be carefully inspected after each administration. Those which have any items marked in any way should be discarded.

The separate answer sheets may be scored either by the International Test Scoring Machine or by hand. A description of the scoring procedure in each case is given below.

Procedure When the Answer Sheets Are to Be Machine-Scored. In most cases, two scoring stencils are needed for each test. One, called the Right Key, has all the right answers punched out. A second stencil, called the Item Elimination Key, has...
all the right answers punched plus all the unused spaces in the fields used.

All the special Cooperative answer sheets give raw score-Scaled Score conversion tables along the left-hand margin. As the operator reads the raw score on the meter, she can encircle the corresponding Scaled Score and thus save the necessity for later conversion. Papers should be scanned for stray marks, use of ineffective pencils, and other failures to follow directions. The insertion of test sheets in the machine at intervals during the scoring of a batch of papers and a certain amount of hand-checking are urgently recommended.

Procedure When the Answer Sheets Are to Be Hand-Scored. Only one stencil is needed, the Rights Key, which has all the right answers punched out.

FOR TESTS ON WHICH A TOTAL SCORE ONLY IS OBTAINED

1. Count the number of spaces the student has blackened on the entire test. Include all marks, even where there is more than one for a question.

2. Place the Rights Key over the answer sheet with the right-hand edges together. Make any necessary slight adjustment so that answer spaces show in the center of all punched holes.

3. Count the number of blackened spaces appearing through the punched holes. This gives the number of right answers.

4. Subtract the number of right answers (Paragraph 3) from the total number of responses (Paragraph 1). This remainder is the number of wrong answers.

5. You now have the number of right answers and the number of wrong answers. The formula for the raw score is usually the number of right answers minus a certain fraction of the number of wrong answers. The more recent forms of the Cooperative tests have a table printed in the test booklet showing the amount to be subtracted from the number of right answers in order to obtain the raw score. If such a table is not provided, consult the statement on the fan key, and subtract the indicated fraction of the wrong answers from the number of right answers. Fractions of \( \frac{1}{4} \) or less are dropped before subtracting. For fractions greater than \( \frac{1}{4} \), increase the amount to be subtracted to the next higher integer. Negative scores are called zero.

6. For the Cooperative tests which have Scaled Scores, look up the raw score, as obtained in Paragraph 5, in the raw score-Scaled Score conversion tables provided on the answer sheets, and encircle the corresponding Scaled Score. Note the examples of how scores are computed, given below.

FOR TESTS ON WHICH PART SCORES ARE OBTAINED

The procedure described above should be followed separately for each part. In counting the number of responses and the number of right answers, care should be taken not to include items in a subsequent or earlier part, particularly where one part ends in the middle of a column, with a different part occupying the lower part of the column. Care must also be taken to apply the appropriate scoring formula to each part, as this formula sometimes differs for various parts of the same test.

Note that, in obtaining the Scaled Score for the total of a test which has Scaled Scores for the various parts, the sum of these Scaled Scores for the parts is used in obtaining from the table the Scaled Score for the total test.

Example of the Scoring of the Cooperative English Test, Form OM

Part I, Usage. Raw score = \( R - \frac{W}{2} \)

(Notice that Part I is scored as a unit. Separate scores on the various sections may be obtained for diagnostic purposes if desired. At the present time, there are no norms for the separate sections.)

Total number of marks on Part I ................. 162
Number of right answers on Part I ............. 87
Number of wrong answers on Part I .......... 75

\( R - \frac{W}{2} = 87 - 37 \text{ (dropping the } \frac{1}{2} \text{)} = 50 \)

Raw score on Part I = 50

Part II, Spelling. Raw score = \( R - \frac{W}{4} \)

Total number of marks on Part II ................ 39
Number of right answers on Part II ........... 30
Number of wrong answers on Part II ........... 9

\( R - \frac{W}{4} = 30 - 2 \text{ (dropping the } \frac{1}{4} \text{)} = 28 \)

Raw score on Part II = 28

Part III, Vocabulary. Raw score = \( R - \frac{W}{4} \)

Total number of marks on Part III .............. 100
Number of right answers on Part III ........ 17
Number of wrong answers on Part III .......... 83

\( R - \frac{W}{4} = 17 - 21 = -4 \), which is called 0

Raw score on Part III = 0

<table>
<thead>
<tr>
<th>Raw Score</th>
<th>Scaled Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>28</td>
<td>58</td>
</tr>
<tr>
<td>0</td>
<td>13</td>
</tr>
</tbody>
</table>

Sum of Scaled Scores = 111

Total Scaled Score = 36
**DIRECTIONS FOR INTERPRETING COOPERATIVE TEST RESULTS**

**THE SCALED SCORES**

The Scaled Scores which are provided for most of the Cooperative tests were devised to enable the teacher and administrator to gain directly as much interpretative information as possible, without reference to norms, equivalent scores, percentiles, or other aids to interpretation. The principal characteristics of the Scaled Scores are:

1. Equality of units throughout the scale. The raw-score units have been replaced by units so scaled that the scores from a single school system will tend to form a normal distribution.

2. A common scale for all tests. The scale to which all tests are referred is so defined that a score of 50 represents the score which the average child would make at the end of the particular course, if he attended an average school and had taken the usual amount of the subject in question. The size of the unit on the common scale is defined as a tenth of the standard deviation of the distribution of scores which would be made by an unselected group of students, if they were all to take the particular subject.

The tables of Scaled Scores are printed on the scoring keys and on the special answer sheets.

At various points along these Scaled Score tables there are short vertical lines which indicate the standard error (laid off in both directions) of scores at those points. Notice that the length of each line is equivalent to twice the standard error. The length of any of these lines shows graphically the range within which would fall the scores obtained by approximately two-thirds of the individuals whose "true" scores are at the particular point. For example, if the line at the Scaled Score of 50 extends two units above and two units below this point, this is interpreted as indicating that about two-thirds of the individuals whose "true" scores are 50 would actually obtain scores on this test between 48 and 52.


**USE OF NORMS TABLES**

The norms for the Cooperative tests are given in the form of percentile tables, which are furnished free with test orders. For some tests, a number of different tables are provided, for different amounts of study and different grade levels. In comparing the scores of a particular group with the norms, the appropriate tables should be chosen.

The percentile value corresponding to a given score shows what percentage of the students in that group achieve scores below that score. For instance, if a tenth-grade student makes a Scaled Score of 54 on the Literary Acquaintance Test, reference to the percentile table for tenth-graders shows that this score corresponds to a percentile value of 83. This means that the pupil's score is higher than the scores of 83% of tenth-graders who have taken the test. Such comparisons with the norms may be made both for individual students and for class averages.

The percentile tables also facilitate the study of the relative standing of an individual or a class on various parts of such tests as the English and language tests. Suppose, for instance, that the average Scaled Score of a second-year French class on the Cooperative French Test given at the end of the year is at the 55th percentile on the two-year norms table on the reading part, at the 60th percentile on the vocabulary part, and at the 45th percentile on the grammar part. This does not necessarily indicate that the teacher of this class ought to put more stress on grammar and less on reading. It does mean that, in grammar, the average achievement of this class is less than that of the average student with the same amount of study, but that, in reading and vocabulary, it is greater. The individual teacher must decide whether he is satisfied to have it so; many instructors prefer to emphasize reading, and a relatively lower average on grammar would be entirely in accord with the objectives of their course. On the other hand, if the teacher had endeavored to lay a particularly good foundation of grammar knowledge in this course, and found his pupils' average score relatively lower on that part, this would indicate the advisability of reconsidering methods in the light of the desired objectives.

* The "true" score may be defined as the average of all the scores that would be obtained by giving the student a very large number of similar tests.