AN EXPERIMENTAL COMPARISON OF TWO STUDY METHODS IN THE TEACHING OF HIGH SCHOOL BIOLOGY

by

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M.E.H.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

THE PROBLEM

In the present day of educational experimentation, much attention is being directed toward the many forms of the "study movement". This experiment is but another attempt to compare the advantages of one type of study technique with those of another. When education was first developed in America classes were small. The teacher gave each pupil a comparatively large amount of individual help. As mass education developed, classes became larger and the teachers had to adjust their technique to fit these new conditions. Group instruction of many types was formulated. Then even greater numbers of pupils crowded into the free schools, especially into the secondary schools. The "study movement" in its many phases, is but one of the many suggestions that are being tried out in an effort to solve the problem of proper handling of these increasing numbers of students.

Biology, one of the subjects taught by the writer, is quite easily adapted to an experiment in study methods. A carefully planned "unit course"[1] organized on the basis of the various underlying principles of biology, in guide sheet or instructional sheet form, was the chief "tool", or teaching device. Several forms of new type tests[2] designed to measure the pupil's understanding and application of these biological principles, were used to measure the results. The use of the

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1. Prepared by Professor E.E. Bayles, University of Kansas.
2. Prepared also by Professor Bayles.

guide sheets made it possible to entirely eliminate the recitation period, a period which seems to have accompanied all previous "study" experiments. Although educational literature is filled with articles advocating the use of "study methods", no studies were found by the writer that sought to measure results obtained by using a study method alone. The recitation period, or some other form of oral pupil activity, was always linked with the study technique. In order to differentiate between the two types of study technique, in this report they are termed the "student-initiative" technique and the "teacher-initiative" technique.

In the student-initiative technique, the pupils were supplied with the guide sheets,* texts, and supplementary books. The pupils were given general and specific oral instructions on methods of study, especially in connection with the guide sheets. After once discussing the method to be used by them, the pupils got their information through reading, and initiated all requests for help from the teacher. The teacher gave help, when requested, to each student individually.

In the teacher-initiative technique, the pupils were supplied with the same tools as those supplied to the student-initiative pupils. General and specific instructions on methods of study were also given to them. The chief difference in this technique lay in the activity of the teacher, who initiated the study of each unit by lecturing to the class at the beginning of the study of each section of the unit. During the period the teacher also sought out the pupils who needed help. When one pupil was found needing aid, it was assumed that others might also

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*For a description of the guide sheets see p. 6 , and for a sample guide sheet see the appendix, pp. 52-55.

need such aid, so the teacher discussed the difficulty before the whole class. Instruction under this type of technique was group instruction, and not individual.

The use of unnatural and artificial settings is a characteristic which has lowered the practical value to the teacher of many previous educational experiments. H.O. Rugg says, in speaking of American laboratory schools, "The laboratory schools have selected pupil bodies (average I.Q.'s of 115 to 120), pupils advanced linguistically and socially several years beyond the level of corresponding public school grades, hence many conclusions from these experiments are not applicable to the rank and file of public schools".[3] Even in experiments carried on in the public schools, the experimental groups are often separated from the regular groups into which they would have fallen in the course of regular enrollment. This makes for somewhat abnormal conditions for an experiment. One of the most extensive studies in teaching pupils how to study was conducted by Butterwick, who makes the following statement in his concluding generalizations, "The situation in which the experiment was conducted was artificial, and although the writer constantly aimed to provide the most natural setting possible, he does not feel that he accomplished this in its entirety".[4] Charters says, "the practical research investigator cannot pick his problem from the air. They are

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3. Rugg, H.O. The American Experimental School, Teachers College Record, Vol. XXX. (Feb. 1929) p. 416.
4. Butterwick, Joseph S. The Problem of Teaching High School Pupils How to Study, (Teachers College, Columbia University, Contributions to Education No. 237) p. 116.

localized within the practice and in the end they must be applied to the improvement of practice. His selection is narrowed by the practical situation in which he works."[5]

It was the writer's desire to conduct as practical and as natural an experiment as possible. This experiment, therefore, is an attempt to set up, in normally enrolled high school biology classes, two types of study technique -- without recitation periods, pupil discussions, etc., -- and to compare the achievements of the pupils as this achievement is influenced by the two techniques.

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5. Charters, W.W. Pure and Practical Research, Journal of Educational Research, September, 1925, pp. 95-101.

CHAPTER II

THE PROCEDURE

The three groups used in this experiment were regularly enrolled, sophomore biology pupils in Manual Training High School at Kansas City, Missouri. The experiment was conducted throughout the entire school year of 1930-1931. The percentage of the pupils was predominately foreign, -- twenty three percent Italian, twenty nine percent Jewish, mostly of the old orthodox type, and forty eight percent American. The fact that the homes of the pupils used in this experiment were on the "North Side" indicates a generally limited supply of supplementary material in the home and unfavorable provisions for home study.

The classes met during the first hour (8:00 to 8:50 A.M.), the fifth hour (11:40 A.M. to 12:30 P.M.), and the sixth hour (1:00 to 1:50 P.M.). The enrollment at Manual is quite shifting, therefore, the records of only those pupils who were present the greater part of the year were used as data. The first hour class, with an enrollment of thirty three, had but twenty three whose records were used. The fifth hour class enrolled thirty six, but the scores of only twenty five were used. In hour six there was an enrollment of forty six, but the scores of only thirty four were used. These figures represent a drop-out of twenty nine percent.

Hours "I" and "V", subsequently termed groups "A" and "B" respectively, were selected as the student-initiative groups, while hour "VI" subsequently referred to as group "X", was the teacher-initiative group. The membership of any group was purely chance, a pupil's com-

plete school program being responsible for his taking biology at that particular hour.

All classes were supplied with printed guide sheets, texts, and supplementary books. Each guide sheet presented a single unit. Each unit developed some underlying principle of biology, and was subdivided into from four to six sections, each section dealing with a major sub-principle. The guide sheets were made up of questions calling for the amassing and interpreting of information necessary to the development of an understanding of these principles. They also contained references to books and articles on the topics presented in the unit. The titles of the units, presented in the order in which they were studied, are as follows:*

Unit I	The Nature of Living Things.
Unit II	How Plants are Adapted for the Manufacture of Food.
Unit III	How Living Things Use Their Food: Digestion and Circulation.
Unit IV	How Living Things Use Their Food: Assimilation; Energy Production; Storage; Excretion.
Unit V	The Control of Plant and Animal Behavior.
Unit VI	How Living Things are Adapted to Their Environment.
Unit VII	How Plants and Animals Maintain Their Kind.
Unit VIII	How Plants and Animals Maintain Their Health.
Unit IX	The Modification and Improvement of Plant and Animal Forms.

Each student in each group answered in a notebook all the questions presented in each guide sheet. Three weeks were allowed for the completion of the study of each unit of work, and four days for the testing and reteaching program, thus, approximately four weeks were used for the com-

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*See the appendix, p. 59 for sample of the guide sheets.

pletion of each unit. All students in all groups began the study of each unit at the same time, but could progress in their study of that unit at their own rate of speed.

In all three groups, the pupils were permitted to study at home, as well as during the regular class period at school. They were not assigned regular seats, either in the lecture chairs or at the laboratory tables, but could work wherever and with whomsoever they wished, or they could work alone, just as long as they were quiet and were really working.

The main duty of the teacher, while the pupils were studying, was to check the notebooks. This was done for each student as he completed each section of a unit. At the first of the year, the notebooks were examined completely and thoroughly. If a given answer indicated incomplete understanding, the difficulty was discussed with the pupil individually, and he was then directed to make the necessary corrections in the notebook. Later on, when the pupils had become acquainted with the routine, only a few questions, samples of the complete section, were checked by the teacher because the work of completely checking all of the notebooks became too heavy. When there were no notebooks to check, the teacher would move about the room and give such suggestions and help as appeared to be necessary. This routine was followed for all classes, but in classes "A" and "B" the pupils had to ask for help, while in class "X" the teacher took the initiative in locating those needing help.

At the beginning of the study of each unit, one form of the

final test was given to all pupils in all classes. This served as a pretest and measured each pupil's achievement at the beginning of each unit. These papers were kept by the teacher and were neither shown to the pupils, nor was any information regarding them given to the pupils, since these scores were to be used only as a starting point from which to measure each pupil's achievement (or gain) in his study of the unit.

After the pretest was given the guide sheets were distributed, and general instructions on "how to study" were discussed before all groups. These general instructions were given at the beginning of the first two units of work, and, after that, only when there was evidence that the pupils were not studying properly, but were trying merely to answer isolated questions. The substance of these instructions is condensed into the following statements:

1-Read all the references, marking in the book the important topics as they occur to you, or making notes on your readings.

2-Endeavor to learn the principles or laws that govern the examples given. Learn to generalize; to organize your ideas.

3-Read the guide sheets through, first the main section headings, and then, as you read the individual questions, try to see in what way they apply to, or tend to explain, the subject of the section.

4-Answer the questions in your notebook.

The following special instruction was given verbatim to the student-initiative groups. "In case you cannot answer any question, leave space in your notebook for it and ask the teacher for personal help the next day". When a call came for help, the pupil was referred to sources where he could find the answer, or the question was answered for him by

the teacher. This help was given to but one pupil at a time and was personal and individual. It will be noted that the student imitiated all calls for help, and received none otherwise. The pupils could progress at their own rate of speed in working out the unit, but had to finish within the three-weeks time allotment.

To the teacher-initiative group, after the guide sheets were distributed the teacher gave a twenty to twenty-five minute lecture on the first section of the unit. Then the pupils were allowed to study according to the general instructions. When the teacher felt that it was the proper time to study the subsequent section, he would give a lecture on that section. It will be noted that in this group, the teacher took the initiative in orienting the students in their study of each section of the unit. The following special instruction was given verbatim to the teacher-initiative group. "In case you cannot answer a given question, leave space for it in your notebook and bring the question up before the class the next day". When one of these questions was asked at the beginning of the period the following day, the teacher either gave directions as to how to find the answer to it, or answered the question before the whole class. Reference was usually made to illustrations used in the first lecture for that section. No answers from other pupils were allowed, but every member of the class received the benefit of the teacher's explanations and the references which he supplied.

To take care, in any group, of the pupils who completed their notebook work ahead of time, these were asked to compile a scientific vocabulary and to construct a notebook of clippings pertaining to the principles set forth in the unit. It was not compulsory, however, that

the pupils study biology during this free time, and several students used the period for the preparation of other lessons. The only requirement was that they should keep busy.

At the end of each three-weeks period, as their first final test, one half of each and all groups was given one form of the test while the other half was given the other form. These tests were scored, and were returned to the pupils the next day. When the tests were returned, the pupils were instructed to try to correct their mistaken notions.

In the student-initiative groups, if a given pupil could not locate the solution of any of his difficulties, the teacher directed his search for the answer, or otherwise, individually and personally, aided in handling his difficulty. In the teacher-initiative groups, a different technique was employed. After giving the pupils sufficient time to locate and correct their mistakes, this group was divided for the discussion of errors according to the test form that they had taken. Each question that had given trouble was discussed in another room before these separate half classes. This prevented the other half of the class from hearing the discussion and receiving coaching on the test that they were about to take. In this way, even though a pupil knew what was correct in connection with the errors he had made, he received additional assistance and training. It will be noted that, in this reteaching period, the help given to the pupils in the student-initiative groups was individual help, while that given to the teacher-initiative group was group help.

On the second day following the first final test -- the first day

having been used for correcting errors, or as a reteaching period -- the alternate form of the test was given as a second final test. These second final tests were scored, but were never returned for inspection unless the pupils requested them. The pupils were informed as to their scores so that they might see what progress they had made.

It was thought at first that any advantage one form of the test might have over the other would be eliminated by giving half of each form to each class as a first final test and reversing the order in giving the second final test. Whatever advantage accrued in this technique was more than lost by evidences of coaching in all groups. Under these first conditions, coaching was easily accomplished because both forms had been corrected by the teacher after the first final test, and the pupils could not be restrained from discussing the questions outside of class. To substantiate the belief that there was coaching, a blind vote was asked on the question, "Did you receive any help, directly or indirectly, on the test questions?" Fifty six voted YES while forty voted NO. To overcome this coaching effect, after the fifth unit all the pupils were given the same form of the test at the same time.

With the exceptions that have been noted, the above technique was continued throughout the whole school year, each group continuing the technique first used in that group. All pupils in all classes began and ended each unit at the same time.

CHAPTER III

JUSTIFICATION OF THE PROCEDURE

In determining which class should be subjected to one or the other experimental factor, the sixth hour was chosen as the teacher-initiative group because it was the largest class and the technique planned was more nearly the customary group method. The classes in hours one and five were subjected to the student-initiative technique, the more individualized type, first, because these were smaller groups and, second, because they came at the periods of the day when the efficiency index is highest. Although studies differ as to the advantage in learning according to the time of day, Miss King's study,* gives the following efficiency indices; 9:30-103, 10:30-98, 11:30-106, 1:30-92 and 2:30-101.

No attempt was made to pair the pupils in each group because a technique for comparing groups according to I.Q., using measures of both central tendency and variability, was decided upon. It was also noted that the M.A. of the groups gave essentially the same comparison, both as to central tendency and to variability, as did the I.Q.s. Mental age was determined from the Terman group intelligence test. This test was given to the pupils as a part of the regular routine work of the educational councilor. Not having given the tests nor knowing the scores of the pupils until the end of the year, the teacher felt there was nothing to bias him regarding any pupil during the progress of the

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*Unpublished, but reported by Thorndike. See Sandiford, "Educational Psychology," p. 272.

experiment.

The opinion might be advanced that when the form, used as a pretest, was given as a final test, the score of the final would be raised, due to the coaching effect of the fact that the pupils had seen the test before. Data were prepared on unit IV in order to compare the gains made by using two different combinations of tests. These combinations were:--

1st Comb.: Form 2 as Pre T., Form 2 as F_1, and Form 1 as F_2.
2nd Comb.: Form 2 as Pre T., Form 1 as F_1, and Form 2 as F_2.

When the first combination was used, a mean gain of 9.4 points was made from the pretest to F_1 and a mean gain of 18.5 from pretest to F_2. When the second combination was used, a mean gain of 7.5 points was made from the pretest to F_1 and a mean gain of 16.2 from pretest to F_2. The mean gain between the first and second finals in each combination is approximately nine points. This comparison shows that there is very little difference in gains made, whether the pretest is used as the first final or as the second final. For fear of being influenced, even unconsciously, into "tutoring" the pupils in the teacher-initiative group, the teacher did not read over any of the tests before administering them.

The data for class "A" were kept separate from those for class "B" when comparing results for these classes with the results for class "X", because Class "A" reacted differently from class "B" even though both were subjected to the same experimental factor.

Each group was a separate entity and it was apparent more information was available where the results for Class "A" were kept separate from Class "B".

In this experiment the major variable is the two types of study technique. However, there is another variable which enters the study. This is the individual type of instruction, used in conjunction with the student-initiative technique, as opposed to the group type of instruction, used with the teacher-initiative technique. In the student-initiative technique, the teacher's help must necessarily be given individually, for usually no two students have the same difficulty at the same time. Each student and each difficulty is somewhat different and an individualized technique is inherent to the student-initiative set up. In the teacher-initiative plan, the teacher's duty is to take the initiative and to direct the group in its study. Therefore, a group type of technique is inherent to the teacher-initiative set up. These secondary teaching factors are, therefore, of necessity adapted to the two major techniques used in this experiment and are inseparable functions of the major variable.

In the correction of note books, the difficulties are necessarily of an individual nature. Therefore, in this phase of the teacher's duties, the work must be done individually with members of all three groups.

In this investigation T-Scores were to be used instead of raw scores because the raw scores were not comparable in any way. One

test had a total raw score of 73 points while another had a total of but 24 points. The data for obtaining these T-Scores were obtained from the records of from two hundred fifty to two hundred seventy five tenth grade pupils taught according to the outlines represented by the guide sheets used in this experiment. Standardization has been carried by the maker of the tests* to the place that the T-Scores are accurate to one T-score point. It is well to note that the T-Scores were not available for all tests until after the regular school year was completed. This made it impossible for the teacher to foresee the outcome of the experiment and thereby be influenced either toward one technique or the other.

In setting up the experiment, all three classes were told at the beginning of the year that an experiment was to be conducted to see which of the methods of study used in the different classes helped the students to learn more. There were no objections raised by the pupils. and tho there was no unusual interest shown, they all seemed to accept the situation and afterwards gave the matter little attention. It was later thought that to rotate the techniques among the classes at the mid-year would be desirable. It was even suggested by some of the pupils that they be changed to the other plan because they thought that it would be easier. However, it was decided to hold the groups to the same technique throughout the entire year and thereby take advantage of any cumulative effect that the continued use of one technique

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*Prof. E.E. Bayles, University of Kansas.

would give. Often experiments are carried on for such a short period of time that any effect the experimental factor would have is not given sufficient opportunity to show the advantages which may be inherent to it. This plan gave each technique as much opportunity as possible to show its effect. Rotation would have tended to equalize any carry over from one technique to the other. The teacher felt confident that his attitude toward one technique or the other was not weighted, although one of the most difficult problems for him to meet was that of refraining consistently from volunteering aid to the student-initiative pupils.

CHAPTER IV

PRESENTATION AND INTERPRETATION OF DATA

In Table I will be found the I.Q., M.A., and C.A. of each pupil in each group in this experiment. The table should be interpreted as follows,--Pupil 1 of class "A" has an I.Q. of 123, an M.A. of 212 and a C.A. of 173. Pupil 1 of class "B" has an I.Q. of 125, an M.A. of 201 and a C.A. of 161, etc.

At the bottom of the table will be found the mean and the standard deviation of the distribution given in each column. Classes "A" and "B" are the student-initiative groups and Class "X" the teacher-initiative group. In interpreting the table, comparison is made between class "A" and class "X" and also between class "B" and class "X". This is done because the conclusions of this experiment are based on the mean gains made by class "X", the teacher-initiative group, compared with the mean gains made by both classes "A" and "B", the student-initiative groups.

In comparing class "A" with class "X" it will be seen that there is very little difference in the means of these two groups. In comparing class "B" with class "X", class "B" has approximately a six point advantage in mean I.Q. and M.A. over class "X". These means are,--

Class "A"	I.Q. 96.78	M.A. 170.43	C.A. 177.91
Class "B"	I.Q. 102.48	M.A. 175.76	C.A. 172.08
Class "X"	I.Q. 96.59	M.A. 169.50	C.A. 175.88

The standard deviations of the distributions of the classes indicate that class "X" is slightly more homogeneous than class "A". Class "B" has a

four point advantage over class "X" in M.A. while the standard deviations of the I.Q.s of these two classes are approximately equal. The standard deviations are:--

Class "A"	I.Q.	13.47	M.A.	17.66	C.A.	10.83
Class "B"	I.Q.	10.83	M.A.	13.28	C.A.	11.71
Class "X"	I.Q.	10.15	M.A.	17.04	C.A.	8.82

In making a general comparison between each of the student-initiative groups and the teacher-initiative group, one would expect about the same results from class "A" and class "X" provided they were subjected to like conditions of study, while better results would be looked for from class "B" than from class "X" under like conditions.

TABLE I

Intelligence Quotients, Mental Ages,* and Chronological Ages of Pupils in Classes "A", "B" and "X"

	Class "A"			Class "B"			Class "X"		
Pupil	I.Q.	M.A.	C.A.	I.Q.	M.A.	C.A.	I.Q.	M.A.	C.A.
1	123	212	173	125	201	161	117	211	180
2	118	197	166	121	195	161	117	196	168
3	114	192	169	120	188	157	112	191	171
4	113	184	162	115	180	157	108	184	171
5	109	184	169	113	204	181	105	179	171
6	107	190	178	111	194	175	105	179	171
7	107	183	171	109	192	177	105	159	152
8	105	181	172	109	184	168	104	192	184
9	104	169	162	108	178	165	102	191	187
10	98	176	179	107	174	163	102	182	179
11	94	171	181	105	169	161	102	182	178
12	94	159	169	101	166	164	102	169	166
13	93	168	181	100	170	171	101	192	191
14	93	164	176	99	178	180	101	176	174
15	92	177	193	97	178	184	99	174	176
16	89	152	170	97	159	164	88	168	171
17	88	168	191	96	171	178	97	172	177
18	86	162	188	96	162	168	96	172	180
19	86	161	188	95	164	172	96	159	166
20	85	163	191	93	163	176	95	164	173
21	84	149	178	92	167	181	94	152	161
22	76	142	186	91	166	182	93	156	167
23	68	136	199	91	153	169	93	153	165
24				90	167	185	92	177	192
25				81	171	212	92	163	177
26							92	163	177
27							91	163	180
28							91	161	176
29							85	149	175
30							84	163	193
31							83	150	181
32							80	145	182
33							79	143	180
34							71	133	188
Means (1	96.78			102.48			96.59		
Column (2		170.43			175.76			169.50	
(3			177.91			172.08			175.88
Sigma (1	13.47			10.83			10.15		
Column (2		17.66			13.28			17.04	
(3			10.15			11.71			8.82

*I.Q. and M.A. based on Raw Scores, Terman Group Intelligence Test.

Interpretation of Tables II to XIX

In the "A" section of Table II are presented the mean test scores, and the gains made between the pretest and the final tests (in T-Score points) made by classes "A" and "X". The second row of the table presents the standard deviations of the distributions for which the means are given in the first row.

In the "B" section of Table II is presented a comparison between class "X" and class "A" of the advantages shown on the final tests. It also gives the statistical significance of the obtained difference, as interpreted by Garrett.*

The abbreviations used in the table are as follows:--

PreT.--the T-score made on the pretest.

F_1-----the T-score made on the first final test.

F_2-----the T-score made on the second final test.

G_1-----the gain in T-score made between the pretest and first final.

G_2-----the gain in T-score made between the pretest and second final.

Adv.---the difference between gains made by class "X" and class "A".

G_1X--G_1A indicates the advantage made by Class "X" on G_1 over Class "A" on G_1.

G_2X--G_2A indicates the advantage made by Class "X" on G_2 over Class "A" on G_2.

The interpretation of table II is as follows:--Class "A" made a mean T-score of 34.33 on the pretest, a mean T-score of 45.62 on the first

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*Garrett, Henry E. Statistics in Psychology and Education, p. 134.

final test and 48.76 on the second final test. The mean T-score gain of the first final test over the pretest was 11.29 (45.62--34.33) while the gain made by the second final test over the pretest was 14.43 (48.76--34.33). In the second row are given the standard deviations of the distributions of the scores that are given in the first row. These S.D.'s are, PreT. 6.71, F_1 7.32, F_2 9.62, G_1 5.70 and G_2 is 10.70. Similar interpretations should be made of the data for Class "X". These figures supply the basic figures for comparing the advantage shown by one type of technique over the other type of technique.

In the "B" section of Table II are given the advantages of Class "X" over Class "A". The row of figures following "G_1X--G_1A" should be interpreted as follows:--6.81 (18.10--11.29) is the advantage in T-score points of Class "X" on G_1 over class "A" on G_1. In interpreting Tables II to XIX if this figure is positive it shows that the advantage goes to class "X" and if negative it indicates an advantage for either class "A" or class "B" as the case may be. The sigma of the difference, or the standard error of this obtained difference is 2.10. This was found by using the formula,

$$\text{Sigma}_{\text{diff}} = \sqrt{\text{sigma}^2_{\text{ave1}} + \text{sigma}^2_{\text{ave2}}}$$

According to Garrett,[1] when an obtained difference is more than three times the sigma of that difference, the obtained difference is spoken of as a "true difference." This means, that one is "practically certain" (99.76 chances in 100) that the differences found, if the experiment were repeated any number of times, will be found to be in the same

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1. Garrett, H.E. Statistics in Psychology and Education, pp. 128-133.

direction as the obtained difference in this experiment. Garrett also supplies a table[1] to show the number of chances in one hundred for a true difference when the obtained difference is less than three times the sigma of that difference.

In Table II, Adv. divided by $Sigma_{diff}$ (6.81/2.10) gives 3.24. This value is .24 greater than three times $Sigma_{diff}$. the amount necessary to indicate a "true difference" (100 chances in 100). The second row, G_2X--G_2A is interpreted as follows: 2.70 (17.13--14.43) is the advantage in T-score points of class "X" on G_2 over class "A" on G_2. 3.01 is the $Sigma_{diff}$ of the obtained difference. .90 indicates that the obtained difference (2.70) is but .90 of the sigma of that difference. According to Garrett's "Table XIV", .90 predicts eighty two chances in one hundred that the true difference would be in favor of class "X".

Tables III to XIX give similar data and comparisons between classes "A" or "B" and class "X" on subsequent units of work, and should be interpreted in a similar manner.

In this study, when the obtained difference is three times the sigma of that difference or 99.76 chances in 100 for a true difference in favor of class "X", it will be considered a "true difference". When the obtained difference is two times the sigma of that difference or ninety eight chances in one hundred for a true difference, it will be considered as a "very satisfactory difference". When the chances are from eighty to ninety eight in one hundred for a true difference it will be considered as a "satisfactory difference". When the chances are shown to be between

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1. op. cit., Table XIV, p. 134.

twenty and eighty chances in one hundred it is considered that no distinct advantage is indicated for either class. When the chances are below 20 in 100, a "significant" advantage is indicated in favor of Class "A" or "B", as the case may be.

Tables showing the individual scores of the pupils on each of the units from which these tables are compiled will be found in the appendix. (Tables XXII to XXX).

TABLE II

A. Mean Scores and Gains Made by Class "A" and "X" on Unit I

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	34.33	45.62	48.76	11.29	14.43
S.D.	6.71	7.32	9.62	5.70	10.70

Class "X"

Mean	27.93	46.03	45.06	18.10	17.13
S.D.	4.71	7.79	8.50	9.26	10.38

B. Advantages in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	$Adv./Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
$G_1X—G_1A$	6.81	2.10	3.24	100 in 100
$G_2X—G_2A$	2.70	3.01	.90	82 in 100

TABLE III

A. Mean Scores and Gains made by Class "B" and Class "X" on Unit I

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	32.70	44.80	48.50	12.10	15.80
S.D.	5.86	7.81	6.56	6.68	6.56

Class "X"

Mean	27.93	46.03	45.06	18.10	17.13
S.D.	4.71	7.79	8.50	9.26	10.38

B. Advantages in Gains Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	6.00	2.25	2.66	99 in 100
G_2X—G_2B	1.33	2.39	.55	71 in 100

TABLE IV

A. Mean Scores and Gains made by Classes "A" and "X" on Unit II

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	34.70	41.78	54.40	7.08	19.70
S.D.	6.70	9.38	12.16	10.23	11.83

Class "X"

Mean	31.50	49.63	58.37	18.13	26.87
S.D.	7.24	6.73	7.90	10.91	11.55

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A	11.05	2.92	3.78	100 in 100
G_2X—G_2A	7.17	3.24	2.21	99 in 100

Table V

A. Mean Scores and Gains made by Classes "B" and "X" on Unit II

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	30.96	42.69	53.86	11.73	22.91
S.D.	5.78	5.48	8.66	8.63	11.43

Class "X"

Mean	31.50	49.63	58.37	18.13	26.87
S.D.	7.24	6.73	7.90	10.91	11.55

B. Advantages in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	6.40	2.68	2.39	99 in 100
G_2X—G_2B	3.96	3.18	1.24	89 in 100

TABLE VI

A. Mean Scores and Gains made by Class "A" and "X" on Unit III

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	33.65	49.09	55.52	15.44	21.87
S.D.	7.64	7.65	11.52	8.84	11.47

Class "X"

Mean	30.58	41.79	48.97	11.21	18.38
S.D.	7.18	8.48	8.59	9.38	11.64

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A—4.23*	2.45	—1.72*		4 in 100
G_2X—G_2A—3.49*	3.12	—1.12*		14 in 100

*A negative figure signifies that Class "A" made a net gain over Class "X".

TABLE VII

A. Mean Scores and Gains made by Classes "B" and "X" on Unit III

Class "B"

	PreT.	F_1	F_2	G_1	G_2
Mean	31.17	44.08	55.13	12.91	23.96
S.D.	5.30	8.72	9.42	9.74	9.35

Class "X"

	PreT.	F_1	F_2	G_1	G_2
Mean	30.58	41.79	48.97	11.21	18.38
S.D.	7.18	8.48	8.59	9.38	11.64

B. Advantage in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	—1.70*	2.59	—.65*	26 in 100
G_2X—G_2B	—5.58*	2.79	—2.00*	2 in 100

*A negative figure signifies that Class "B" made a net gain over Class "X"

TABLE VIII

A. Mean Scores and Gains made by Classes "A" and "X" on Unit IV

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	38.52	48.91	54.09	10.39	15.57
S.D.	5.38	8.75	12.55	9.05	12.56

Class "X"

Mean	37.53	47.24	54.65	9.71	17.12
S.D.	6.23	8.76	8.30	8.51	8.83

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X-G_1A	—.68*	2.39	—.28	39 in 100
G_2X-G_2A	1.55	3.02	.51	69 in 100

*A negative figure signifies that Class "A" made a net gain over Class "X".

TABLE IX

A. Mean Scores and Gains Made by Classes "B" and "X" on Unit IV

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	36.46	43.71	53.13	7.25	16.67
S.D.	7.07	8.68	8.52	9.97	12.08

Class "X"

Mean	37.53	47.24	54.65	9.71	17.12
S.D.	6.23	8.76	8.30	8.51	8.83

B. Advantage in Gains Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	2.46	2.50	.98	83 in 100
G_2X—G_2B	.45	2.89	.15	56 in 100

TABLE X

A. Mean Scores and Gains made by Classes "A" and "X" on Unit V

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	39.26	46.04	51.65	6.78	12.39
S.D.	9.55	8.78	12.13	7.21	7.82

Class "X"

Mean	39.59	49.44	53.09	9.85	13.50
S.D.	8.39	10.78	11.27	9.95	9.35

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A	3.07	2.27	1.35	91 in 100
G_2X—G_2A	1.11	2.29	.48	68 in 100

TABLE XI

A. Mean Scores and Gains Made by Classes "B" and "X" on Unit V

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	44.00	49.72	52.20	5.72	8.20
S.D.	6.97	10.74	9.17	8.69	9.88

Class "X"

Mean	39.59	49.44	53.09	9.85	13.50
S.D.	8.39	10.78	11.27	9.95	9.35

B. Advantage in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./Sigma diff.	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	4.13	2.44	1.69	96 in 100
G_2X—G_2B	5.30	2.55	2.08	98 in 100

TABLE XII

A. Mean Scores and Gains Made by Class "A" and "X" on Unit VI

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	36.00	45.78	48.22	9.78	12.22
S.D.	8.55	6.08	9.89	8.78	6.89

Class "X"

Mean	35.03	44.64	46.82	9.61	11.79
S.D.	7.48	8.73	10.86	7.14	7.68

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A	—.17*	2.20	—.08*	48 in 100
G_2X—G_2A	—.43*	1.94	—.23*	41 in 100

*A negative figure signifies that Class "A" made a net gain over Class "X"

TABLE XIII

A. Mean Scores and Gains Made by Classes "B" and "X" on Unit VI

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	36.48	45.72	44.28	9.24	7.80
S.D.	8.03	11.46	8.47	8.77	5.78

Class "X"

Mean	35.05	44.64	46.82	9.61	11.79
S.D.	7.48	8.73	10.86	7.14	7.68

B. Advantage in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	.37	2.13	.17	56 in 100
G_2X—G_2B	3.97	1.76	2.25	99 in 100

TABLE XIV

A. Mean Scores and Gains Made by Classes "A" and "X" on Unit VII

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	37.83	48.52	48.78	10.69	10.95
S.D.	8.55	9.47	6.67	12.52	9.13

Class "X"

Mean	36.03	52.39	56.64	16.06	20.61
S.D.	7.14	11.63	10.60	13.46	11.73

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A	5.37	3.50	1.53	93 in 100
G_2X—G_2A	9.66	2.78	3.47	100 in 100

TABLE XV

A. Mean Scores and Gains Made by Classes "B" and "X" on Unit VII

	Pre T.	F_1	F_2	G_1	G_2
Class "B"					
Mean	39.24	50.24	50.04	11.00	10.80
S.D.	7.69	8.74	8.51	14.09	10.90
Class "X"					
Mean	36.03	52.39	56.64	16.06	20.61
S.D.	7.14	11.63	10.60	13.46	11.73

B. Advantage in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X--G_1B	5.06	3.66	1.38	92 in 100
G_2X--G_2B	9.81	2.98	3.29	100 in 100

TABLE XVI

A. Mean Scores and Gains Made by Classes "A" and "X" on Unit VIII

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	39.70	46.52	44.96	6.82	5.26
S.D.	9.46	10.02	9.58	11.89	7.90

Class "X"

Mean	38.03	43.56	48.91	5.53	10.88
S.D.	8.31	7.17	8.08	8.39	9.22

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A	—1.29*	2.87	—.45*	33 in 100
G_2X—G_2A	5.62	2.29	2.45	99 in 100

*A negative figure signifies that class "A" made a net gain over Class "X".

TABLE XVII

A. Mean Scores and Gains Made by Classes "B" and "X" on Unit VIII

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	36.08	50.64	49.00	14.56	12.92
S.D.	6.75	6.78	5.86	8.25	8.02

Class "X"

Mean	38.03	43.56	48.91	5.53	10.88
S.D.	8.31	7.17	8.08	8.39	9.22

B. Advantage in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X-G_1B	—9.03*	2.19	—4.12*	0 in 100
G_2X-G_2B	—2.04*	2.25	—.91*	18 in 100

*A negative figure signifies that Class "B" made a net gain over Class "X".

TABLE XVIII

A. Mean Scores and Gains Made by Class "A" and "X" on Unit IX

Class "A"

	Pre T.	F_1	F_2	G_1	G_2
Mean	36.59	51.77	49.32	15.18	12.73
S.D.	12.19	10.88	9.96	12.36	7.82

Class "X"

Mean	38.03	50.59	52.59	12.56	14.56
S.D.	8.80	9.82	7.99	10.92	8.31

B. Advantage in Gains - Class "X" over Class "A"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1A	—2.62*	3.24	—.81*	21 in 100
G_2X—G_2A	1.83	2.19	.83	80 in 100

*A negative figure signifies that Class "A" made a net gain over Class "X".

TABLE XIX

A. Mean Scores and Gains Made by Classes "B" and "X" on Unit IX

Class "B"

	Pre T.	F_1	F_2	G_1	G_2
Mean	37.00	47.24	50.44	10.24	13.44
S.D.	6.79	5.81	5.71	6.74	7.60

Class "X"

Mean	38.03	50.59	52.59	12.56	14.56
S.D.	8.80	9.82	7.99	10.92	8.31

B. Advantage in Gains - Class "X" over Class "B"

	Adv.	$Sigma_{diff.}$	Adv./$Sigma_{diff.}$	Chances in 100 that the true diff. is in favor of Class "X"
G_1X—G_1B	2.32	2.31	1.00	84 in 100
G_2X—G_2B	1.12	2.09	.54	71 in 100

Interpretation of Tables XX and XXI

Tables XX and XXI summarize the advantages, with the statistical significance of the differences, as shown throughout the entire experiment. The units are numbered in the order in which they were studied.

In the second and third colums of Table XX are shown the advantages in T-Score points of Class "X" over Class "A". When the figure is negative it indicates that class "A" excelled class "X". It will be noted that class "X" produced better results in four of the nine units on the first final tests (Units I, II, V, and VII), while class "X" excelled in seven of the nine units on the second final tests (Units I, II, IV, V, VII, VIII, and IX).

The statistical significance of these obtained differences is given in the last two columns of the table. This significance is stated in terms of the chances in one hundred that the obtained difference will be found in the same direction as in this experiment. When a difference is likely to recur in the same direction 99.76 chances in one hundred, it is considered a "true difference" in favor of class "X" and the number is followed by the letter "T". If the chances are ninety eight or ninety nine in one hundred, it is considered a "very satisfactory difference" in favor of class "X" and is followed by the letters "VS". If the probable chances are above eighty in one hundred, it is termed a"satisfactory difference" in favor of Class "X" and is marked "S". When the figures show less than twenty chances in one

hundred, it indicates a "satisfactory or better" difference in the other direction, or in favor of class "A" or class "B" as the case may be, and is followed by an asterisk (*). If 0 (zero) chances in one hundred, it indicates a "true difference" in favor of class "A" or "B". If one or two chances in one hundred it represents a "very satisfactory difference" in favor of class "A" or "B". If three to twenty chances in one hundred, it represents a "satisfactory difference" for class "A" or "B". The interpretation of the figures below twenty is therefore the reverse of the interpretation of the figures above eighty. Figures between twenty and eighty are interpreted as indicating no distinct or significant advantage for either class.

Considering the advantages shown on the first final tests, the method used in class "X" appears to be the more advantageous in four of the nine units, with four units showing no distinct advantage for either class. A "T" difference is shown in two units (I and II) and an "S" difference in two other units (V and VII). The results from the method used in class "A" shows an "S" advantage for unit III only. Considering the advantages shown on the second final tests, the method used in class "X" is shown to be the more advantageous in all but two of the nine units (Units III and VI), with one "T" (Unit VII), two "VS" (Units II and VIII), and two "S" (Units I and IX) differences. Class "A" again excelled in unit III with an "S" advantage.*

In comparing class "B" with class "X" (Table XXI), the advantages ofclass "X" on the first final tests excelled those of class

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*See page 47 for a discussion of Unit III.

"B" in seven of the nine units (Units I, II, IV, V, VI, VII, and IX). Class "X" excelled class "B" in the same seven units as to advantages shown on the second final tests. The data presented in the last two columns show that the method used in class "X" gives some advantage in all but one unit on the first final tests (unit VIII). There are two "VS" (units I and II) and four "S" (Units IV, V, VII, and IX) differences. The method used by class "B" shows a "true difference", on unit VIII. Considering the second final tests, the method used by class "X" appears to be the more advantageous in all but two of the nine units (units III and VIII). There are one "T" (Unit VII), two "VS" (units V and VI), and one "S" (Unit II) differences. The method used in class "B" is shown to be the more advantageous on two units, Unit III with a "VS" difference, and Unit VIII with an "S" difference.

TABLE XX

Summary of Advantages of Class "X" over Class "A"

	Advantage in Gains Class "X" over Class "A"		Chances in 100 that the true diff. is in favor of Class "X"	
	F_1	F_2	F_1	F_2
Unit I	6.81	2.70	100 T	82 S
II	11.05	7.17	100 T	99 VS
III	--4.23	--3.49	4 S*	14 S*
IV	--.68	1.55	39	69
V	3.07	1.11	91 S	68
VI	--.17	--.45	48	41
VII	5.37	9.66	93 S	100 T
VIII	--1.29	5.62	33	99 VS
IX	--2.62	1.83	21	80 S

TABLE XXI

Summary of Advantages of Class "X" over Class "B"

	Advantages in Gains Class "X" over Class "B"		Chances in 100 that the true diff. is in favor of Class "X"	
	F_1	F_2	F_1	F_2
Unit I	6.00	1.33	99 VS	71
II	6.40	3.96	99 VS	89 S
III	--1.70	--5.58	26	2 VS*
IV	2.46	.45	83 S	56
V	4.13	5.30	96 S	98 VS
VI	.37	3.97	56	99 VS
VII	5.06	9.81	92 S	100 T
VIII	--9.03	--2.04	0 T*	18 S*
IX	2.32	1.12	84 S	71

CHAPTER V

CONCLUSIONS

In drawing conclusions from the findings of this experiment,* the reader will notice, first, that the two classes using the student-initiative technique did not show results in accordance with expectations. Class "B", according to the I.Q. and M.A. data, should have made a better showing in comparison with Class "X" than should class "A". Instead, however, class "A" shows advantages over class "X" in five units, while class "B" shows advantages over class "X" in only two units. These figures perhaps should be reduced by one each because Unit III, in which both classes show an advantage over class "X", was handled somewhat differently than were any of the other units in the student-initiative groups.

This unit (No. III) was the first one in which the human body was studied. Since the texts were rather meager in their discussions of the general anatomy of the body, and since it seemed that the human body and its functioning was one of the most important divisions of biology, the teacher gave a general lecture to the "A" and "B" groups as well as to class "X", at the beginning of the study of this unit. This was the only case where the student-initiative method was not consistently followed in classes "A" and "B". The writer believes that the reason the results for unit III differ so drastically from those of the units preceding and following it, is that, due to the change, the "A" and "B" pupils gave much closer attention during the lecture than did the

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*See Tables XX and XXI.

"X" pupils.

Considering the results of both student-initiative classes in comparison with Class "X", the teacher-initiative technique shows up as the more advantageous method on the first final tests in eleven of the eighteen units, and on the second final tests in fourteen of the eighteen units. When the significance of these differences is considered, however, we find that ten out of the eleven advantages on the first final tests are statistically significant (eighty chances in one hundred, or better) in favor of the teacher-initiative method, and are divided into two "T", two "VS" and six "S" differences. Considering the second final test results, the teacher-initiative method shows two "T", four "VS" and three "S" differences, or nine significant advantages out of a possible fourteen.

The first conclusion, therefore, is that, under the conditions of this experiment, the advantage is decidedly in favor of the teacher-initiative technique.

But this is not the whole story that the data in Tables XX and XXI tell. It will be noted, in examining the advantages shown for class "X" during the first part of the year (Units I and II) as compared with those shown at the end of the year (Units VII and IX) that the tendency is for the student-initiative technique to reduce these advantages for the teacher-initiative technique as the year progressed. For example, in Table XX, on the first final tests, the teacher-initiative group was reduced from showing a "T" difference on the first two units, to two units that show only a "33" and "21" chance difference: By further examination, it will be noted that

smaller advantages were registered on the second final tests than were made on the first final tests in nine of the eighteen units. These reduced advantages caused by the student-initiative groups learning more during the reteaching period - are shown in Units I, II, V, and VI in Table XX and units I, II, III, IV, and IX in Table XXI. Although the teacher-initiative technique produced more advantageous results in fourteen units out of eighteen on the second final tests, nevertheless, the advantages were reduced in nine of these units from the advantages shown on the first final tests. This would indicate that the students using the student-initiative technique learned more in the period between the two final tests.

The second conclusion, therefore, is that, if the time were extended under the conditions of this experiment, the student-initiative technique might prove finally to be the better.

Perhaps, after all, a more pertinent general conclusion to be drawn from the results of this experiment is, that the pupils will learn more and be more greatly benefited if they are taught by some method such as that used by the student-initiative groups. The students in all groups had been taught practically always during their school experience by methods similar to the teacher-initiative technique. Those in the student-initiative groups had to overcome the habits of these past years of training, and had to acquaint themselves with and adjust themselves to this new "self-directed" method of study. After leaving school, the pupils must be self-reliant and self

directive. Therefore, pupils taught by some sort of student-initiative method probably will be better trained for future life than when trained by some sort of teacher-initiative method.

To summarize the conclusions which seem to be justified from a study of the data obtained in this experiment, it may therefore be said,

First, that the method used by the teacher-initiative group produced the most satisfactory results,

Second, that, if the experiment were continued for a sufficiently long period, the student-initiative method might show results that would prove it to be the more advantageous method to use, and

Third, that a method similar to the one used by the student-initiative groups probably would be better training for students as a preparation for life.

APPENDIX

A copy of the guide sheets and both forms of the test for Unit II are given on the following pages. Form I of the test will be seen to be a true false test, while Form II is the controlled completion type. These two types of tests together with three others, the modified true false, the divided sentence and the multiple choice types were used in different combinations in the other eight units. A copy of the modified true false test is also included because it is a relatively unfamiliar type.

Following these samples of "tools" used in the experiment are tables that present the T-scores made by the individual pupils throughout the experiment.

BIOLOGY

Unit II Name _____

HOW PLANTS ARE ADAPTED FOR THE MANUFACTURE OF FOOD

I. How plants manufacture food.

1. After finding some ways in which animals are adapted for obtaining food we turn to the problem of how plants obtain food. Plants are, on the whole, not able to move about, and so use other means for getting food. Plants are food makers--food factories. In what part or parts of the plant does this food making process take place? What types of food (nutrients) are manufactured by plants? What type is produced in greatest abundance?
2. The process of food manufacture is called photosynthesis. Explain the derivation of this term, and its meaning.
3. What are the raw materials that are used in the photosynthesis of starches and sugars? Give the chemical equation for this reaction. What gas is produced as a by-product of this chemical action? What becomes of this product? Of what advantage is this to animals?
4. What chemical elements do proteins contain that carbohydrates do not? From what source do these elements come? (This is a function of the soil water.)
5. What substance in the leaves of a plant is responsible for carrying on this photosynthetic process? Describe it.
6. Examine a leaf in cross section. Make a drawing of it under the microscope and label the parts. Indicate the upper epidermis, lower epidermis, palisade cells, chlorophyll bodies, spongy layer, stomata.
7. Give the function of each of the parts indicated in the drawing.
8. Why are the cells of a leaf rather far apart, giving the leaf a rather spongy texture?
9. Under what conditions does this photosynthetic process proceed? Examine plants that have grown in the light and those grown in the dark. Compare them. What differences do you note? Test for the presence of starch in the leaves of both plants.
10. Is it true that plants obtain all their food from the soil? Explain.
11. Will plants which are not green manufacture food? Explain.

II. How food-making materials are taken from the soil.

1. Is a proper soil necessary for the growth of plants? Why? Are there any exceptions? If so, what?
2. Make a list of about ten elements which are used in the makeup of plant food. Give the chemical symbol for each.
3. Which of these elements are obtained primarily from the air in the process of food manufacture? Which from the soil?
4. How is the root specially adapted to take up these materials from the soil? Examine root hairs, and make drawings of them. Also make a cross section drawing of a root, and label the parts.
5. Explain osmosis. In what condition must any material be in order to pass through a plant or animal membrane by osmosis? Therefore, what is one very important function of the water in the soil?

6. Explain how the root, by osmotic action, is able to take water, together with the dissolved food materials, from the soil, and raise it clear to the tips of the topmost leaves of the plant. (Note: Osmotic pressure is probably not the only cause of this action; scientists do not yet have a fully satisfactory explanation. It is probably the principal cause.)
7. In osmosis, there is passage of liquids both ways. What purpose, if any, does the water serve that goes out from the roots into the soil? How is this an advantage?
8. What other purpose or purposes has the root? Discuss fully.
9. Are all roots alike in size, structure, and function? Illustrate and discuss.
10. In a paragraph, summarize by telling how the roots contribute to the welfare of plants.

III. How food-making materials are transported from the soil to the leaves.

A. Functions of the stem.
1. Where does the soil water go after it enters the root?
2. In the osmotic action of the root, more water enters the plant than goes back into the soil. Is all the water that is sent upward from the root through the stem, used by the leaves in the manufacture of food? If not, what becomes of it? What is this process called?
3. Why is there a downward movement of sap through the stem? In what part of the stem does this downward movement of sap occur? The upward movement? Give evidence for this conclusion.
4. What materials, if any, are carried by the downward movement of the sap, and what is their function? Why is it inaccurate to speak of the "circulation" of the sap?
5. Stems serve as a means of support, or as a framework for the plant. Classify stems according to their manner of serving as a support. Describe stems according to their types. Give examples.

B. The growth of stems.
1. The growing part of the stem is called the cambium. Where is the cambium located in the stem of a dicot? Of a monocot? Give examples of each of these types of plant. What is the significance of these names?
2. Would you expect this growing part to be in a place that is reached by both descending and ascending sap? Why?
3. Why does the process of "girdling" a tree kill it? Why must young fruit trees have wire netting or other guards placed around their trunks close to the ground in winter?
4. Distinguish between "determinate" and "indeterminate" growth of stems.
5. What is a "bud"? Describe one. What is its purpose? How can one distinguish between leaf buds and flower buds from visual observation.

C. Arrangement of stems.
1. Describe the excurrent type of branching and give several examples.

3. What is the significance of those two terms, that they should be used to indicate these two types of stem arrangements?
4. Describe the alternate arrangement of buds on the stem. The opposite arrangement.
5. Take a number of stems, with leaves attached, and, holding them in their normal position on the tree, look at them from the direction that the sun's rays fall upon them at noon. What do you find about the position of the leaves with reference to the sun's rays? How does the alternate or opposite leaf arrangement bring about this condition?
6. How does the size of the leaves at the upper part of the stem compare with that of the lower part? Of what advantage is this?
7. What happens to the lowest branches of a tree as the tree grows taller and larger? Note this especially among forest trees. Why is this?
8. Why is a forest tree, of the excurrent type, that has grown up among many others of the same size, a much better tree for producing lumber than one which has grown up by itself? What has caused this?
9. What, in general, is the purpose of any special type of stem arrangement of a plant?

D. In a paragraph, summarize by telling how stems are arranged so that they can most effectively aid the plant in food manufacture.

IV. How non-green plants obtain food.

1. Name several plants that do not manufacture their own food. How is the external appearance of all these plants different from the appearance of other plants?
2. How do these plants obtain their food? Discuss.
3. Describe each of the following plants as to appearance, food habits, and habitat; Indian pipe, mushroom, Pitcher Plant, bread mold.
4. What term is applied to organisms of this type; that is, those which depend for their living upon other organisms and give nothing in return? What are saprophytes? Give examples.

V. Summary.

Write a page or so on the topic of how plants are adapted for the manufacture of food, in which you summarize the essential points brought out in this unit.

Laboratory exercises:

Study osmotic action by using a potato and by using the regular apparatus designed for the purpose. Use both soluble and non-soluble materials, and also solutions of varying density. Make cross-section drawings of root, stem (both monocot and dicot), and leaf, using the high power compound microscope as necessary. Field trip to study leaf arrangements and to gather non-green plants.

References:

Andrews, Prac. Botany; Chap. 3, 4, 5, 6.
Bergen & Caldwell, Prac. Botany; Chap. 2, 3, 4.
Atwood; Pp. 38-88.
Clement; Chap. 28, 29, 30, 31.
Kinsey; Chap. 13.
Hunter, New Essentials; Chap. 7, 8, 9.
Moon; Chap. 8, 9, 10, 11, 12, 13.
Smallwood, Reveley & Bailey; (New); Chap. 26, 27, 28, 29, 33.

Biology. Unit II, Test 1. Date_____ Name_____

(Directions: Some of the following statements are true and some are false. In the parenthesis which immediately follows each statement, place a plus if the statement is true, and a minus if it is false (not true).

I

a. The process of photosynthesis is carried on only in green, chlorophyll-bearing plants. ( )a.
b. In a healthy leaf which is green with white strips, it is very likely that one would not find starch in the white portion, but would find it only in the green part. ( )b.
c. Oxygen is taken from the air by plants in the process of photosynthesis. ( )c.
d. A plant will be likely to produce more starch on a cloudy day than on a day that is bright and clear, because less energy is taken away from the photosynthetic process for carrying on respiration. ( )d.
e. Water and carbon dioxide are the raw materials used by the plant in the manufacture of starch. ( )e.
f. The soil salts, containing nitrogen, phosphorus, potassium, etc. are used by the plant in the making of proteins, but not for the making of starches and sugars. ( )f.
g. As a result of the photosynthetic process, plants give off large quantities of oxygen into the air. ( )g.
h. All the cells of a green leaf are very closely packed together in order to make possible the passage of sap from one cell to another. ( )h.
i. The chlorophyll bodies (chloroplasts) are usually found in all the cells of a leaf except those of the upper and lower epidermis, and possibly of the veins. ( )i.
j. The stomata and lenticels are passageways which carry water from the base of the leaf toward the tip. ( )j.

II

a. Roots serve as a means of anchorage or support and often for the storage of food, as well as for the purpose of obtaining food materials from the soil. ( )a.
b. The sap travels toward the stem, along the outer part of the root, just underneath the epidermis. ( )b.
c. Water is obtained from the soil by the root through very tiny tubes which open into the soil at the tips of the root hairs and lead from these tips to the stem and the leaves. ( )c.
d. The root hairs are the long, slender fibers which divide and subdivide at the outer end of each root. ( )d.
e. Each root hair is composed of one cell only, and is therefore very tiny. ( )e.
f. If the membrane which surrounds the root hair is semi-permeable it is not able to take moisture from the soil. ( )f.

g. In the process of growth, the root lengthens at the tip only; not at the base near the stem. ( )g.
h. Food material can be obtained from the soil by the root only when it is dissolved in the soil water. ( )h.
i. Any and all soil material, containing the proper elements, that is located near enough to the plant to be reached by the roots, is available to the plant as food. ( )i.
j. Osmotic pressure is probably the principal force that lifts the soil water from the root to the tips of the leaves. ( )j.

III

a. The sole and only purpose of the stem is to transport soil water from the roots to the leaves of the plant. ( )a.
b. The growing portion of a monocot stem is the outer part, just inside the bark. ( )b.
c. Rings of annual growth are shown by dicot stems only. ( )c.
d. A tree increases in height by growth at the tips of the stems only. ( )d.
e. There is sap moving downward as well as upward through the trunk of a tree. ( )e.
f. In the dicot stem the cambium layer is located just inside the bark. ( )f.
g. The upward-moving sap is richer in sugar, and the downward-moving sap is richer in soil salts. ( )g.
h. Starch will usually be found in the sap which oozes from a freshly made cut in some part of a plant. ( )h.
i. If one should look at a small plant in the direction that the sun's rays shine upon it, only a few of the leaves could be seen, since most of the top leaves would cover up the lower ones. ( )i.
j. A tree that shows the excurrent type of branching would be good for making into a telephone pole. ( )j.

IV

a. Plants which do not bear chlorophyll are of no service in supplying oxygen to the air for the breathing of animals. ( )a.
b. All plants which do not bear chlorophyll must be either parasitic or saprophytic. ( )b.
c. The mistletoe is a parasitic plant which has green leaves; it will therefore need to obtain only sugar from the host tree on which it grows. ( )c.
d. The pitcher plant, which obtains its food from the bodies of insects which it traps, is a saprophyte. ( )d.
e. Green plants are usually parasitic. ( )e.

Date_____ Biology. Unit II. Test 2. Name_____

Directions: In each of the paragraphs below, certain words or phrases are omitted, and blanks appear in their places. On each blank, place the number of the word or phrase (which you find in the column to the right) that properly fills in the omission, and also place this same number in the parenthesis which appears directly to the left of the blank. Any number may be used as many times as it is needed. Keep sentence structure correct. See that each number is recorded first in the proper blank and second in the proper parenthesis. Take your time and do not rush.

I

The manufacture of starches and sugars from
( ) _____ and water takes place in
( ) _____ plants only and only in the
( ) _____ parts of these plants. As a result
( ) of this process, large quantities of _____
are given off into the air. Soil salts
that are taken into the plant are used in
( ) the formation of_____, but not in forming
( ) _____. The photosynthetic process is car-
( ) ried on in the_____ of a plant, and the
cells of these organs are arranged toge-
( ) ther_____. The chlorophyll bodies are
( ) usually located near the _____ of each of
the cells in which they are found. Sun-
( ) light_____ pass through the cells of the
upper epidermis. Gases pass in and out,
in the photosynthetic process, through the
( ) _____, most of which are located in the
( ) _____ of the leaf. Water is distributed
to the various parts of the leaf by the
( ) _____.

1. cannot
2. upper surface
3. oxygen
4. upper epidermis
5. palisade cells
6. all
7. starch
8. tightly
9. can
10. center
11. stomata
12. non-green
13. loosely
14. veins
15. outer surface
16. leaves
17. carbon dioxide
18. lower epidermis
19. green
20. stems
21. protein

II

Beside furnishing food material to the plant,
the root usually serves as a means of an-
( ) chorage and often for the purpose of _____
In order to be taken into the root, the
( ) soil foods must be_____, and when in
this condition, they pass into the root
( ) by_____. In order to do this, the sur-
( ) faces of the root hairs must be _____
( ) Root hairs are made up of_____, and are
( ) found_____ of the root. Through the cen-
tral cylinder of the root, the sap is tra-
( ) veling_____ the stem. The principal force
which causes the upward movement of the sap
( ) in a tree is_____.

1. osmotic pressure
2. toward
3. dissolved in water
4. one cell each
5. photosynthesis
6. food storage
7. at the base
8. semi-permeable
9. in solid form
10. many cells
11. osmosis
12. transpiration
13. near the middle
14. gravity
15. near the tip
16. away from
17. non-porous

Sap is carried upward through a dicot stem
( ) _____. In a monocot stem, the movement
( ) of sap occurs _____. A tree that is
densely covered with leaves at the outer
( ) ends of its branches will have_____
leaves on the larger branches inside.
A branch that is a certain distance above
the ground in a young dicot tree will, bar-
( ) ring accident, be found to be_____dis-
tance above the ground after the tree has
grown for a period of ten years or more.
Upwardmoving sap which issues from a
wound in a tree will usually be found to
( ) contain a relatively high amount of _____
( ) and only a relatively small amount of_____
as compared with downward-moving sap. The
type of branching shown by an elm or oak
( ) tree is _____. Leaf arrangements are
always found to be made with reference to
( ) the _____.

1. along the medullary rays
2. efflorescent
3. near the bark
4. a greater
5. sugar
6. in the heartwood
7. few
8. starch
9. in scattered places throughout the stem
10. many
11. about the same
12. position of the sun
13. a smaller
14. deliquescent
15. alternate
16. pull of gravity
17. soil salts
18. flow of the sap

IV

Certain non-green plants, such as mushrooms and
( ) toadstools, are_____, since they usually
( ) obtain food_____. Green plants are usu-
( ) ally_____. If a plant, a bacterium for
example, obtains its livelihood from a live
( ) organism, it is said to be_____. A car-
nivorous plant, such as the pitcher plant
( ) or Venus Fly Trap, has to obtain_____
from the ground through its roots.

1. from dead organic matter
2. parasitic
3. self-supporting
4. through photosynthesis
5. water and minerals
6. communistic
7. starches and proteins
8. chlorophyll
9. saprophytic

Date_____. Biology. Unit I, Test 2. Name_____

Directions: Some of the following statements are true and some are not true (false.). The true statements are to be left alone, without being marked in any way. The false statements are all to be so changed as to make them true. To change the false statements, words or phrases are to be added, omitted, or changed in whatever way may be necessary. When you hand in the test paper with the changes which you think are needed, all the statements should be true. The false statements are to be so changed as to make positive statements. No correction will be satisfactory which merely inserts a "not" somewhere in the false statement, except in rare cases when the correction can be made in no other way.

I.

a. An object which is knocked over when struck by a hammer or a club is one that is living, since it possesses the power of motion.

b. Living things differ from non-living things in that they occupy space and have weight, while non-living things do not.

c. Living things will not fall when support is removed, as will non-living things.

d. Living things are subject to all the laws which govern non-living things, and also to other laws or principles which do not govern non-living things.

e. Most living things, but not all, are able to use food for the purpose of making living tissue.

II.

a. All living things possess protoplasm; non-living things do not.

b. All living things, except the mammals, are made up of one or more cells.

c. Protoplasm is a material that is usually found in cells, but it is sometimes replaced by other non-living material.

d. Tissues make up a cell just as bricks make up a wall.

e. A tissue is usually made up of several organs.

f. An organism is any living individual, large or small, simple or complex.

III

a. The little one-celled animal, the amoeba, carries on just as many life functions as the bird.

b. A simple, one-celled organism is different from a complex (many-celled) organism in that it has much fewer life processes to perform.

c. The higher the amount of division of labor shown in a plant or animal, the more simple is the plant or animal.

d. All the life processes which are common to animals are also common to plants.

e. The process of nutrition is carried on by the amoeba, but the process of excretion is not.

IV

a. Living things are divided by biologists into three different kingdoms; plant, animal, and human.

b. Phylum vertebrata is a subdivision of the class mammalia.

c. When there are two parts to the scientific name of a given organism, these two parts indicate the class and the order.

d. The cat belongs to the genus felis; felis therefore appears as the first part of the scientific name for the domestic cat.

e. To locate a given plant in its proper scientific classification, one must know the place where it was found in order to know what other plants of known classification it was found with.

f. Scientific names are usually of Latin origin.

g. The common name for any organism is the same, regardless of the locality in which it is found, or of the nationality of the person naming it.

Interpretation of Tables XXII to XXX

In reading the Tables XXII to XXX, the following interpretation should be given,--the list of T-Scores in the five columns each for each class, are given under headings that are the same as those used in Tables II to XIX. The pupils are numbered instead of being named. Pupils "1A", "1B", and "1X" are the same three pupils in all nine tables. This was done so that the complete record of any one pupil could be read from these tables. Because of cramped space and the two point decimals used for the means and sigmas, these figures are staggered at the foot of the columns. In Table XXII the means should be read as follows,--33.42 is the mean for the Pre T., column, 45.62 the mean for the F_1 column, 48.76 the mean for the F_2 column, 11.29 the mean for the G_1 column and 14.43 the mean for the G_2 column. 32.70 is the mean for the Pre T. column of class "B", 44.80 the mean for the F_1 column, etc.

The sigmas for the distributions are given under the means, also in staggered form. 6.71 is the sigma for the Pre T. column, 7.32 the sigma for the F_1 column, 9.62 the sigma for the F_2 column, etc.

Table XXII

T-scores Unit I.

Pupil	Class "A" Pre.	F_1	F_2	G_1	G_2	Class "B" Pre.	F_1	F_2	G_1	G_2	Class "X" Pre.	F_1	F_2	G_1	G_2
1	55	56	50	1	(5)	25	57	50	32	25	42	50	39	8	(3)
2	35	56	58	21	23	40	44	50	4	10	29	37	39	8	10
3	35	43	46	8	11	40	51	53	11	13	23	60	63	37	40
4	38	56	61	18	23	--	--	--	--	--	23	53	44	30	21
5	42	43	48	1	6	38	51	50	13	12	29	44	59	15	30
6	40	59	63	19	23	44	61	53	17	9	26	43	32	17	6
7	44	55	50	11	6	32	51	63	19	31	26	56	48	30	22
8	30	42	27	12	(3)	35	49	56	14	21	29	53	57	24	28
9	37	43	37	6	0	40	47	46	7	6	25	49	53	24	28
10	31	37	47	6	16	26	30	36	4	10	29	66	66	37	37
11	37	46	56	9	19	--	--	--	--	--	--	--	--	--	--
12	29	39	51	10	22	30	42	47	12	17	35	35	43	0	8
13	27	40	39	13	12	--	--	--	--	--	25	38	47	13	22
14	32	48	68	16	36	--	--	--	--	--	24	49	39	25	15
15	32	33	35	1	3	31	33	35	2	4	25	27	48	2	23
16	25	37	50	12	25	29	47	51	18	22	--	--	--	--	--
17	31	50	40	19	9	28	39	46	11	18	29	46	47	17	18
18	29	43	49	14	20	37	47	53	10	16	26	53	46	27	20
19	35	49	50	14	15	--	--	--	--	--	24	48	30	24	6
20	--	--	--	--	--	28	47	46	19	18	24	43	40	19	16
21	25	37	56	12	31	29	36	40	7	11	--	--	--	--	--
22	32	46	43	14	11	40	47	57	7	17	31	48	43	17	12
23	--	--	--	--	--	26	35	39	9	13	35	36	32	1	(3)
24						25	36	46	11	21	26	47	42	21	16
25						31	46	53	15	22	37	50	53	13	16
26											37	48	36	11	(1)
27											26	47	51	21	25
28											25	47	46	22	21
29											28	43	53	15	25
30											--	--	--	--	--
31											27	36	40	9	13
32											24	44	39	20	15
33											25	46	33	21	8
34											24	39	44	15	20
Mean (	34.33	48.76	14.43			44.80	12.10				27.93	45.06	17.13		
Mean (	45.62	11.29				32.70	48.50	15.80			46.03	18.10			
Sigma (	6.71	9.62	10.70			7.81	6.68				4.71	8.50	10.38		
Sigma (	7.32	5.70				5.86	6.56	6.56			7.79	9.26			

Table XXIII

T-Scores Unit II

	Class "A"					Class "B"					Class "X"				
Pupil	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2
1	42	48	61	6	19	44	35	54	(9)	10	38	57	58	19	20
2	42	50	63	8	21	27	40	54	13	27	40	60	53	20	13
3	33	32	60	(1)	27	31	46	57	15	26	40	52	66	12	26
4	35	56	63	21	28	33	32	40	(1)	7	21	56	71	35	50
5	33	54	71	21	38	29	48	53	19	24	38	46	61	8	23
6	31	50	67	19	36	21	40	54	19	33	40	50	60	10	20
7	33	38	52	5	19	21	54	69	33	48	29	50	77	21	48
8	21	50	38	29	17	27	46	48	19	21	31	43	52	12	21
9	33	36	44	3	11	35	50	50	15	15	21	54	66	33	45
10	27	42	43	15	16	27	38	59	11	32	35	61	67	26	32
11	38	48	66	10	28	--	--	--	--	--	--	--	--	--	--
12	48	45	59	(3)	11	29	46	58	17	29	21	55	50	34	29
13	35	57	44	22	9	--	--	--	--	--	38	48	66	10	28
14	33	38	69	5	36	27	33	61	6	34	29	55	57	26	28
15	21	30	38	9	17	38	40	52	2	14	27	50	60	23	33
16	33	21	48	(12)	15	38	45	59	7	21	--	--	--	--	--
17	40	40	60	0	20	31	42	63	11	32	38	50	54	12	16
18	46	52	71	8	25	31	47	38	16	7	21	44	46	23	25
19	35	33	58	(2)	23	31	35	52	4	21	21	60	63	39	42
20	29	35	56	6	27	38	47	67	9	29	21	48	67	27	46
21	33	42	56	9	23	33	45	44	12	11	--	--	--	--	--
22	33	33	40	0	7	21	47	67	26	46	44	40	44	(4)	0
23	44	31	24	(13)	(20)	29	42	45	13	16	44	40	55	(4)	11
24						33	40	38	7	5	35	56	46	21	11
25						38	44	57	6	19	35	36	59	1	24
26											31	55	61	24	30
27											29	43	46	14	17
28											33	40	67	7	34
29											27	48	55	21	28
30											--	--	--	--	--
31											33	38	60	5	27
32											21	50	58	29	37
33											33	55	56	22	23
34											31	50	50	19	19
Mean	34.70	54.40		19.70		42.69			11.73		31.50	58.37		26.87	
	41.78		7.08			30.96	53.86		22.91		49.73		18.13		
Sigma	6.70	12.16		11.83		5.48		8.63			7.24		7.90	11.55	
	9.38		10.23			5.78		8.66	11.43		6.73		10.91		

Table XXIV

T-Scores Unit III

Pupil	Class "A" Pre.	F_1	F_2	G_1	G_2	Class "B" Pre.	F_1	F_2	G_1	G_2	Class "X" Pre.	F_1	F_2	G_1	G_2
1	47	60	73	13	26	38	47	60	9	22	53	60	60	7	7
2	38	58	48	20	10	35	52	55	17	20	28	53	55	25	27
3	38	49	45	11	7	25	46	66	21	41	24	47	63	23	39
4	36	55	69	19	33	35	44	43	9	8	33	53	69	20	36
5	42	55	50	13	8	33	42	60	9	27	33	45	53	12	20
6	33	55	50	22	17	23	53	63	30	40	40	44	38	4	(2)
7	45	50	53	5	8	35	54	78	19	43	24	49	50	25	26
8	23	45	44	22	21	36	47	69	11	24	41	49	48	8	7
9	24	38	40	14	16	35	47	65	12	30	26	54	55	28	29
10	33	48	66	15	33	39	38	52	(1)	13	25	60	64	35	39
11	28	50	69	22	41	--	--	--	--	--	24	30	44	6	20
12	33	47	60	14	27	24	36	58	12	34	41	42	44	1	3
13	33	44	47	11	14	--	--	--	--	--	28	44	51	16	23
14	35	50	73	15	38	31	33	51	2	20	30	40	44	10	14
15	31	44	33	13	2	30	55	48	25	18	24	41	62	17	38
16	23	30	63	7	40	35	49	59	14	24	25	24	58	(1)	33
17	23	63	47	40	24	24	47	43	23	19	38	43	41	5	3
18	39	63	67	24	28	28	38	50	10	22	24	41	62	17	38
19	26	48	63	22	37	23	26	44	3	21	35	35	41	0	6
20	30	47	60	17	30	31	31	69	0	38	24	44	43	20	19
21	38	36	53	(2)	15	33	38	52	5	19	28	38	41	10	13
22	26	47	38	21	12	36	49	48	13	12	24	33	35	9	11
23	50	47	66	(3)	16	26	65	41	39	15	24	44	39	20	15
24						24	38	43	14	19	35	35	44	0	9
25						38	39	60	1	22	38	49	43	11	5
26											22	35	51	13	29
27											26	41	43	15	17
28											43	35	54	(8)	11
29											33	41	41	8	8
30											36	41	43	5	7
31											31	41	48	10	17
32											26	28	53	2	27
33											26	33	44	7	18
34											28	29	41	1	13
Mean	33.65	55.52		21.87		44.08			12.91		30.58	48.97		18.38	
	49.09		15.44			31.17	55.13		28.96		41.79		11.21		
Sigma	7.64	11.52		11.47		8.72			9.74		7.18	8.59		11.64	
	7.65		8.84			5.30	9.42		9.35		8.48		9.38		

Table XXV

T-Scores Unit IV

Pupil	Class "A" Pre.	F_1	F_2	G_1	G_2	Class "B" Pre.	F_1	F_2	G_1	G_2	Class "X" Pre.	F_1	F_2	G_1	G_2
1	47	56	71	9	24	39	43	44	4	5	45	49	50	4	5
2	49	52	56	3	7	41	41	57	0	16	47	52	60	5	13
3	34	42	39	8	5	41	60	67	19	26	52	60	62	8	10
4	36	64	68	28	36	39	42	39	3	0	41	58	56	17	15
5	39	56	58	17	17	43	52	55	9	12	45	54	46	9	1
6	41	52	62	11	21	45	49	52	4	7	39	42	62	3	32
7	34	47	58	13	24	31	52	58	21	27	43	40	68	(3)	25
8	39	45	38	6	(1)	39	45	40	6	1	36	50	49	14	13
9	39	38	47	(1)	8	36	38	68	2	32	45	62	48	17	3
10	45	54	55	9	10	43	40	47	(3)	4	52	52	60	0	8
11	39	56	55	17	16	--	--	--	--	--	39	41	58	2	19
12	34	52	74	18	40	43	47	55	4	12	36	49	58	13	22
13	36	47	27	11	(9)	31	41	71	10	40	34	52	53	18	19
14	41	47	62	6	21	41	34	46	(7)	5	31	52	69	21	38
15	28	44	43	16	15	43	38	45	(5)	2	36	52	60	16	24
16	31	31	60	0	29	39	35	53	(4)	17	41	41	64	0	23
17	45	46	60	1	15	24	55	49	31	25	36	49	44	13	8
18	31	56	60	25	29	43	46	52	3	9	36	35	43	(1)	7
19	34	52	55	18	21	24	24	60	0	36	31	36	55	5	24
20	39	54	60	15	21	39	55	62	16	23	34	54	62	20	28
21	39	24	58	(15)	19	34	60	52	26	18	31	32	39	1	8
22	39	54	24	15	(15)	41	40	49	(1)	8	36	62	60	26	24
23	47	56	56	9	9	24	43	55	19	31	34	35	47	1	13
24						21	35	56	14	35	41	46	49	5	8
25						31	34	40	3	9	39	35	62	(4)	23
26											31	39	52	8	21
27											36	32	60	(4)	24
28											39	55	52	16	13
29											39	52	68	13	29
30											24	32	52	8	28
31											34	48	41	14	7
32											28	52	46	24	18
33											34	54	62	20	28
34											31	52	41	21	10
Mean	38.52		54.09		15.57	43.71			7.25		37.53		54.65		17.12
		48.91		10.39			36.46	53.13		16.67		47.24		9.71	
Sigma	5.38		12.55		12.56	8.68			9.97		6.23		8.30		8.83
		8.75		9.05			7.07	8.52		12.08		8.76		8.51	

Table XXVI

T-Scores Unit V

Pupil	Class "A" Pre.	F_1	F_2	G_1	G_2	Class "B" Pre.	F_1	F_2	G_1	G_2	Class "XW" Pre.	F_1	F_2	G_1	G_2
1	50	53	70	3	20	56	76	46	21	(10)	42	58	56	16	14
2	42	52	64	10	22	48	64	44	16	(4)	43	50	58	7	15
3	56	56	68	0	12	42	51	58	9	16	44	60	68	16	14
4	46	58	62	12	16	32	48	44	16	12	44	54	76	10	32
5	50	46	64	(4)	14	53	66	41	13	(12)	44	72	61	28	17
6	44	61	64	17	20	43	64	61	21	18	43	44	64	1	21
7	48	48	48	0	0	43	53	54	10	11	42	61	58	19	16
8	35	46	35	11	0	42	58	52	16	10	56	56	72	00	16
9	40	44	46	4	6	51	44	68	(7)	17	37	50	48	13	11
10	32	44	50	12	18	43	35	56	(8)	13	50	52	68	2	18
11	40	53	54	13	14	40	48	48	8	8	35	37	52	2	17
12	43	38	51	(5)	8	37	48	46	11	9	32	53	32	21	0
13	46	48	50	2	4	51	56	44	5	(7)	28	60	46	32	18
14	21	37	46	16	25	28	32	48	4	20	32	56	70	24	38
15	32	46	53	14	21	51	50	66	(1)	15	37	41	35	4	(2)
16	28	32	40	4	12	46	48	66	2	20	50	64	44	14	(6)
17	50	41	60	(9)	10	44	48	72	4	28	35	46	46	11	11
18	44	61	68	17	24	51	56	53	5	2	44	50	60	6	16
19	37	48	44	111	7	42	35	38	(7)	(4)	32	37	35	5	3
20	37	40	38	3	1	51	44	50	(7)	(1)	44	32	50	(12)	6
21	21	35	21	14	0	42	41	51	(1)	9	28	25	32	(3)	4
22	21	26	38	5	17	44	58	56	14	12	37	40	41	3	4
23	40	46	54	6	14	32	32	44	0	12	26	35	37	9	11
24						51	46	58	(5)	7	51	56	60	5	9
25						37	42	41	5	4	51	54	56	3	5
26											32	43	48	11	16
27											46	52	62	6	16
28											42	44	60	2	18
29											46	52	58	6	12
30											50	56	58	6	8
31											37	70	53	33	16
32											21	32	46	11	25
33											28	51	61	23	33
34											37	38	44	1	7
Mean	39.26	51.65	12.39			44.00	52.20	8.20			39.59	53.09	13.50		
	46.04	6.78				49.72	5.72				49.44	9.85			
Sigma	9.55	12.13	7.82			6.97	9.17	9.88			8.39	11.27	9.35		
	8.78	7.21				10.74	8.69				10.78	9.95			

Table XXVII

T-Scores Unit VI

	Class "A"					Class "B"					Class "X"				
Pupil	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2
1	55	48	61	(7)	6	39	70	57	31	18	55	55	67	0	12
2	46	48	70	2	24	61	61	54	0	(7)	44	55	57	11	13
3	39	51	51	12	12	33	44	40	11	7	41	61	64	20	23
4	35	54	61	19	26	33	35	39	2	6	36	48	55	12	19
5	36	57	55	21	19	44	55	48	11	4	46	55	57	9	11
6	46	54	55	8	9	46	61	60	15	14	35	37	46	2	11
7	33	54	55	21	22	35	48	51	13	16	27	46	48	19	21
8	39	43	51	14	12	44	61	46	17	2	41	35	61	(6)	20
9	48	51	51	3	3	36	48	46	12	10	36	51	51	15	15
10	46	43	51	(3)	5	33	43	46	10	13	39	64	55	25	16
11	41	43	61	2	20	39	43	41	4	2	35	41	40	6	5
12	39	37	41	(2)	2	39	61	48	22	9	35	55	51	20	16
13	36	48	51	12	15	33	55	37	22	4	33	48	51	15	18
14	29	43	44	14	15	29	44	27	15	(2)	35	41	54	6	19
15	33	48	36	15	3	46	43	55	(3)	9	27	35	44	8	17
16	29	46	46	17	17	41	40	48	(1)	7	35	41	37	6	1
17	36	43	46	7	10	36	43	39	7	3	21	41	27	20	6
18	35	31	46	(4)	11	36	48	48	12	12	39	35	55	(4)	16
19	33	48	41	15	8	21	31	31	10	10	31	36	27	5	(4)
20	21	43	31	22	10	31	21	36	(10)	5	31	46	51	15	20
21	21	40	36	19	15	31	40	39	9	8	27	27	27	0	0
22	31	40	33	9	2	39	46	55	7	16	29	39	40	10	11
23	21	40	36	10	15	21	21	31	0	10	33	48	46	15	13
24						33	48	48	15	15	39	43	48	4	9
25						33	33	37	0	4	48	51	55	3	7
26											39	48	37	9	(2)
27											33	46	51	13	18
28											31	35	60	4	29
29											48	54	51	6	3
30											31	40	35	9	4
31											21	33	31	12	10
32											27	36	40	9	13
33											36	55	46	19	10
34											27	37	27	10	0
Mean	36.00	45.78	48.22	9.78	12.22	36.48	45.72	44.28	9.24	7.80	35.03	44.64	46.82	9.61	11.77
Sigma	8.55	6.08	9.89	8.78	6.89	8.03	11.46	8.47	8.77	5.78	7.48	8.73	10.86	7.14	7.68

Table XXVIII

T-Scores Unit VII

	Class "A"					Class "B"					Class "X"				
Pupil	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2
1	44	51	57	7	13	49	45	49	(4)	0	44	60	63	16	19
2	44	57	47	13	3	42	52	53	10	11	49	52	57	3	8
3	33	47	49	14	16	33	67	53	34	20	51	62	67	11	16
4	36	56	57	20	21	44	49	47	5	3	36	48	76	12	40
5	42	55	47	13	5	42	52	53	10	11	44	71	57	27	13
6	44	56	60	12	16	42	52	57	10	15	36	39	47	3	11
7	39	51	57	12	18	44	55	42	11	(2)	39	43	76	4	37
8	36	49	47	13	11	44	49	47	5	3	42	45	47	3	5
9	42	54	53	12	11	42	57	55	15	13	39	72	60	33	21
10	39	41	47	2	8	44	39	36	(5)	(8)	47	58	72	11	25
11	47	49	60	2	13	34	46	47	11	13	34	45	60	11	26
12	21	39	42	18	21	42	43	72	1	30	27	72	47	45	20
13	44	54	47	10	3	33	37	30	4	(3)	39	60	53	21	14
14	60	35	44	(25)	(16)	47	31	57	(16)	10	27	67	60	40	33
15	42	34	36	(8)	(6)	51	45	41	(6)	0	21	33	34	12	13
16	33	36	36	3	3	39	52	57	13	18	39	51	47	12	8
17	33	42	51	9	18	39	51	49	12	10	36	51	51	15	15
18	34	76	44	42	10	44	55	42	11	(2)	34	45	44	11	10
19	34	60	55	26	21	21	64	51	43	30	36	67	57	31	21
20	25	47	44	22	19	34	42	47	8	13	39	51	67	12	28
21	33	39	49	6	16	21	55	49	34	28	34	45	51	11	17
22	21	43	42	22	21	42	43	42	1	0	39	47	67	8	28
23	44	45	51	1	7	25	64	47	39	22	30	55	51	25	21
24						39	64	67	25	28	42	45	51	3	9
25						44	48	51	4	7	34	58	60	24	26
26											34	45	63	11	29
27											34	30	47	(4)	13
28											25	39	55	14	30
29											30	55	63	25	33
30											44	28	33	(16)	(11)
31											34	60	53	16	19
32											25	66	57	41	32
33											25	64	76	39	51
34											--	--	--	--	--
Mean	37.83	48.78	10.95			50.24	11.00				36.03	56.64	20.61		
	48.52	10.69				39.24	50.04	10.80			52.39	16.06			
Sigma	8.55	6.67	9.13			8.74	14.09				7.14	10.60	11.73		
	9.47	12.52				7.69	8.51	10.90			11.63	13.46			

Table XXIX

T-Scores Unit VIII

	Class "A"					Class "B"					Class "X"				
Pupil	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2	Pre.	F_1	F_2	G_1	G_2
1	58	50	63	(8)	5	28	45	53	12	25	55	54	66	(1)	11
2	32	50	50	18	18	34	54	60	20	26	53	48	47	(5)	(6)
3	39	43	50	4	11	39	60	42	21	3	55	65	63	10	8
4	44	62	63	18	19	39	40	47	1	8	32	46	44	14	12
5	44	35	50	(9)	6	42	45	47	3	5	50	54	47	4	(3)
6	50	65	58	15	8	53	54	53	1	0	34	33	47	(1)	13
7	42	48	55	6	13	44	65	55	21	11	47	40	44	(7)	(3)
8	42	57	39	15	(3)	44	50	60	6	16	47	43	58	(4)	11
9	42	30	47	(12)	5	42	57	50	15	8	34	46	63	12	29
10	32	40	37	8	5	34	41	50	7	16	37	46	58	9	21
11	47	62	47	15	0	37	52	55	15	18	42	46	50	4	8
12	37	50	39	13	2	37	50	50	13	13	32	55	42	23	10
13	37	52	53	15	16	34	48	50	14	16	32	46	55	14	23
14	30	48	44	18	14	34	43	42	9	8	32	40	50	8	18
15	47	45	42	(2)	(5)	30	52	50	22	20	30	35	47	5	17
16	34	50	32	(16)	(2)	28	46	53	18	25	32	43	55	11	23
17	39	43	39	4	0	34	52	44	18	10	39	50	50	11	11
18	26	35	37	9	11	32	46	42	14	10	28	48	58	20	30
19	47	35	47	(12)	0	34	60	47	26	13	28	35	47	7	19
20	26	37	37	11	11	28	54	42	26	14	37	27	32	(10)	(5)
21	37	27	34	(10)	(3)	26	54	44	28	18	47	43	47	(4)	0
22	21	54	24	33	3	47	50	39	3	(8)	50	37	42	(13)	(8)
23	60	52	47	(8)	(13)	42	48	58	6	16	37	45	42	8	5
24						34	62	42	28	8	47	40	58	(7)	11
25						26	38	50	12	24	44	48	58	4	14
26											32	37	50	5	18
27											32	41	47	9	15
28											30	43	42	13	12
29											39	46	50	7	11
30											32	43	37	11	5
31											39	37	50	(2)	11
32											30	35	34	5	4
33											28	40	44	12	16
34											30	46	39	16	9
Mean	39.70		44.96		5.26	36.08		49.00		12.92	38.03		48.91		10.88
		46.52		6.82			50.64		14.56			43.56		5.53	
Sigma	9.46		9.58		7.90	6.75		5.86		8.02	8.31		8.08		9.22
		10.02		11.89			6.78		8.25		7.17		8.39		

Table XXX

T-Scores Unit IX

Pupil	Class "A" Pre.	F_1	F_2	G_1	G_2	Class "B" Pre.	F_1	F_2	G_1	G_2	Class "X" Pre.	F_1	F_2	G_1	G_2
1	55	59	78	4	23	42	63	53	21	11	55	63	64	8	9
2	46	55	48	9	2	41	50	57	9	16	43	55	49	12	6
3	48	62	57	15	9	38	46	55	8	17	51	63	57	12	6
4	46	59	53	13	7	35	40	42	5	7	41	46	51	5	10
5	40	46	45	6	5	43	46	53	3	10	40	68	61	28	21
6	46	59	61	13	15	43	55	53	12	10	51	50	64	(1)	13
7	32	59	45	27	13	43	52	61	9	18	22	48	49	26	27
8	32	52	53	20	21	38	59	53	21	15	49	46	49	(3)	0
9	41	46	46	5	5	40	46	43	6	3	36	55	57	19	21
10	33	52	49	19	16	21	46	46	25	25	45	63	53	13	8
11	55	63	57	8	2	36	52	53	16	17	41	40	46	(1)	5
12	30	32	53	2	23	40	46	51	6	11	46	55	53	9	7
13	43	52	49	9	6	35	50	49	15	14	36	43	51	7	16
14	21	59	51	38	30	35	43	42	8	7	43	52	57	9	14
15	32	43	42	11	10	37	50	51	13	14	21	37	36	16	15
16	--	--	--	--	--	33	46	53	13	20	35	37	43	2	8
17	37	63	48	26	11	40	48	49	8	9	38	50	53	12	15
18	22	59	46	37	24	48	48	53	0	5	37	40	37	3	0
19	53	48	61	(5)	8	33	40	36	7	3	36	68	61	32	25
20	21	43	43	22	22	42	46	55	4	13	25	50	40	25	15
21	21	33	32	12	11	22	37	55	15	33	33	50	55	17	22
22	21	26	33	5	12	40	46	42	6	2	21	52	38	31	17
23	30	68	35	38	5	43	43	51	0	8	41	35	57	(6)	16
24						36	40	57	4	21	42	52	57	10	15
25						21	43	48	22	27	45	59	61	14	16
26											25	48	61	23	36
27											33	37	42	4	9
28											42	63	53	21	11
29											45	55	69	10	24
30											37	37	53	0	16
31											37	59	48	22	11
32											21	55	57	34	36
33											43	59	57	16	14
34											37	30	49	(7)	12
Mean	36.59	49.32		12.73		37.00	50.44		13.44		38.03	52.59		14.56	
	51.77		15.18			47.24		10.24			50.59		12.56		
Sigma	12.19	9.96		7.82		6.79	5.71		7.60		8.80	7.99		8.31	
	10.88		12.36			5.81		6.74			9.82		10.92		