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A national survey of the opinions of
biology teachers as to the most
important areas in high school biology
and an achievement test in these areas

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A NATIONAL SURVEY OF THE OPINIONS OF BIOLOGY TEACHERS
AS TO THE MOST IMPORTANT AREAS IN HIGH SCHOOL BIOLOGY
AND AN ACHIEVEMENT TEST IN THESE AREAS

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In Partial Fulfillment of Requirements for
the Degree of Doctor of Education

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CHAPTER I
CHARACTERISTICS OF THE STUDY

1. Purpose of the Study

All of the areas of biology cannot possibly be taught in a beginning course, which also is usually a terminal course. Therefore, it becomes of prime importance to know those areas of biology which are most important. This study has, as one of its main objectives, the determination of these most important biological areas.

There seems to be no truly objective method of determining these areas. Textbooks are at variance with one another. Hence, a survey of their contents would offer little help. An analysis of various courses of study seems at first to offer a plausible method. Yet, when one considers that some courses of study have become obsolete and that many revisions have amounted to little more than a change in publication date, he realizes that this method would not be a wise choice.

Since the teacher of biology is the one who is most apt to have given careful thought to the pupils' needs in the biological sciences, it was decided that a survey of

their opinions would yield valid results. This was the method chosen for part one of the study.

After determining the needs of pupils in terms of areas of biology, it is only fair to ask whether or not these needs are being met. While there is a majority opinion among biology teachers, there is not a uniformity of opinion as to the most important and the least important areas of biology. Further, most biology teachers are forced to follow a specified course of study. In many cases, if the course of study does not contain the material which the individual teacher feels is most important, it must be omitted from the course.

It is, then, quite possible that the areas which are determined to be most important are being taught to a limited extent in some schools and not at all in others.

The second main objective of this study is to construct and administer an achievement test in those areas of biology which have been determined as most important. The test is to be constructed so as to give an indication and only an indication of the extent to which these areas of biology are being mastered by pupils enrolled in courses of General Biology.

If these areas of biology are not being properly absorbed by pupils, wherein lies the difficulty? Is it

because the teacher has not been covering this material in his course? If this is the case, then it is for one of two reasons or for both reasons. It is possible that the material is not in the course of study and that the teacher is bound not to digress from such a course. On the other hand, it is possible that the teacher, heretofore, has not considered this material important enough to be included in the course. It is quite possible that both of these circumstances prevail in a given situation.

In any case, however, the results of this study should foster deeper thought among biology teachers as to the inclusion or exclusion of certain areas of biology. If, after much consideration, the teacher feels that more emphasis should be placed on certain topics and less on others, he can either directly or indirectly bring about changes in his present course of study.

It is possible that the important areas of biology are not being properly absorbed by pupils because too little emphasis is being placed on these areas in the textbooks. If this is the case, then this study could bring about a re-evaluation of material by authors of biology texts.

It is for these reasons that a side-study of the recently published biology texts be made. This study will be an analysis of texts to determine the amount of coverage

given to those areas of biology which are deemed most important. This study will give us a much clearer picture of the biology being taught in high schools, today.

In general, the two most objective methods of measuring course content are by an analysis of the textbooks used and by an analysis of tests which are used. It should be noted here that objectivity does not imply validity. However, this study would be found lacking if an analysis of recently published tests were not included. This analysis of tests will be made to ascertain the degree of importance which has been placed on those areas determined to be most important.

2. Justification for the Study

In a report by the Federal Office of Education on the teaching of general biology in the public high schools of the United States, the statement is made that "...practically all of the pupils entering our high schools take at least one course in biological science during their high-school years. In the majority of cases this course is general biology, or its equivalent."^{1/} The question then arises as to whether or not these pupils are being taught

1/W. Edgar Martin, The Teaching of General Biology in the Public High Schools of the United States, Bulletin, 1952, Number 9, Federal Security Agency, Office of Education, Washington, D. C., p. 11.

the most important areas of biology.

Many school authorities and certainly all biology teachers are aware of the vast amount of material that may properly be classified under the heading "General Biology". All of this material cannot possibly be taught in a one-year course in high school biology. In many cases, we find schools offering separate courses in such subjects as Health, Agriculture, Hygiene, Physiology, Conservation, and Nature Study. Where such courses serve a recognized need and are practicable, they should be offered. However, for the great majority of high school students, a one-year course in General Biology is the beginning and the end of their formal training in the life sciences.

The fact that teachers are aware that biology has become an unruly subject because of the vastness of its content is reflected in the biology texts now being used in high schools. No longer is one text essentially the same as the next. In chemistry and physics we find the material and presentation very much alike in the various texts. This is not the case with biology. Here, we find a great variation not only as to the material which the author includes, but also as to the presentation of that material. Some of today's texts present a classification type biology, where representatives from each phylum are studied, first in the

plant kingdom and then in the animal kingdom. Some texts attempt to show the relationships existing among living things and this tone is carried through the entire book. Still other texts have man as the focal point and discuss other living things only as they are directly concerned with man.

From another point of view, some biology texts attempt to be all-inclusive while others go to the other extreme, that of oversimplification.

3. Scope of the Study

Because of the very nature of the study there was little need for involved statistical analyses. To attempt such a procedure would have seriously detracted from the value of the study. It would have clouded the answers to the two main questions. These questions are:

- | | |
|--|--|
| A. What are the most important areas of biology? | B. Are these areas being mastered by high school pupils? |
|--|--|

Concerning a limited amount of statistics McNemar^{1/} states that:

"The presence or absence of statistical analysis per se is not a safe criterion for judging the worth of a study - some studies would have been improved by the use of statistics, whereas others would be better if they had been so designed as to depend less upon statistical analysis."

^{1/}McNemar Quinn, Psychological Statistics, John Wiley & Sons, Inc., New York, 1955, p. 4.

After reaching a decision as to the most plausible method of solving the problem, the next step was to determine the size of the sample. Since the entire study proceeds in a step by step fashion, it was necessary that the first sampling be sufficiently large and yet feasible from a point of view of time as well as one of economy. It was decided that the opinions of 500 teachers, located throughout the country, would give valid results. In order to obtain results from 500 teachers, it was thought necessary to request assistance from a minimum of 2000. As will be seen later, this did not prove true.

The 2000 teachers that were first asked to participate were taken from the mailing list of the "National Association of Biology Teachers".

In order to get an indication of the extent to which the important areas of biology are being mastered by pupils, it was felt that the test should be given to at least fifty classes and that these should be scattered throughout the country.^{1/} It was further decided that these classes should be of normal size, that is, a size ranging somewhere between 20 and 30 pupils. In regard to class size in General Biology, for the school year, 1949-1950 "...the average enrollment for each section for all types of high schools

^{1/}See p. 41.

was 29.32 pupils for the first term and 29.10 for the second term; the average for senior high schools for the first term was 32.85 and for the second term, 33.21."^{1/}

If the classes used for this testing were of a size other than one which approximated the average, it would seem that we would be introducing an unnecessary variable, namely, the effect of class size on the rate of learning.

L/W. Edgar Martin, op. cit., p. 11.

CHAPTER II

SURVEY OF RELATED LITERATURE

1. Importance of Biology

In a survey of general biology, made by Martin^{1/} during 1949 and 1950, it was found that 95.1 per cent of the public high schools which responded to the questionnaire offered a course in general biology or its equivalent. While some students do not take any course in biology, the great majority do take at least one course in biology, and this is usually general biology. Martin^{2/} found that "...practically all of the pupils entering our high schools take at least one course in biological science during their high school years. In the majority of cases this course is general biology, or its equivalent, taken in the tenth grade." Since the great majority of high school pupils do take biology, it is imperative that much thought be given to the content of the course.

Biology also derives added importance from the fact that, for many students, it is their only look at science.

1/W. Edgar Martin, The Teaching of General Biology in the Public High Schools of the United States, Bulletin, 1952, Number 9, Federal Security Agency, Office of Education, pp. 3, 4.

2/Op. cit., p. 11.

In many instances biology is preceded by a course in general science, but this is not always the case. Klinge^{1/} says: "The biology course is probably the only science course in which most high school graduates have been enrolled. It is not only the terminal science class for many; it is their only science exposure."

Curtis^{2/} in speaking of the importance of biology states: "Biology is potentially one of the most valuable subjects in the entire program of studies of the secondary school, and hence should be a required part of every pupil's education."

Lowry^{3/} in discussing the reasons for transferring biology to grade nine states: "There was general agreement among the faculty that biology was doing more to give the student learning experiences and help in meeting the many needs of adolescent youth than any other one course in the science curriculum."

There is no dispute on the importance of biology. On the contrary, more and more schools are making it a required

1/Paul Klinge, "Is Biology a Science Course?" School Science and Mathematics (May, 1950), 50:379-383, p. 379.

2/Francis D. Curtis, "Some Practical Suggestions for the Teaching of Biology," School Science and Mathematics (February, 1951), 51:95-104, p. 95.

3/Nelson L. Lowry, "Biology and Physical Science for Ninth- and Tenth-Grade Students," Science Education (March, 1951) 35:71-73, p. 72.

course for non-college as well as for college preparatory students.

2. Objectives of Biology Teaching

Certainly it is true that sound, realistic objectives should be very clear before any teacher attempts to organize a course. In biology, as in some other courses, there appears to be a wide variation in objectives. In discussing this point McKibben^{1/} states:

"Every high school teacher realizes the importance of the use of objectives in guiding learning, but a study of the objectives of biology for general education as set forth in high school textbooks, courses of study, and professional literature reveals that these objectives are numerous and varied."

A bright ray in this unhappy situation is the apparent agreement among biology teachers that the training of specialists in biology is not one of the objectives of the course. Fitzpatrick^{2/} says: "In the general education approach, it is clear that the training of professional biologists is not the aim of the secondary school biology course."

^{1/}Margaret McKibben, "The Present Status of General Objectives in the Teaching of Secondary Biology," Science Education (April, 1947), 31:171-175, p. 171.

^{2/}Fred Fitzpatrick, Trends in High School Biology, The Bulletin of the National Association of Secondary School Principals, Washington, D. C., (January, 1953) 37:56-67, p. 58.

Regarding the objectives of a course Martin^{1/} says:

"The manner in which a course is organized for instructional purposes is in all probability a more reliable index of the philosophy underlying the course and the major objectives sought in the instruction than a written statement of the philosophy or a listing of the major objectives."

With this thought in mind, one of the inquiries made by Martin, in his survey of the teaching of biology in the public high schools, dealt with the organization of the course.^{2/} He found that 76.5 per cent of the schools offering biology based the course organization on principles related to the whole field of biology. In 12.6 per cent of the cases, the course was divided into botany, zoology, and physiology. And, in 10.9 per cent of the cases, it was based on important topics of daily life. Even though we can infer from this report that the majority of schools are teaching biology on an integrated basis, it seems that we still cannot get a great deal of insight into the objectives underlying these different courses. We certainly can say, however, that these different approaches to course organization imply a wide variation in course objectives.

3. Subject Matter of Biology

Unnecessary Subject Matter.-- While much of the biology

1/Op. cit., p. 19.

2/Op. cit., pp. 19, 20.

which is given to the high school student of today is most worthwhile, some topics have their sole merit simply because they have been present in the biology course for many years.

Speaking of the development of biological offerings over the past hundred years, Fitzpatrick^{1/} says: "We reject an outmoded educational theory, but items of so-called subject matter selected according to the tenets of that theory continue to be employed in instruction even though the justification for such employment no longer exists." In writing along the same lines, Miller^{2/} says: "Much of the biology taught in secondary schools today is the same as that taught 20 years ago. The passage of time does not necessarily make all old things obsolete, but neither does it make them indispensable."

A grave injustice is being done to the students if we omit certain topics of biology simply because we dare not delete material that has been with us for many years. Fitzpatrick^{3/} says, "...much functional biological knowledge has been acquired in very recent times and has not yet

1/Op. cit., p. 58.

2/Jesse V. Miller, "Biology-1949 Model," The American Biology Teacher (April, 1949), 11:101-104, p. 101.

3/Loc. cit., p. 58.

been generally utilized as material of instruction."

Variation in subject matter.-- Even the most cursory glance at some of the high school biology texts shows that there must be a wide variation in the subject matter being taught. Martin^{1/} found that there were a large number of areas, giving a great deal of emphasis by different teachers. He found that nearly 6 per cent of the teachers in his survey gave major emphasis to paleontology. Over 3 per cent gave major emphasis to embryonic development. Results like this certainly point to wide disagreement as to the most important areas of biology. In discussing this variation in subject matter, McFadden^{2/} states:

"A survey of textbook units and problems, or topical development will show great variation in subject matter. Some authors have ridden their hobbies. One of the older texts is largely systematic botany, another entymology. Following publication of the seven cardinal principles, one text went all out for teaching health...."

It is safe to assume that if this variation in subject matter is so apparent in textbooks, it must also be finding its way into various biology classes. Of 783 schools who answered a question concerning the organization of the

1/Op. cit., p. 21.

2/M. G. McFadden, "Recent Trends in the Teaching of Biology and some Recommendations Relative to the Development of a Course of Study," Science Education (February, 1950), 34:451-471, p. 48.

general biology course, Martin^{1/} found that 499 or 63.7 per cent of the schools were following a basic text.

In speaking of the fact that if biology is a science, it should be based on fundamental truths or laws, McAtee^{2/} says, "...an analysis of textbooks and courses of study reveals a wide range of opinions in the selection of subject matter and the degree of emphasis given to the different areas chosen." Discussing the matter further she says,^{3/} "There seems to be no agreement, however, among those which contain basic truths as to what truths were basic." Klinge feels that the wide variation in subject matter has led to speciality courses being taught under the name of general biology. He states:^{4/} "Since the field is so broad, full of facts, and difficult, the biology course offers a convenient place to ride a hobby horse in glorious isolation from criticism." That this is true is evidenced by the fact that some teachers give major emphasis to such areas as paleontology or embryonic development.

1/Op. cit., p. 21.

2/Veva McAtee, "Is Biology a Science or a Fad," School, Science and Mathematics (March, 1946), 46:206-208, p. 206.

3/Loc cit., p. 206.

4/Op. cit., p. 379.

This variation in subject matter, as found in the texts, is not new. In 1933, Weltzin^{1/} analyzed five popular biology textbooks and found that there was little agreement among them in either content or organization. Noll, in discussing the revisions of texts that had taken place prior to 1939 says:^{2/} "These changes have tended to increase the variation in treatment and content of textbooks."

Some defense for this variation of subject matter is found in the Forty-Sixth Yearbook of the National Society for the Study of Education, wherein it is stated:^{3/}

"Since the logical development and mastery of the subject matter of biology is not of itself a primary goal and since in any event the field is far too broad to be covered adequately in the time provided in school, then it follows that considerable variation in topics covered and in the order of topics will be legitimate and desirable, as circumstances vary."

While this may lend some solace to those concerned about the variation in subject matter, it does not excuse the whimsical

^{1/}Elmer M. Weltzin, "The Content of Biology in High School Texts," Unpublished Master's Thesis, State University of Iowa, 1933.

^{2/}Victor H. Noll, The Teaching of Science in Elementary and Secondary Schools, Longmans, Green & Co., New York, 1939, p. 127.

^{3/}Nelson B. Henry (Editor), The Forty-Sixth Yearbook of the National Society for the Study of Education, Part I, Science Education in American Schools, The University of Chicago Press, Chicago, 1947, p. 184.

inclusion of subject areas at the expense of others which may be more important.

Selection of subject matter.-- It is this great variation in subject matter which makes it so important to be very careful in our choice of areas. Fitzpatrick^{1/} states that:

"The point is made that there is challenge to select wisely from a wealth of potential instructional material without undue concern for traditional 'content' or 'mastery' of a subject at the lower levels of educational experience, but with continuous effort to establish and refine a program that will best fit pupils and future citizens to make appropriate choices and decisions."

The selection of subject matter in biology is extremely important from another aspect. As was previously mentioned, biology for many students is their only exposure to any formal science study. The method of selection of subject matter may take one of several forms. It may be purely subjective where the teacher picks and chooses to suit his own desires. It may be left entirely in the hands of the textbook author. It may be left in the hands of a course of study committee. It might be a combination of these, or it might be one of various other types.

One method of selection of subject matter made use of

1/Op. cit., p. 63.

the opinions of pupils. Schneck^{1/} conducted the study in order to determine the needs and interests of pupils enrolled in a course in biology. It was limited to 131 pupils in a single school. They were asked to list the practical things which they had learned or wished had been included in their biology course. He found that the human body was mentioned most often as being most important and he concludes that, "...if a course in biology is to be based on the criteria of student interest, it must be largely centered about the problem of human behavior and health."^{2/}

Need for research.-- It seems evident that there is a good deal of unnecessary subject matter being taught in many of our high school biology courses. That there is a tremendous variation in subject matter among the various high school biology courses is undeniable. High school biology teachers admit to these facts, and yet there has been very little done with an aim toward improving the situation. We must be slow to criticize a particular teacher for having selected certain areas for his course and having omitted others. There has been very little done to give the teacher

^{1/}John W. Schneck, "The Practical Value of Certain Topics In a Course in Biology," School Science and Mathematics (April, 1946), 46:318-322.

^{2/}Op. cit., p. 322.

the objective help which he needs. Hoff,^{1/} in speaking of the curriculum in biology says that: "Relatively few curriculum studies have been made in the field of biology, the greatest number being in the analysis of the current literature." While an analysis of the literature is important, it does not help the biology teacher, faced with the very real problem of trying wisely to decide what material to include and what material to delete from the course which he teaches.

Recent trends.-- Although we are still searching for the ideal course in biology, we can be heartened by fact that there has been a decided shift from the highly technical, taxonomical, morphological type biology to a type more suitable to the needs of pupils. In speaking of the development of the biology curricula, Isenbarger and Mayfield^{1/} state:

"In brief, biology courses have shifted away from special subject content patterned after college courses to content selected and arranged to develop in students the practical, esthetic, and intellectual values of biological knowledge in everyday living."

Today, much high school biology is not being taught as

1/Arthur G. Hoff, Secondary School Science Teaching, The Blakiston Company, Philadelphia, 1950, p. 92.

2/Jerome C. Isenbarger and John C. Mayfield, A Half Century of Science and Mathematics Teaching, Central Association of Science and Mathematics Teachers, Inc., Oak Park, Illinois 1950, p. 107.

a miniature college course, but rather as a course having a practical value in everyday life. We find stated in the Forty-Sixth Yearbook^{1/} that:

"As the high school population became less selective, significant modifications of the biology course were instituted. From necessity, the subject matter has become less technical, more practical, and the trend has been toward a unified course, with increasing emphasis on its functional values."

1/Op. cit., p. 183.

CHAPTER III

RESEARCH PROCEDURE

1. Five hundred biology teachers were asked to name the most important and the least important areas of biology. Letters with postal enclosures were sent to 2000 members of the "National Association of Biology Teachers". They were asked to state (a) the area of biology that they consider most important, (b) the area of biology that they consider least important, and (c) whether or not they would be willing to be of further assistance in this study.

In this first survey, the teachers were asked to give only one area, because it was felt that this would require great thought and very careful selection. To ask for a lengthy list of areas might result in areas being given not because the teacher felt that they were most important, but merely because the teacher felt that they were of some importance. It is readily admitted that this is an untried method of gathering information. However, if there were faults inherent in this method of survey, they were corrected by the second survey, which more closely followed the recognized procedure.

The teachers chosen for this survey had one thing in common, namely, their membership in the N.A.B.T. The reason for using this membership list was threefold. First, it provided, without further effort, a list of biology teachers located in all parts of the country. Second, these teachers by mere virtue of belonging to this association had demonstrated an interest in biology and the problems of teaching biology and would probably cooperate with a study of this type. Third, these teachers, having demonstrated an interest in the teaching of biology, had in all likelihood spent considerable time attempting to solve some of the problems associated with it.

2. When the replies were received, the areas were tabulated and placed in order, according to their frequency of being named most important. They were also listed in order according to their frequency of being named least important.

3. The first twenty or so areas, named most frequently as most important, were listed. The reason for taking approximately the first 20 areas was to allow for a natural breaking point, by frequencies, which was likely to occur at various places in the list.

The areas on the list were then placed in alphabetical order and this placement was pointed out to the teachers in

the next survey.

4. The list of most important areas was sent to 793 biology teachers, located in various parts of the country. They were asked to choose the three most important and the three least important areas from this list.

5. The results of this survey were tabulated and lists made of the most important and the least important areas of biology.

6. An achievement test of the first four most important areas of biology was constructed.

The material for the test was based on material found in various high school biology texts.

7. The tests were administered to 50 biology classes, located in various parts of the country.

8. A minimum of 75 biology teachers, located throughout the country, were asked to review the test from the point of view of whether or not the items were teachable to high school pupils. They were also asked for other criticisms of the test.

9. The tests were scored and the degree of difficulty of each item was determined.

10. From the scores on the tests, conclusions were drawn as to how well or how poorly these areas of biology were absorbed by high school pupils.

11. In addition, recently published biology texts and tests were reviewed to determine the degree of emphasis which was being placed on the areas of biology which this survey shows as most important.

12. All of the above data were analyzed and recommendations were made.

CHAPTER IV
EVALUATION TECHNIQUE

1. The First Survey

Introduction.-- In the first part of this thesis, teachers were asked to state the area of biology that they considered most important and the area of biology that they considered least important. A great deal of thought was given to deciding whether or not to define the word "area". Although the word seemed to have a consistent definition among biology teachers, it seemed quite possible that it be misconstrued by some. However, for the word to be clearly defined, examples would have to be given. This could well have narrowed the thinking of the individual teachers, with the result of destroying the purpose of this first survey.

Some might claim that it would have been better, at this point, to furnish a list of the areas of biology. This also would do away with the purpose; namely, free thought on the problem. To supply a list, at this time, would also be objectionable from other aspects. If the list were short, it might well have been that areas that should have been included had been overlooked. If the list

were lengthy, the teacher would probably have given insufficient consideration to each area on the list and would in some cases merely have scanned the list.

The next problem was to make a decision as to how large the sample should be. It was felt that if the survey were to have meaning, replies must be received from at least 500 biology teachers. Also it was felt that the replies must not come from one state, but must come from teachers located in various parts of the country.

Since the teachers most apt to respond and most apt to be interested were the members of the National Association of Biology Teachers, its officers were contacted. They could neither give nor sell a mailing list of their members, but after some communication did agree to mail the letters and postcards which I would send to them.

Sample.-- In order to be sure of 500 replies, 2000 members of the National Association of Biology Teachers were contacted. Letters were sent to them which asked them to name the area of biology that they considered most important and the area of biology that they considered least important. They were also asked to give their name and address and to tell whether or not they would be willing to be of further assistance in this study. A self-addressed

postcard, having places for the replies, was included with each letter.

Replies received.-- To the 2,000 letters sent, 931 replies were received. Of these, 793 indicated that they would be willing to do further work on the study.

Replies were received from 39 states and Washington, D. C. The states not heard from were: Rhode Island, South Carolina; South Dakota; Tennessee; Texas; Utah; Washington; Wisconsin; and Wyoming. There were 22 states having 10 or more replies.

Evaluation of the replies.-- Of the cards received, 49 were not used at all in this part of the study. They were discarded for such reasons as: No answer; the claim that it depends on too many factors; the claim that it could only be answered if a list were supplied; etc.

The first section of this part of the study was to determine the most important areas. For this section a total of 87 replies were discarded. Eighty-one of these were discarded because four or more areas were listed as most important. The other six were discarded because the areas were not clearly defined. Table 1 gives the results of this first section of this part of the study.

Table 1. The First Thirty Most Important Areas, Determined by Those Making One, Two, and Three Selections

Area (1)	Place (2)	Number Of Points a/ (3)	The Placing and Points of these Areas, Determined by those making only One Selec- tion	
			Place (4)	Number Of Points (5)
Human Biology.....	1	138 1/2	1	120
Conservation (general).....	2	85 5/6	2	61
Human Physiology.....	3	79	4	48
Ecology (general)....	4	67 1/2	3	51
Health & Hygiene.....	5	51	5	28
Physiology (general).	6	39 2/3	6	22
Genetics (general)...	7	35 1/3	7	20
Human Anatomy.....	8	31 5/6	13	8
Essential Life Processes.....	9	28 1/3	7	20
Biology Applied to Humans.....	10	20 2/3	9	18
Zoology.....	11	20 1/3	13	8
Disease.....	12	19 2/3	13	8
Ecologic Relations to Man.....	13	15 1/6	11	10
Protoplasm and the Cell.....	14	14	10	12
Botany.....	15	12 5/6	22	3
Reproduction (general).....	16	12 1/3	16	6
Conservation of Natural Resources....	17	11 1/6	11	10
Anatomy (general)....	18	9 1/6	36	1
Genetics (human)....	19	7 1/6	18	4
Scientific Method....	20	6 1/3	17	5

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Table 1. (concluded)

Area	Place	Number Of Points a/	The Placing and Points of these Areas, Determined by those making only One Selec- tion	
			Place	Number Of Points
(1)	(2)	(3)	(4)	(5)
Foods & Nutrition....	21	6 1/6	22	3
Reproduction (human).	22	5 5/6	18	4
Metazoan Vertebrates.	23	5 1/3	18	4
Biological Principles Kinds of Living Things.....	24	4 1/2	22	3
Evolution.....	24	4 1/2	18	4
Evolution.....	26	4 1/3	36	1
Nature Study.....	26	4 1/3	22	3
Economic Significance of Biology.....	28	3 1/3	28	2
Embryology.....	28	3 1/3	28	2
Entomology.....	28	3 1/3	22	3

a/One point was given if the person made but one selection; 1/2 point was given for each selection, if the person made two selections; 1/3 point was given for each selection if the person made three selections.

The total number of areas named by those giving but one answer was 46. The total number of areas named by those giving one, two, or three answers was 64. Table 2 gives a complete list of those areas named as most important by those teachers who gave but one answer.

Table 2. A Complete List of the Forty-Six
Areas Named as the One Most Important
Area by One or More Persons

Areas of Most Importance

Adjustment of the Human
Anatomy (general)
Application of Biology to Everyday Life
Appreciation of Nature
Bacteriology

Behavior (general)
Biological Principles
Biological Vocations and Avocations
Biology Applied to Humans
Botany

Conservation (general)
Conservation (wild life)
Conservation of Natural Resources
Disease
Ecologic Relations to Man

Ecology (general)
Economic Significance of Biology
Embryology
Energy Concept
Entomology

Essential Life Processes
Evolution
Familiar Plants and Animals
Foods and Nutrition
Genetics (human)

Genetics (general)
Human Behavior
Human Biology
Human Physiology

(concluded on next page)

Table 2. (concluded)

Areas of Most Importance
Hygiene & Health
Kinds of Living Things
Metabolism
Metazoan Vertebrates
Microscopic Life
Nature of Life
Nature Study
Needs of Living Things
Physical Chemistry of Biology
Physiology (general)
Protoplasm and the Cell
Reproduction (general)
Reproduction (human)
Scientific Method
Taxonomy
Zoology

The second section of this part of the study was to determine the least important areas. For this section a total of 53 replies was discarded. Fourteen of these were discarded because four or more areas were listed as least important. Twenty-six gave no answer, and the other 13 were discarded because the areas were not clearly defined.

The total number of areas named by those giving but one answer was 72. The total number of areas named by those giving one, two, or three answers was 91.

Table 3 gives the results of this section of this part of the study.

Table 3. The First Twenty-Nine ^{a/} Least Important Areas, Determined by Those Making One, Two, and Three Selections

Area	Place	Number Of Points	The Placing and Points of these Areas, Determined by those making only One Selection	
			Place	Number Of Points
(1)	(2)	(3)	(4)	(5)
Classification.....	1	133 1/2	1	121
Taxonomy.....	2	111 1/6	2	100
Botany.....	3	48 1/2	3	44
Evolution.....	4	46 1/6	4	38
Paleontology.....	5	37 1/3	5	31
Metazoan Invertebrates.	6	35 1/6	7	24
Flowerless Plants.....	7	33 5/6	6	25
Anatomy (general).....	8	25 1/3	8	20
Anatomy (plant).....	9	23 2/3	8	20
History of Biology.....	10	21 1/3	10	19
Detail.....	11	18 5/6	11	18
Genetics (general).....	12	18	13	14
Conservation (general).	13	17 5/6	12	15
Health & Hygiene ^{b/}	14	17	14	11
Ecology (general).....	15	14 1/2	14	11
Microscopic Life.....	16	10 5/6	16	9
Life Cycles of Lower Plants.....	17	9	16	9
Health & Hygiene.....	18	8 1/2	19	6
Human Physiology ^{b/}	19	7 1/2	23	5
Technical Study.....	19	7 1/2	18	7

(concluded on next page)

Table 3. (concluded)

Area (1)	Place (2)	Number Of Points (3)	The Placing and Points of these Areas, Determined by those making only one Selec- tion	
			Place (4)	Number Of Points (5)
Changes in Living Things.....	21	7 1/3	19	6
Conservation <u>b/</u>	21	7 1/3	19	6
Disease <u>b/</u>	21	7 1/3	19	6
Geographical Distribu- tion of Organisms.....	24	6 1/2	23	5
Geology.....	24	6 1/2	23	5
Foods & Nutrition.....	26	5 5/6	23	5
Dissection.....	27	5 1/2	30	4
Histology.....	27	5 1/2	23	5
Anatomy (animal).....	29	5 1/3	23	5

a/ Twenty-nine areas, rather than 30 are given because to include one more would necessitate including four more, since there are four areas having the same number of points.

b/ These are included as separate areas because in each case the reason given for naming them as least important was because the material was being covered in other classes.

In this first survey, eight of the first 30 areas named most often as most important were also found among the 29 areas named most often as least important. These areas were: Anatomy; botany; conservation; ecology; evolution; foods and nutrition; genetics; health and hygiene. While it was

interesting to note this overlapping of areas, it did not present a problem in constructing the list of areas for the second survey since no area was excluded from the list of areas for the second survey on the basis that it was included in the list of 29 least important areas.

2. The Second Survey

Introduction.-- As can be seen by an examination of the list of 30 most important areas given in the preceding section, six of the areas are too inclusive to be used in this second survey. These areas are human biology, biology applied to humans; zoology; botany; and metazoan vertebrates. The remaining 24 areas were placed in alphabetical order and were used for this survey.

Sample.-- Once again return postal cards were enclosed and the letters were sent to the 793 people who had indicated that they would be willing to do further work on the study. These teachers were supplied a list of the 24 most important areas of biology, as determined by part 1 of the survey.

They were asked to choose, from this list, the three areas which they considered most important and the three areas which they considered least important.

Replies received.-- To the 793 letters sent, 527 replies were received. Replies were received from 41 states and

Washington, D. C. Replies were received from two states, Texas and Tennessee, which had no replies in the first survey.^{1/} This can be explained by the probability that two teachers had moved in the time that elapsed between the first and second survey.

Evaluation of the replies.-- From the replies which were received, 477 were able to be used in determining the most important areas. A total of 50 replies were not used in determining the most important areas, for the following reasons: (1) only two areas given, 2 replies; (2) cards incorrectly filled out, 5 replies; (3) four or more areas listed, 23 replies; (4) claim that areas overlap one another, 20 replies.

Table 4 gives a ranking of the areas, according to the number of times that they were named as most important.

Table 4. A Ranking of the 24 Areas According to the Number of Times that they were Chosen Among the Three Most Important areas

Area	Number of Times Chosen
(1)	(2)
Essential Life Processes.....	250
Biological Principles.....	249
Conservation of Natural Resources.....	157
Human Physiology.....	99
Health & Hygiene.....	91

(concluded on next page)

1/See page 27.

Table 4. (concluded)

Area (1)	Number of Times Chosen (2)
Protoplasm and the Cell.....	57
Kinds of Living Things.....	56
Ecologic Relations to Man.....	55
Foods & Nutrition.....	48
Economic Significance of Biology.....	45
Nature Study.....	38
Anatomy of Plants & Animals Without Emphasis on Man.....	37
Disease.....	36
Genetics of the Human.....	36
Human Reproduction.....	28
Human Anatomy.....	26
Physiology of Plants & Animals Without Emphasis on Man.....	26
Ecology Without Emphasis on Man.....	21
Genetics of Plants & Animals Without Emphasis on Man.....	21
Conservation Without Emphasis on Natural Resources.....	18
Reproduction of Plants & Animals Without Emphasis on Man.....	16
Evolution.....	16
Entomology.....	6
Embryology.....	3

Five hundred and one replies were usable in determining the least important areas. A total of 26 replies was not used in determining the least important areas, for the following reasons: (1) only one area given, 1 reply;

(2) only two areas given, 7 replies; (3) cards incorrectly filled out, 2 replies; (4) four or more areas listed, 13 replies; (5) claim that areas overlap one another, 3 replies.

Table 5 gives a ranking of the areas, according to the number of times that they were named as least important.

Table 5. A Ranking of the 24 Areas According to the Number of Times that they were Chosen Among the Three Least Important Areas

Area	Number of Times Chosen
(1)	(2)
Embryology.....	169
Conservation Without Emphasis on Natural Resources.....	149
Anatomy of Plants & Animals Without Emphasis on Man.....	148
Evolution.....	145
Ecology Without Emphasis on Man	104
Entomology.....	99
Nature Study.....	83
Physiology of Plants & Animals Without Emphasis on Man.....	81
Genetics of Plants & Animals Without Emphasis on Man.....	63
Kinds of Living Things.....	60
Health & Hygiene.....	48
Economic Significance of Biology.....	44
Reproduction of Plants & Animals Without Emphasis on Man	42
Disease.....	38

(concluded on next page)

Table 5. (concluded)

Area (1)	Number of Times Chosen (2)
Human Anatomy.....	36
Ecologic Relations to Man.....	34
Foods & Nutrition.....	33
Protoplasm and the Cell.....	31
Human Reproduction.....	29
Genetics of the Human.....	28
Conservation of Natural Resources.	16
Biological Principles.....	11
Human Physiology.....	10
Essential Life Processes.....	2

In this second survey the area of "essential life processes" was named most often as most important and it was named least often (two teachers) as least important. The area of "biological principles" which ranked second in the list of most important areas, was third from last in the list of least important areas. The area of "conservation of natural resources" which was third in the list of most important areas, was fourth from last in the list of least important areas. The area of "human physiology" which ranked fourth in the list of most important areas, was second from the last in the list of least important areas. Further, the area of "embryology", which was named least often as most important, was named most often as least

important.

3. The Test Construction

Areas to be included.-- In the second survey the four areas that were named most often as most important were named least often as least important. In the areas named as most important, there was a definite breaking point after the fifth area, health and hygiene. Since, in many schools, this is offered as a course, separate from general biology, there would be a definite disadvantage to including this as one of the areas of the test.

In examining the list of most important areas, we find that the sixth and subsequent areas were each named as most important by fewer than 58 teachers. Since replies from 477 teachers were included in this part of the study, 57 teachers would represent less than 12 per cent of the group. This gives us an additional and very important reason for choosing only four areas.

Also, in the list of least important areas, a definite breaking point was found just prior to the last four items. For these reasons the four areas were: (1) Essential Life Processes, (2) Biological Principles, (3) Conservation of Natural Resources, and (4) Human Physiology, and accordingly a test was made to give an indication of the extent to which these areas were being learned.

Type of test items.-- It was felt that the multiple-choice type item offered more advantages than any other type. First, this type item would test for recognition rather than recall. This seems important in a test given nationally on material that may or may not have been covered in class. Secondly, this type item probably would be familiar to most of the pupils to be tested and even if it were not, it would be an easily understood type of test item. Thirdly, this type of item is capable of being corrected with high objectivity.

To have all of the items of the same type reduced to a minimum the directions needed by the pupils being tested. This would also allow more items to be done by the pupils in the allotted time.

Number of test items.-- Since this was an attempt to test for a knowledge of the four previously mentioned areas of biology, rather than speed in test taking, it seemed desirable to keep the number of items such that they could all be answered by all pupils in the allotted time. Tests were held in one school, and it was determined that 100 multiple-choice items could be answered by all pupils in a thirty-minute time period. Thus, 100 multiple-choice items were divided among the four areas named as most important. Those items having high discriminatory power and median

difficulty were used for computing the reliability of the final test.^{1/}

Subject matter of test items.-- The material for which the items were intended to test was taken from numerous high school biology texts. Since all of the material was taken from high school biology texts, these serve as the authority for the correctness of the items. The material for three areas; namely, Essential Life Processes, Conservation of Natural Resources, and Human Physiology was clearly and uniformly defined and described in the biology texts. However, this was not the case with the area of Biological Principles.

While some of the texts clearly defined this area, others completely omitted any mention of the term as such. Although the principles could have been read into the content of the text, they were not expressed as principles.

4. Survey Concerning Biological Principles

Purpose.-- After being constructed, to be certain that the section of the test on Biological Principles had face validity, another survey was deemed necessary.

Method.-- Five items taken as samples from the section of the test on Biological Principles, together with the

1/See page 72.

principles being tested, were sent to 50 teachers. Each one of these 50 teachers had previously listed Biological Principles as one of the three most important areas of biology. They were now asked whether or not the items tested for a knowledge of biological principles. They were also requested to make comments if they so desired.

Results.-- There were 40 replies received. Four of these claimed that an objective test was inadequate in testing for a knowledge of biological principles. Thirty-six of these, or 90 per cent, stated that the items did test for a knowledge of biological principles. By virtue of this response, it was felt that the items had face validity.

5. Description of Test Population

Method of obtaining and choosing classes.-- Letters were sent to 100 teachers, briefly explaining the results of the previous parts of the study. The four most named areas were listed, and the teachers were asked if they would be willing to give a test in these four areas. It was explained that, if they were willing, 30 copies of the test would be sent to them some time near the end of the school year. It was further explained that the tests would take about 35 minutes to administer and they would not be required to do any of the correcting of the tests.

Eighty-five teachers replied to this letter. Seventy-seven said that they would be able to give the test. The others were unable to give it for various reasons. Five of the teachers who were able to give the test wanted considerably more than thirty copies and seven of the teachers who were able to give the test wanted fewer than 20 copies. For these reasons, these 12 teachers were not used in this part of the study. Of the 65 remaining teachers, 50 were chosen on the basis of the widest possible geographical distribution. A letter of explanation and thanks was sent to the 27 teachers who said that they would be willing to give the tests, but who were not sent a set of 30 tests for one of the above-mentioned reasons. However, these teachers were sent a copy of the test together with a brief explanation. They were asked to make comments on the test.

Suggestions for administering the test.-- Thirty copies of the test were sent to the 50 teachers selected to give the test. A letter was enclosed which explained that the test was divided into four sections of 25 items each. They were asked to allow 9 minutes for each group of 25 questions. This was to prevent a pupil from spending too much time on any one group of questions. However, it was explained that if a pupil finished one group of questions before 9 minutes had elapsed, he should be allowed to continue on with

the next group of questions.

Request for criticism of the test.-- These teachers were asked to make comments or criticisms of the test. They were especially asked to indicate any items which they felt were not teachable; i.e., items in which the difficulty level of the material was too high for high school pupils.^{1/}

Number of tests returned and corrected.-- All of the 50 sets of tests were returned. However, two of the sets were not used. These schools had an early closing date, and the teachers had received them too late to administer them. Two other sets of tests were not returned until the following fall, and since much of the statistical work had already been done, they were not included.

Forty-six sets, with a total of 1,260 tests, were corrected and included in the study. These tests were all administered sometime between May 20th and June 15th. This was to be sure that most of the year's material had already been covered. The size of the classes ranged from a low of 20 to a high of 30. The average was 27.39. Only one set of tests was given in any one school. Geographically, the schools were located in 18 states. The states were: California, Connecticut, Florida, Illinois, Indiana, Iowa,

1/For results, see Appendix A

Kansas, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania.

6. Results Obtained in the Test

Introduction.-- As was previously explained, 50 sets of tests were distributed. Two sets were not used by the teachers and two other sets were returned too late to be included in the study. Forty-six sets, with a total of 1,260 tests, were corrected and included in the study.

After all of the tests were scored, the highest 27 per cent and the lowest 27 per cent were grouped for further study. Regarding this, Kirkpatrick and Cureton wrote:

"Ideally the high and low criterion groups should each contain 27 per cent of the total experimental sample, but each group may contain anywhere from 18 to 36 per cent with comparatively little loss of efficiency."^{1/} In discussing the

size of upper and lower groups, Kelley states: "Upper and lower groups consisting of 27 per cent from the extremes of the criterion score distribution are optimal for the study of test items...."^{2/} In writing of the use of the upper

^{1/}James J. Kirkpatrick and Edward E. Cureton, Simplified Tables for Item Analysis, Educational and Psychological Measurement (Winter 1954), 14:709-714, p. 709.

^{2/}Truman L. Kelley, The Selection of Upper and Lower Groups for the validation of Test Items, Journal of Educational Psychology (January, 1939), 30:17-24, p. 24.

27 per cent and the lower 27 per cent, Thorndike says:
 "We can reject the middle 46 per cent of cases, reducing
 the clerical labor of tallying almost by half and at the
 same time increase the precision of our results."^{1/} There
 were 340 pupils in both the high and the low groups.

Responses for each item in the high and the low
 group.-- The next step consisted in determining the number
 of pupils in both the high group and the low group who
 responded to the different choices for each item. Table 6
 gives the responses for each item in the highest 27 per
 cent of the sample. The total number of pupils in the
 sample was 1,260. There were 340 pupils in both the upper
 and the lower 27 per cents.

Table 6. Responses for Each Item in the Highest
 27 Per Cent

Item	Choice				Omitted	Correct Response
	A	B	C	D		
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1.....	312	8	4	15	1	A
2.....	180	12	2	146	0	D
3.....	11	249	9	70	1	B
4.....	261	35	10	32	2	A
5.....	331	2	1	6	0	A

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^{1/}Robert L. Thorndike, Personnel Selection, John Wiley and
 Sons, Inc., New York, 1949, p. 241.

Table 6. (continued)

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
6.....	13	287	33	6	1	B
7.....	11	5	299	24	1	C
8.....	24	305	2	9	0	B
9.....	2	309	2	27	0	B
10.....	80	21	227	11	1	C
11.....	4	2	11	322	0	D
12.....	22	88	226	3	1	C
13.....	21	217	0	2	0	B
14.....	0	303	30	6	1	B
15.....	10	5	8	317	0	D
16.....	20	269	0	50	1	B
17.....	277	3	29	31	0	A
18.....	99	7	9	225	0	D
19.....	16	194	120	10	0	B
20.....	212	98	23	6	1	A
21.....	1	335	4	0	0	B
22.....	3	335	1	1	0	B
23.....	18	16	177	128	1	C
24.....	4	306	29	1	0	B
25.....	301	8	27	3	1	A
26.....	30	295	12	3	0	B
27.....	4	64	250	21	1	C
28.....	4	17	33	286	0	D
29.....	2	332	2	4	0	B
30.....	37	63	33	195	12	D
31.....	2	281	18	39	0	B
32.....	108	27	143	61	1	C
33.....	0	277	36	26	1	B
34.....	24	8	19	289	0	D
35.....	0	8	23	209	0	D

(continued on next page)

Table 6. (continued)

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
36.....	11	286	33	8	2	B
37.....	1	329	4	6	0	B
38.....	118	195	3	23	1	A
39.....	319	7	7	7	0	A
40.....	14	16	302	8	0	C
41.....	7	72	240	19	2	C
42.....	12	279	40	6	3	B
43.....	1	3	4	332	0	D
44.....	332	3	1	4	0	A
45.....	60	279	1	0	0	B
46.....	64	8	19	243	4	D
47.....	291	35	4	10	0	A
48.....	327	0	10	3	0	A
49.....	63	3	267	7	0	C
50.....	133	195	9	1	2	B
51.....	107	1	4	228	0	D
52.....	334	4	1	1	0	A
53.....	2	61	273	4	0	C
54.....	13	17	296	13	1	C
55.....	24	208	22	85	1	B
56.....	7	1	316	16	0	C
57.....	155	16	4	164	1	A
58.....	28	9	17	285	1	D
59.....	17	13	1	309	0	D
60.....	8	15	4	311	2	D
61.....	8	265	8	59	0	B
62.....	45	3	9	282	1	D
63.....	2	1	2	336	0	D
64.....	0	269	63	8	0	B
65.....	27	5	307	1	0	C

(concluded on next page)

Table 6. (concluded)

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
66.....	2	23	289	26	0	C
67.....	327	1	12	0	0	A
68.....	319	10	10	0	1	A
69.....	57	8	266	6	3	C
70.....	220	0	1	118	1	A
71.....	269	52	0	18	1	A
72.....	13	4	2	321	0	D
73.....	26	3	12	299	0	D
74.....	11	43	284	2	0	C
75.....	13	2	296	28	1	C
76.....	0	333	0	7	0	B
77.....	5	16	50	269	0	D
78.....	0	0	340	0	0	C
79.....	7	304	25	4	0	B
80.....	308	10	10	12	0	A
81.....	32	0	300	7	1	C
82.....	2	19	1	318	0	D
83.....	6	10	306	18	0	C
84.....	53	24	183	72	8	C
85.....	295	10	32	1	2	A
86.....	11	296	21	12	0	B
87.....	14	39	21	253	3	B
88.....	84	77	174	2	3	C
89.....	144	11	2	180	3	D
90.....	15	322	0	3	0	B
91.....	1	0	292	47	0	D
92.....	14	25	139	159	3	C
93.....	44	21	266	9	0	C
94.....	0	10	5	325	0	D
95.....	0	12	320	7	1	C
96.....	21	304	13	1	1	B
97.....	16	305	6	12	1	B
98.....	55	50	65	163	7	D
99.....	294	18	6	15	7	A
100.....	272	12	26	28	2	A

Table 7 gives the responses for each item in the lowest 27 per cent of the sample.

Table 7. Responses for Each Item in the Lowest 27 Per Cent

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
1.....	252	22	25	30	11	A
2.....	197	34	3	105	1	D
3.....	29	170	22	107	12	B
4.....	78	69	37	140	16	A
5.....	278	18	8	31	5	A
6.....	47	176	87	23	7	B
7.....	26	52	190	54	18	C
8.....	114	192	8	22	4	B
9.....	26	198	25	82	9	B
10.....	56	46	177	54	7	C
11.....	44	6	103	182	5	D
12.....	93	92	87	51	17	C
13.....	77	216	8	26	13	B
14.....	52	188	56	26	18	B
15.....	25	8	24	277	6	D
16.....	116	111	3	105	5	B
17.....	101	36	116	77	10	A
18.....	129	35	32	112	32	D
19.....	30	98	184	20	8	B
20.....	43	192	45	37	23	A
21.....	6	270	27	21	16	B
22.....	26	285	4	10	15	B
23.....	38	43	80	152	27	C
24.....	17	196	85	21	21	B
25.....	169	37	72	53	9	A

(continued on next page)

Table 7. (continued)

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
26.....	164	118	19	35	4	B
27.....	22	136	105	60	17	C
28.....	31	31	69	198	11	D
29.....	23	266	34	11	6	B
30.....	39	106	54	102	39	D
31.....	26	125	69	112	8	B
32.....	95	61	150	23	11	C
33.....	3	254	50	24	9	B
34.....	75	23	107	111	24	D
35.....	40	35	81	178	6	D
36.....	80	72	127	45	16	B
37.....	54	205	48	25	8	B
38.....	57	122	53	92	16	A
39.....	179	11	88	51	11	A
40.....	39	127	144	21	9	C
41.....	23	61	174	57	25	C
42.....	58	92	93	69	28	B
43.....	23	30	57	214	16	D
44.....	223	63	9	25	20	A
45.....	83	202	24	10	25	B
46.....	68	77	90	70	35	D
47.....	140	57	41	78	24	A
48.....	248	9	41	23	19	A
49.....	68	36	162	47	27	C
50.....	108	130	33	36	33	B
51.....	139	16	70	106	9	D
52.....	301	26	4	5	4	A
53.....	16	135	145	37	7	C
54.....	95	54	128	49	14	C
55.....	73	93	27	132	15	B

(continued on next page)

Table 7. (continued)

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
56.....	18	60	216	32	14	C
57.....	47	46	55	174	18	A
58.....	33	42	86	163	16	D
59.....	70	9	29	219	13	D
60.....	83	35	26	180	16	D
61.....	41	130	34	117	18	B
62.....	62	6	23	238	11	D
63.....	40	22	36	227	15	D
64.....	4	178	118	27	13	B
65.....	155	29	116	14	26	C
66.....	42	101	102	71	24	C
67.....	166	35	86	24	29	C
68.....	231	36	42	10	21	A
69.....	70	23	193	34	20	A
70.....	122	14	28	156	20	C
71.....	164	88	9	58	21	A
72.....	88	27	14	198	13	A
73.....	62	14	44	212	8	D
74.....	81	118	115	12	14	D
75.....	65	8	189	58	20	C
76.....	16	244	28	37	15	C
77.....	32	23	73	190	22	B
78.....	17	7	242	54	20	C
79.....	51	200	55	17	17	B
80.....	142	64	33	78	23	A
81.....	73	4	190	45	28	C
82.....	6	17	6	304	7	D
83.....	58	43	164	57	18	C
84.....	88	50	76	99	27	C
85.....	147	52	67	50	24	A

(concluded on next page)

Table 7. (concluded)

Item (1)	Choice				Omitted (6)	Correct Response (7)
	A (2)	B (3)	C (4)	D (5)		
86.....	47	157	51	70	16	B
87.....	56	48	93	119	24	B
88.....	97	94	108	8	33	C
89.....	90	58	20	143	29	D
90.....	46	185	48	30	31	B
91.....	14	17	200	84	25	D
92.....	45	108	37	124	26	C
93.....	122	30	136	27	25	C
94.....	15	86	27	183	29	D
95.....	25	69	163	49	34	C
96.....	77	126	71	37	29	B
97.....	58	116	40	93	33	B
98.....	74	52	79	90	45	D
99.....	122	40	46	65	67	A
100.....	68	36	107	88	41	A

By examining Tables 6 and 7, we can see that some of the choices were eliminated by nearly all of the examinees and therefore were poor distracters for the particular item. In other cases, it can be seen that there was an approximately equal distribution of wrong answers among the three distracters, thus indicating that they are suitable for the particular item.

Per cent in each group with the correct response.-- The next step was an arithmetical determination of the per cent in the high group and the per cent in the low group who

responded correctly to each response. These per cents are given in Table 8.

Table 8. Per Cents of Examinees in Each Group With The Correct Response

Item (1)	Group		Item (1)	Group	
	High (2)	Low (3)		High (2)	Low (3)
1.....	91.8	74.2	26.....	86.7	31.8
2.....	43.0	30.9	27.....	73.6	30.9
3.....	73.3	50.0	28.....	84.2	58.3
4.....	76.8	22.9	29.....	97.7	78.3
5.....	97.5	81.8	30.....	57.4	30.0
6.....	84.5	51.8	31.....	82.6	36.8
7.....	88.1	56.0	32.....	42.0	44.1
8.....	89.7	56.5	33.....	81.5	74.7
9.....	91.0	58.3	34.....	85.0	32.7
10.....	66.8	52.1	35.....	91.0	52.4
11.....	94.7	53.6	36.....	84.2	21.2
12.....	66.5	25.6	37.....	96.7	60.3
13.....	93.4	63.6	38.....	34.7	16.8
14.....	89.2	55.3	39.....	93.8	52.6
15.....	93.3	81.5	40.....	88.8	42.4
16.....	79.1	32.6	41.....	70.6	51.2
17.....	81.5	29.7	42.....	82.1	27.0
18.....	66.2	33.0	43.....	97.7	63.0
19.....	57.1	28.8	44.....	97.7	65.6
20.....	62.4	12.6	45.....	82.1	59.5
21.....	98.5	78.5	46.....	71.6	20.6
22.....	98.5	83.8	47.....	85.6	41.2
23.....	52.1	23.5	48.....	96.2	73.0
24.....	90.0	57.6	49.....	78.6	47.6
25.....	88.6	49.7	50.....	57.4	38.2

(concluded on next page)

Table 8. (concluded)

Item (1)	Group		Item (1)	Group	
	High (2)	Low (3)		High (2)	Low (3)
51.....	67.1	31.2	76.....	98.0	71.8
52.....	98.3	88.5	77.....	79.2	55.9
53.....	80.3	42.7	78.....	100.0	71.2
54.....	87.0	37.7	79.....	89.4	58.8
55.....	61.2	27.4	80.....	90.6	41.8
56.....	93.0	60.6	81.....	88.3	55.9
57.....	45.6	13.8	82.....	93.6	89.4
58.....	83.8	48.0	83.....	90.0	48.3
59.....	91.0	64.5	84.....	53.8	22.3
60.....	91.6	53.0	85.....	86.8	43.2
61.....	78.0	38.3	86.....	87.1	45.8
62.....	83.0	70.0	87.....	11.5	14.1
63.....	98.9	66.8	88.....	51.2	31.8
64.....	79.1	52.3	89.....	52.9	42.1
65.....	90.3	34.1	90.....	94.7	54.4
66.....	85.0	30.0	91.....	13.8	24.7
67.....	96.2	48.8	92.....	40.8	10.9
68.....	93.8	68.0	93.....	78.3	40.0
69.....	78.3	56.8	94.....	95.7	53.8
70.....	64.7	35.9	95.....	94.2	48.0
71.....	79.2	48.2	96.....	89.4	37.1
72.....	94.5	58.2	97.....	89.8	34.1
73.....	88.0	62.4	98.....	47.9	26.4
74.....	83.6	33.9	99.....	86.5	35.9
75.....	87.1	55.6	100.....	80.0	20.0

Correction of the highest 27 per cent and the lowest 27 per cent for chance success.-- Since each item was of the multiple choice type, guessing has played an important part in increasing the per cent of individuals who responded

correctly to each item. Guilford says: "In the multiple choice type of test, however, lucky guessing increases a student's score considerably and also increases the proportion of passing individuals."^{1/} It is necessary therefore to correct the proportions reported in Table 8 for guessing. Guilford says further: "Proportions that are thus artificially inflated because of the factor of guessing should not ordinarily be used for scaling purposes unless corrections for guessing are made."^{2/} In order to correct for chance success, the per cents given in Table 8 were rounded to two places, and these were then translated into corrected per cents according to a correction table by Guilford.^{3/} These corrected responses are found in Table 9.

Table 9. Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

Item	Group		Item	Group	
	High	Low		High	Low
(1)	(2)	(3)	(1)	(2)	(3)
1.....	89.3	65.3	4.....	69.3	0.0
2.....	24.0	8.0	5.....	97.3	76.0
3.....	64.0	33.3	6.....	80.0	36.0

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^{1/}J. P. Guilford, Fundamental Statistics in Psychology and Education, McGraw-Hill Book Co., Inc., New York, 1950, p. 550.

^{2/}Ibid., p. 550

^{3/}Op. cit., p. 552.

Table 9. (continued)

Item (1)	Group		Item (1)	Group	
	High (2)	Low (3)		High (2)	Low (3)
7.....	84.0	41.3	37.....	96.0	46.7
8.....	86.7	42.7	38.....	13.3	0.0
9.....	88.0	44.0	39.....	92.0	37.3
10.....	56.0	36.0	40.....	85.3	22.7
11.....	93.3	38.7	41.....	60.0	34.7
12.....	56.0	1.3	42.....	76.0	2.7
13.....	90.7	52.0	43.....	97.3	50.7
14.....	85.3	40.0	44.....	97.3	54.7
15.....	90.7	76.0	45.....	76.0	46.7
16.....	72.0	10.7	46.....	62.7	0.0
17.....	76.0	6.7	47.....	81.3	21.3
18.....	54.7	10.7	48.....	94.7	64.0
19.....	42.7	5.3	49.....	72.0	30.7
20.....	49.3	0.0	50.....	42.7	17.3
21.....	98.7	72.0	51.....	56.0	8.0
22.....	98.7	78.7	52.....	97.3	85.3
23.....	36.0	0.0	53.....	73.3	24.0
24.....	86.7	44.0	54.....	82.7	17.3
25.....	85.3	33.3	55.....	48.0	2.7
26.....	82.7	9.3	56.....	90.7	48.0
27.....	65.3	8.0	57.....	28.0	0.0
28.....	78.7	44.0	58.....	78.7	30.7
29.....	97.3	70.7	59.....	88.0	53.3
30.....	42.7	6.7	60.....	89.3	37.3
31.....	77.3	16.0	61.....	70.7	17.3
32.....	22.7	25.3	62.....	77.3	60.0
33.....	76.0	66.7	63.....	98.7	56.0
34.....	80.0	10.7	64.....	72.0	36.0
35.....	88.0	36.0	65.....	86.7	12.0
36.....	78.7	0.0	66.....	80.0	6.7

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Table 9. (concluded)

Item (1)	Group		Item (1)	Group	
	High (2)	Low (3)		High (2)	Low (3)
67.....	94.7	32.0	84.....	38.7	0.0
68.....	92.0	57.3	85.....	82.7	24.0
69.....	70.7	42.7	86.....	82.7	28.0
70.....	53.3	14.7	87.....	0.0	0.0
71.....	72.0	30.7	88.....	34.7	9.3
72.....	93.3	44.0	89.....	37.3	22.7
73.....	84.0	49.3	90.....	93.3	38.7
74.....	78.7	12.0	91.....	0.0	0.0
75.....	82.7	41.3	92.....	21.3	0.0
76.....	97.3	62.7	93.....	70.7	20.0
77.....	72.0	41.3	94.....	94.7	38.7
78.....	100.0	61.3	95.....	92.0	30.7
79.....	85.3	45.3	96.....	85.3	16.0
80.....	88.0	22.7	97.....	86.7	12.0
81.....	84.0	41.3	98.....	30.7	1.3
82.....	92.0	85.3	99.....	82.7	14.7
83.....	86.7	30.7	100.....	73.3	0.0

Total per cent who were assumed to know the correct answer.-- To determine the total per cent of those who were assumed to have known the correct answer, one needed only average the corrected per cents of the high and the low groups. This has been done in many studies. However, concerning this method of arriving at a total per cent of those who know the correct response, Fan^{1/} states:

1/Chung-Teh Fan, Item Analysis Table, Educational Testing Service, Princeton, New Jersey, 1952, p. 3.

"It has been observed, however, that this estimate is subject to systematic error, particularly in the cases of extreme values of P and high values of the discrimination index. For a normal distribution, the mean of P_H and P_L overestimates values of P less than .50 and underestimates values of P greater than .50."

In order that this error might not occur, the per cent of those assumed to know the correct answer was determined by using the tables by Fan.^{1/}

To make possible the use of these tables, the decimal found for each per cent in Table 9 was rounded. For example, item Number 1 was changed from 89.3 to 89; item Number 8 was changed from 86.7 to 87. The per cent of those who were assumed to know the correct answer is given in Table 10.

Table 10. Per Cent of Examinees Who Were Assumed to Know the Correct Answer to Each Item

Item	Per Cent	Item	Per Cent
(1)	(2)	(1)	(2)
1.....	78	11.....	69
2.....	15	12.....	22
3.....	48	13.....	74
4.....	27	14.....	64
5.....	88	15.....	84
6.....	59	16.....	39
7.....	64	17.....	38
8.....	67	18.....	31
9.....	68	19.....	21
10.....	46	20.....	19

(continued on next page)

Table 10. (continued)

Item	Per Cent	Item	Per Cent
(1)	(2)	(1)	(2)
21.....	89	53.....	48
22.....	91	54.....	50
23.....	14	55.....	21
24.....	67	56.....	72
25.....	60	57.....	11
26.....	44	58.....	56
27.....	34	59.....	72
28.....	62	60.....	65
29.....	86	61.....	43
30.....	23	62.....	69
31.....	46	63.....	83
32.....	24	64.....	54
33.....	72	65.....	49
34.....	44	66.....	41
35.....	64	67.....	68
36.....	32	68.....	76
37.....	76	69.....	57
38.....	06	70.....	33
39.....	67	71.....	52
40.....	55	72.....	72
41.....	47	73.....	68
42.....	34	74.....	44
43.....	78	75.....	63
44.....	80	76.....	83
45.....	62	77.....	57
46.....	25	78.....	85
47.....	51	79.....	66
48.....	82	80.....	57
49.....	52	81.....	64
50.....	29	82.....	89
51.....	29	83.....	61
52.....	92	84.....	15

(concluded on next page)

Table 10. (concluded)

Item	Per Cent	Item	Per Cent
(1)	(2)	(1)	(2)
85.....	54	93.....	45
86.....	56	94.....	71
87.....	00	95.....	64
88.....	21	96.....	51
89.....	30	97.....	49
90.....	69	98.....	12
91.....	00	99.....	49
92.....	09	100.....	29

Difficulty Index.-- The per cents given in Table 10 give a true value for the difficulty of each item. However, these per cents do not constitute a linear scale and therefore, with such values we are unable to compare^{1/} one item with another or one group of items with another group. It is therefore necessary to state the difficulty of each item in terms of a linear scale. This is done by using a chart devised by Davis.^{2/} From this chart both the difficulty index and the discrimination index may be obtained from the percentages of successes in the highest and in the lowest 27 per cent of the sample. This chart was used to obtain the difficulty indices found in Table 11.

1/For a comparison, see p. 65.

2/Frederick B. Davis, Item Analysis Chart, Cooperative Test Service of the American Council on Education, New York, 1944.

Table 11. Difficulty Index for Each Item

Item (1)	Difficulty Index (2)	Item (1)	Difficulty Index (2)
1.....	66	31.....	48
2.....	29	32.....	35
3.....	49	33.....	62
4.....	42	34.....	48
5.....	72	35.....	56
6.....	54	36.....	45
7.....	57	37.....	62
8.....	58	38.....	19
9.....	59	39.....	58
10.....	48	40.....	52
11.....	59	41.....	49
12.....	38	42.....	45
13.....	61	43.....	63
14.....	57	44.....	65
15.....	71	45.....	56
16.....	46	46.....	40
17.....	62	47.....	51
18.....	41	48.....	68
19.....	35	49.....	51
20.....	36	50.....	39
21.....	72	51.....	40
22.....	76	52.....	78
23.....	31	53.....	49
24.....	59	54.....	50
25.....	55	55.....	36
26.....	48	56.....	61
27.....	43	57.....	28
28.....	56	58.....	53
29.....	71	59.....	61
30.....	36	60.....	57

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Table 11. (concluded)

Item (1)	Difficulty Index (2)	Item (1)	Difficulty Index (2)
61.....	47	81.....	57
62.....	60	82.....	76
63.....	66	83.....	55
64.....	52	84.....	32
65.....	50	85.....	52
66.....	47	86.....	53
67.....	58	87.....	0
68.....	64	88.....	34
69.....	54	89.....	39
70.....	41	90.....	59
71.....	51	91.....	0
72.....	60	92.....	24
73.....	59	93.....	48
74.....	48	94.....	59
75.....	56	95.....	56
76.....	68	96.....	51
77.....	54	97.....	50
78.....	68	98.....	30
79.....	58	99.....	50
80.....	53	100.....	43

In order to use this chart of Davis, the per cents found in Table 9 were rounded to two places. In those cases in which the percentage of success in the lowest 27 per cent of the sample were zero, the difficulty indices were obtained according to a method recommended by Davis,^{1/} who states

1/Frederick B. Davis, Item-Analysis Data Their Computation, Interpretation, and Use in Test Construction, Graduate School of Education, Harvard University, Cambridge, Mass., 1949, pp. 35, 36.

that: "For an item of this sort, a satisfactory difficulty index may be obtained by averaging the proportions of successes (corrected for chance) in the highest and lowest 27 per cent of the sample and reading the difficulty index." This was done and the difficulty index determined from the table by Davis^{1/} for this purpose. For example, Table Number 9 gives 89.3 as the per cent of examinees in the upper 27 per cent who had the correct response, after correction for chance success. This same table gives 65.3 as the per cent of examinees in the lower 27 per cent who had the correct response, after correction for chance success. These numbers were rounded to 89 and 65 respectively and then used in Davis' chart to give a difficulty index of 66.

In the two cases (Item Number 87^{2/} and Item Number 91^{3/}) in which the percentages of success in both the high and the low group were zero, the difficulty index is given as zero. Davis^{4/} states that, "...if both percentages are zero, the 1/Op. cit., p. 38.

2/Item 87. The type of soil which is best able to hold water is a (a) sandy soil; (b) clay soil; (c) mixture of sand and clay; (d) loamy soil.

3/Item 91. Many wild flowers are protected by law and must not be picked. This is because these flowers (a) are poisonous; (b) cause allergies; (c) are becoming extinct; (d) furnish food and shelter to birds.

4/Ibid., p. 37.

discrimination index is zero, and the difficulty index may be recorded as zero."

It is interesting to note that no teacher commented on either Item 87 or Item 91. Yet, these are the two items which proved to be the poorest in the test, in terms of test results.

In Item 87, a loamy soil was given as the correct answer by most of the pupils who took the test. This answer could well come from an association of water in the soil and soil fertility. While this association is incorrect, it is nevertheless rather common. In Item 91, the most popular answer was that the wild flowers are becoming extinct. While this is true, and while there is at present a strong movement to protect them for this reason, the laws have been passed for the protection of birds rather than for the flowers themselves.

The difficulty indices for each section of the test were averaged for comparison. It was found that the mean of the indices for the items on biological principles was 53.32. This was slightly higher than the average of the indices for the items on human physiology, which was 53.04. For the items on essential life processes, the average of the indices was 50.64. The lowest average index was for the items which dealt with conservation. It was 46.76. This could indicate that of these four areas, conservation has been most seriously

neglected.

Discrimination Index.-- In an item analysis, it is necessary to determine the discriminating power of each item. In those cases where the discriminating power is low or even negative, we must carefully consider the usability of such items. Davis' Item Analysis Chart^{1/} was again used to determine the discrimination index for each test item. The discrimination indices of Davis have values ranging from zero to 100. Regarding the values, Davis^{2/} says:

"In actual practice, discrimination indices close to 100 will virtually never be obtained. Items with discrimination indices above 20 will ordinarily be found to have sufficient discriminating power for use in most achievement and aptitude tests."

The discrimination indices for each item are reported in Table 12. Since the discrimination indices of Davis are not as familiar as either Pearson's product-moment coefficients of correlation (r) or Flanagan's product-moment coefficients of correlation (z), the equivalent values for these are also given in Table 12. The discrimination index has been translated into both r and z by using a table devised by Davis.^{3/} In those cases where the percentages of successes in the lowest 27 per cent of the sample is

1/Op. cit.

2/Ibid., p. 15.

3/Ibid., pp. 13, 14.

zero, adjustment was described by Davis.^{1/} In each case the new percentage became one. However, Davis^{2/} states: "A discrimination index obtained by this procedure is always an underestimate, and this fact can be noted conveniently by adding a plus-sign superscript to the index." As can be seen from Table 12, this method has been followed.

Table 12. Discrimination Index and Equivalent Values of r^a and z^b

Item	Discrimination Index	r	z
(1)	(2)	(3)	(4)
1.....	21	.34	.35
2.....	17	.27	.28
3.....	19	.31	.32
4.....	67+	.80+	1.11+
5.....	19	.31	.32
6.....	30	.46	.50
7.....	30	.46	.50
8.....	32	.48	.53
9.....	32	.48	.53
10.....	32	.20	.20
11.....	12	.61	.71
12.....	43	.75	.97
13.....	58	.47	.51
14.....	31	.48	.53
15.....	32	.26	.27

(continued on next page)

1/Ibid., p. 35.

2/Loc. cit.

Table 12. (continued)

Item	Discrimination Index	r	z
(1)	(2)	(3)	(4)
16.....	45	.63	.74
17.....	7	.12	.12
18.....	34	.51	.56
19.....	36	.54	.60
20.....	55	.72	.91
21.....	43	.61	.71
22.....	37	.55	.61
23.....	48+	.66+	.79+
24.....	31	.47	.51
25.....	36	.54	.60
26.....	56	.73	.93
27.....	44	.62	.73
28.....	24	.38	.40
29.....	33	.50	.55
30.....	33	.50	.55
31.....	43	.61	.71
32.....	-2	-.04	-.04
33.....	7	.12	.12
34.....	51	.69	.85
35.....	37	.55	.61
36.....	73+	.84+	1.21+
37.....	45	.63	.74
38.....	29+	.45+	.48+
39.....	43	.61	.71
40.....	44	.62	.73
41.....	16	.26	.27
42.....	62	.77	1.03
43.....	46	.64	.76
44.....	43	.61	.71
45.....	20	.32	.33

(continued on next page)

Table 12. (continued)

Item	Discrimination Index	r	z
(1)	(2)	(3)	(4)
46.....	63+	.78	1.05
47.....	42	.60	.69
48.....	32	.48	.53
49.....	26	.40	.43
50.....	19	.31	.32
51.....	38	.56	.63
52.....	21	.34	.35
53.....	32	.48	.53
54.....	47	.65	.78
55.....	46	.64	.76
56.....	35	.52	.58
57.....	43+	.61	.71
58.....	32	.48	.53
59.....	27	.41	.44
60.....	38	.56	.63
61.....	37	.55	.61
62.....	12	.20	.20
63.....	52	.70	.87
64.....	23	.36	.38
65.....	55	.72	.91
66.....	56	.73	.93
67.....	52	.70	.87
68.....	30	.46	.50
69.....	18	.29	.30
70.....	27	.41	.44
71.....	26	.40	.43
72.....	40	.58	.66
73.....	25	.39	.41
74.....	49	.67	.81
75.....	29	.45	.48

(concluded on next page)

Table 12. (concluded)

Item	Discrimination Index	r	z
(1)	(2)	(3)	(4)
76.....	39	.57	.65
77.....	20	.32	.33
78.....	50	.68	.83
79.....	29	.45	.48
80.....	47	.65	.78
81.....	30	.46	.50
82.....	9	.15	.15
83.....	40	.58	.66
84.....	50+	.68+	.83+
85.....	41	.59	.68
86.....	38	.56	.63
87.....	0	.00	.00
88.....	23	.36	.38
89.....	10	.17	.17
90.....	43	.61	.71
91.....	0	.00	.00
92.....	37+	.55+	.61+
93.....	35	.52	.58
94.....	47	.65	.78
95.....	47	.65	.78
96.....	50	.68	.83
97.....	55	.72	.91
98.....	45	.63	.74
99.....	48	.66	.79
100.....	70+	.82+	1.16+

a/Pearson's Product-Moment Coefficient of Correlation.

b/Flanagan's Product-Moment Coefficient of Correlation.

Revision of the test.-- Since a number of items in the test were not of a high discriminatory nature, they were deleted from the final test. Other items were deleted because they were too easy or too difficult.

This procedure was followed by Read^{1/} in the construction of a non-verbal picture test. Further justification for this method of test revision can be found in an article by Horst^{2/} who discusses the construction of a final test through one administration by first giving an excess number of items and then eliminating some of them. Under this system no pilot test was needed.

In determining the items to be eliminated, Davis' Difficulty Index for each item was used together with Pearson's Product-Moment Coefficient of Correlation for each item. Any item which had a difficulty index of 0-30 or 76-100 was eliminated.

There were 10 items which came in these categories. They were items Number 2, 22, 38, 52, 57, 82, 87, 91, 92, and 98. Any item which had a coefficient of correlation

^{1/}John G. Read, "Measuring with a Non-Verbal Picture Test, The Ability to Recognize and Classify some Objects and Situations Associated with the Physical Science Environment," Unpublished Doctoral Dissertation, Boston University School of Education, 1954, p. 37.

^{2/}Paul Horst, "Item Selection by Means of a Maximizing Function," Psychometrika, Volume 1, Number 4, December 1936, pp. 229-244.

of 0 to 30 was eliminated. There were 13 items which came in this category. They were items Number 2, 10, 15, 17, 32, 33, 41, 62, 69, 82, 87, 89, 91.

This method of eliminating items by inspection is justified in an article by Richardson and Adkins^{1/} where they state: "Regardless of what procedure is used, the item indices are subject to sampling fluctuations which possibly are of such magnitude that the choice among methods is practically a matter of no importance."

Since four items (Numbers 2, 82, 87, 91) were deleted from the test, because of both their difficulty index and their coefficient of correlation, there was a total of 19 items deleted from the test. An estimated reliability coefficient was then obtained for the 81 remaining items.

Estimated reliability coefficient of the revised test.--

An estimated reliability coefficient was obtained using the item-test correlations of the 81 items in the revised test, according to a method described by Guilford.^{2/} To obtain an estimated reliability according to this method, it is necessary to compute the mean of the point-biserial rs.

1/M. W. Richardson and Dorothy C. Adkins, "A Rapid Method of Selecting Test Items," Journal of Educational Psychology, 29:547-552, 1939, p. 547.

2/J. P. Guilford, Fundamental Statistics in Psychology and Education, McGraw-Hill Book Co., Inc., New York, 1956, pp. 453-454.

In this test, scored as it was, a point-biserial r is the same as a product-moment r . Guilford^{1/} states that:

"If we gave a "score" of +1 to each person with a correct answer and a "score" of zero to each person with a wrong answer, in the item variable we should have only two class intervals and we treat them as if they were genuine categories. A product-moment r could be computed with Pearson's basic formula. The result would be a point-biserial r ."

The mean of the correlations of items with a total test score (\bar{r}_{it}) was computed and found to be .56. The number of items (n) in the revised test was 81. These figures were used in the following formula, found in Guilford:^{2/}

$$r_{tt} = \frac{n \bar{r}_{it}^2}{1 + (n-1) \bar{r}_{it}^2}$$

The estimated reliability coefficient, as determined by use of this formula was .97. This coefficient seems to be spuriously high, and it is undoubtedly due both to the wide range of difficulty of the items and also to the range among the product-moment coefficients for each item. On this matter, Guilford^{3/} writes:

"In estimating an internal consistency r_{tt} , most methods rest upon the assumption of equivalence of parts in the sense of equality of difficulty and equality of intercorrelation. If these conditions are

1/op. cit., p. 302.

2/op. cit., p. 454.

3/op. cit., p. 457.

not satisfied, estimates of r_{tt} may still be made, but the farther the departure of the situation from these specifications, the more is r_{tt} likely to be in error."

Analysis of each item.-- In order that the information given in tabular form in the preceding pages may prove more meaningful with respect to each item, a complete analysis of each item is given in the following pages.

This analysis of each item, giving all of the information on one page, could be a great aid to biology teachers and others engaged in the construction of biology tests. By examining a particular item we can obtain indications as to effective distracters, and also we can gain some insight into the thinking of these young people when they give incorrect answers to these items. A few examples might clarify these points.

In item Number 45, "Absorption of a substance through a membrane is termed (a) diffusion; (b) osmosis; (c) catabolism; (d) erosion." the only good distracter seems to be (a). This would seem to indicate that nearly all of the students have a knowledge of diffusion and osmosis, but many have failed to grasp the significant difference between the two processes.

In item Number 50, "Seedless oranges are propagated by (a) hybridization; (b) grafting; (c) hydroponics; (d) fission." the best distracter is (a). Yet, if the students were reason-

able and careful in their thinking, they would have eliminated this distracter, knowing that hybridization is performed to produce new varieties rather than propagate those already in existence.

In Item 51, "The part of the human body in which bile is stored is the (a) liver; (b) duodenum; (c) pancreas; (d) gall bladder." choice (c) was a suitable distracter for the low group, but not for the high group. However, choice (a) was attractive to both groups. In the low group more marked choice (a) than marked the correct choice. It is possible that the relative size of these two organs has some bearing on the evident confusion. Some teachers may have observed this matter of a considerably smaller organ storing the product of a larger organ to be a point of confusion with many of their students.

Here, it may be worthwhile to repeat the breakdown of items:

1 - 25.....	Biological Principles
26 - 50.....	Essential Life Processes
51 - 75.....	Human Physiology
76 - 100.....	Conservation

Item #1 The strongest indication that evolution has occurred is (a) fossil records; (b) uplifting of mountains; (c) sinking of land; (d) geographic isolation.

Responses for Each Item in the Highest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
312	8	4	15	1

Responses for Each Item in the Lowest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
252	22	25	30	11

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

<u>High</u>	<u>Low</u>
91.8	74.2

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

<u>High</u>	<u>Low</u>
89.3	65.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 78

Difficulty Index..... 66

Discrimination Index..... 21

Equivalent Value of Pearson's r..... .34

Equivalent Value of Fisher's z..... .35

Item #2 When identical twins do not do equally well in school, it is probably because (a) they were born with different capacities; (b) there is a difference in the size of their brains; (c) there is a difference in the size of their bodies; (d) there is somewhat of a difference in their environment.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
180	12	2	146	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
197	34	3	105	1

Correct Response..... D

Per Cent of Examinees in Each Group With The Correct Response

High	Low
43.0	30.9

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
24.0	8.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 15

Difficulty Index..... 29

Discrimination Index..... 17

Equivalent Value of Pearson's r..... .27

Equivalent Value of Fisher's z..... .28

Item #3 For their food supply, all living things are dependent upon (a) nucleoplasm; (b) chlorophyll; (c) chromatin; (d) cytoplasm.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
11	249	9	70	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
29	170	22	107	12

Correct Response..... B

Per Cent of Examinees in Each Group With The Correct Response

High	Low
73.3	50.0

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
64.0	33.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 48

Difficulty Index..... 49

Discrimination Index..... 19

Equivalent Value of Pearson's r31

Equivalent Value of Fisher's z32

Item #4 The fact that new kinds of living things have come into existence is best explained by (a) the mutation theory; (b) the theory of acquired traits; (c) the theory of over-production; (d) creation.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
261	35	10	32	2

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
78	69	37	140	16

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
76.8	22.9

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
69.3	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 27-

Difficulty Index..... 42

Discrimination Index..... 67+

Equivalent Value of Pearson's r..... 80+

Equivalent Value of Fisher's z..... 1.11+

Item #5 Heredity determiners are (a) genes; (b) nuclei;
(c) nucleoli; (d) centrosomes.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
331	2	1	6	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
278	18	8	31	5

Correct Response,..... A

Per Cents of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
97.5	81.8

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
97.3	76

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 88

Difficulty Index..... 72

Discrimination Index..... 19

Equivalent Value of Pearson's r..... .31

Equivalent Value of Fisher's z..... .32

Item #6 When we exercise, we breathe faster because
 (a) we are tired; (b) we need energy; (c) there
 is less oxygen in the air; (d) there is less
 carbon dioxide in the air.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
13	287	33	6	1

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
47	176	87	23	7

Correct Response..... B

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
84.5	51.8

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
80.0	36.0

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 59

Difficulty Index..... 54

Discrimination Index..... 30

Equivalent Value of Pearson's r..... .46

Equivalent Value of Fisher's z..... .50

- Item #7 The term evolution means that (a) life came from non-life; (b) we have uncovered fossils; (c) living things are constantly changing; (d) man descended from the ape.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
11	5	299	24	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
26	52	190	54	18

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
88.1	56.0

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
84.0	41.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 64

Difficulty Index..... 57

Discrimination Index..... 30

Equivalent Value of Pearson's r..... .46

Equivalent Value of Fisher's z..... .50

Item #8 The ultimate source of the energy of all living things is (a) food; (b) the sun; (c) the soil; (d) green plants.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
24	305	2	9	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
114	192	8	22	4

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
89.7	56.5

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
86.7	42.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 67

Difficulty Index..... 58

Discrimination Index..... 32

Equivalent Value of Pearson's r..... .48

Equivalent Value of Fisher's z..... .53

Item #9 The basic unit of plant and animal structure is the (a) tissue; (b) cell; (c) egg; (d) nucleus.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
2	309	2	27	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
26	198	25	82	9

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
91.0	58.3

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
88.0	44.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 68

Difficulty Index..... 59

Discrimination Index..... 32

Equivalent Value of Pearson's r..... .48

Equivalent Value of Fisher's z..... .53

Item #10 A knowledge of chemistry is important in the study of biology, because (a) living things are made up of chemicals; (b) living things are dependent upon chemicals; (c) life processes involve chemical change; (d) a biologist should have a knowledge of the other sciences.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
80	21	227	11	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
56	46	177	54	7

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
66.8	52.1

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
56.0	36.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 46

Difficulty Index..... 48

Discrimination Index..... 12

Equivalent Value of Pearson's r..... .20

Equivalent Value of Fisher's z..... .20

Item #11 The basic substance of all life is (a) the nucleus; (b) the nucleolus; (c) the cell; (d) protoplasm.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
4	3	11	322	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
44	6	103	182	5

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
94.7	53.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
93.3	38.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 69

Difficulty Index..... 59

Discrimination Index..... 43

Equivalent Value of Pearson's r..... .61

Equivalent Value of Fisher's z..... .71

Item #12 In plant and animal life, whenever the structure of an organism becomes more complex, then there is always an increase in (a) the size of the organism; (b) the needs of the organism; (c) the division of labor within the organism; (d) the number of offspring produced by the organism.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
22	88	226	3	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
93	92	87	51	17

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
66.5	25.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
56.0	1.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 22

Difficulty Index..... 38

Discrimination Index..... 58

Equivalent Value of Pearson's r..... .75

Equivalent Value of Fisher's z..... .97

- Item # 13 The crow, the English sparrow, and the starling occur over a very wide area because (a) they produce great numbers of offspring; (b) they are able to vary their diets and living conditions; (c) they require very little food; (d) they are protected by law.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
21	317	0	2	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
77	216	8	26	13

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
93.4	63.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
90.7	52.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 74

Difficulty Index..... 61

Discrimination Index..... 31

Equivalent Value of Pearson's r..... .47

Equivalent Value of Fisher's z..... .51

Item #14 The fact that the European corn borer is widespread in the United States indicates that (a) it is a pest; (b) it has adjusted to the environment; (c) it cannot be controlled; (d) it is not a harmful insect.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
0	303	30	6	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
52	188	56	26	18

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
89.2	55.3

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
85.3	40.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 64

Difficulty Index..... 57

Discrimination Index..... 32

Equivalent Value of Pearson's r..... .48

Equivalent Value of Fisher's z..... .53

Item #15 In the human, there is a building up of protoplasm (a) only when the person is young; (b) only when the person is eating; (c) only when the person is sleeping; (d) during the entire life of the person.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
10	5	8	317	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
25	8	24	277	6

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
93.3	81.5

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
90.7	76.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 84

Difficulty Index..... 71

Discrimination Index..... 16

Equivalent Value of Pearson's r..... .26

Equivalent Value of Fisher's z..... .27

Item # 16 Mosquitoes come into existence from
 (a) stagnant water; (b) eggs; (c) decaying
 food; (d) all of these.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
20	269	0	50	1

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
116	111	3	105	5

Correct Response..... B

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
79.1	32.6

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
72.0	10.7

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 39

Difficulty Index..... 46

Discrimination Index..... 45

Equivalent Value of Pearson's r..... .63

Equivalent Value of Fisher's z..... .74

Item #17 If all green plants were to suddenly die, the gas that would soon disappear is (a) oxygen; (b) carbon monoxide; (c) carbon dioxide; (d) nitrogen.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
277	3	29	31	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
101	36	116	77	10

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
81.5	29.7

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
76.0	6.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 38

Difficulty Index..... 62

Discrimination Index..... 7

Equivalent Value of Pearson's r..... .12

Equivalent Value of Fisher's z..... .12

Item #18 Certain bacteria can resist adverse conditions by (a) growing in colonies; (b) producing carbon dioxide; (c) protective coloration; (d) forming spores.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
99	7	9	225	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
129	35	32	112	32

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
66.2	33.0

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
54.7	10.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 31

Difficulty Index..... 41

Discrimination Index..... 34

Equivalent Value of Pearson's r..... .51

Equivalent Value of Fisher's z..... .56

Item #19 A man is most like an ape in his (a) size;
(b) life processes; (c) shape; (d) habits.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
16	194	120	10	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
30	98	184	20	8

Correct Response..... B

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
57.1	28.8

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
42.7	5.3

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 21

Difficulty Index..... 35

Discrimination Index..... 36

Equivalent Value of Pearson's r..... .54

Equivalent Value of Fisher's z..... .60

Item #20 Protein food is essential because (a) it contains nitrogen, which is found in protoplasm; (b) it is a good energy food; (c) it contains oxygen, which is essential to protoplasm; (d) it is found in all meat.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
212	98	23	6	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
43	192	45	37	23

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
62.4	12.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
49.3	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 19-

Difficulty Index..... 36

Discrimination Index..... 55+

Equivalent Value of Pearson's r..... .72

Equivalent Value of Fisher's z..... .91

- Item # 21 The fact that dinosaurs are now extinct indicates that (a) they were too big; (b) they were not suited to survive the changing conditions of the earth; (c) there was not enough food; (d) they fought with each other.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
1	335	4	0	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
6	270	27	21	16

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
98.5	78.5

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
98.7	72.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 89

Difficulty Index..... 72

Discrimination Index..... 43

Equivalent Value of Pearson's r..... .61

Equivalent Value of Fisher's z..... .71

Item # 22 The clam has a hard shell, in order that it may (a) burrow in the mud; (b) be protected against enemies; (c) get food; (d) not be affected by cold water.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
3	335	1	1	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
26	285	4	10	15

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
------	-----

98.5	83.8
------	------

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
------	-----

98.7	78.7
------	------

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 91

Difficulty Index..... 76

Discrimination Index..... 37

Equivalent Value of Pearson's r..... .55

Equivalent Value of Fisher's z..... .61

Item # 23 Which one of the following factors would be least apt to explain the geographic distribution of plants and animals? (a) heat; (b) light; (c) nitrogen; (d) pressure.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
18	16	177	128	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
38	43	80	152	27

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
52.1	23.5

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
36.0	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 14-

Difficulty Index..... 31

Discrimination Index..... 48+

Equivalent Value of Pearson's r..... .66+

Equivalent Value of Fisher's z..... .79+

Item #24 If a species of animal life were to suddenly lose the ability to reproduce, as a direct result (a) the animals would all die; (b) the species would become extinct; (c) both of these things would happen; (d) neither of these things would happen.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
4	306	29	1	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
17	196	85	21	21

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
90.0	57.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
86.7	44.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 67

Difficulty Index..... 59

Discrimination Index..... 31

Equivalent Value of Pearson's r..... .47

Equivalent Value of Fisher's z..... .51

Item # 25 An aquarium having both plants and animals is a good example of (a) balance in the world of life; (b) pond life; (c) marine life; (d) how to care for living things.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
301	8	27	3	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
169	37	72	53	9

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
88.6	49.7

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
85.3	33.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 60

Difficulty Index..... 55

Discrimination Index..... 36

Equivalent Value of Pearson's r..... .54

Equivalent Value of Fisher's z..... .60

Item #26 For the food making process green plants do not need (a) carbon dioxide; (b) oxygen; (c) water; (d) light.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
30	295	12	3	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
164	118	19	35	4

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

<u>High</u>	<u>Low</u>
86.7	31.8

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

<u>High</u>	<u>Low</u>
82.7	9.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 44

Difficulty Index..... 48

Discrimination Index..... 56

Equivalent Value of Pearson's r..... .73

Equivalent Value of Fisher's z..... .93

Item #27 A life process most likely to be associated with the lungs and skin is (a) digestion; (b) absorption; (c) excretion; (d) secretion.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
4	64	250	21	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
22	136	105	60	17

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
73.6	30.9

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
65.3	8.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 34

Difficulty Index..... 43

Discrimination Index..... 44

Equivalent Value of Pearson's r..... .62

Equivalent Value of Fisher's z..... .73

Item #28 Fission is a type of (a) excretion;
 (b) absorption; (c) assimilation;
 (d) reproduction.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
4	17	33	286	0

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
31	31	69	198	11

Correct Response..... D

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
84.2	58.3

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
78.7	44.0

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 62

Difficulty Index..... 56

Discrimination Index..... 24

Equivalent Value of Pearson's r..... .38

Equivalent Value of Fisher's z..... .40

Item # 29 When a male cell unites with a female cell to produce the young; the reproduction is termed (a) parthenogenesis; (b) sexual; (c) asexual; (d) dioecious.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
2	332	2	4	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
23	266	34	11	6

Correct Response..... B

Per Cent of Examinees in Each Group With The Correct Response

High	Low
97.7	78.3

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
97.3	70.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 86

Difficulty Index..... 71

Discrimination Index..... 33

Equivalent Value of Pearson's r..... .50

Equivalent Value of Fisher's z..... .55

Item # 30 Ingestion is a process which occurs (a) in all plants and no animals; (b) in all animals and no plants; (c) in all plants and some animals; (d) in all animals and some plants.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
37	63	33	195	12

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
39	106	54	102	39

Correct Response.....D

Per Cent of Examinees in Each Group With The
Correct Response

High	Low
57.4	30.0

Per Cent of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
42.7	6.7

Per Cent of Examinees Who Know the Correct Answer To Each Item.....	23
Difficulty Index.....	36
Discrimination Index.....	33
Equivalent Value of Pearson's r.....	.50
Equivalent Value of Fisher's z.....	.55

- Item # 31 Which of the following life processes is not essential to the existence of the individual (a) respiration; (b) reproduction; (c) secretion; (d) absorption.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
2	281	18	39	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
26	125	69	112	8

Correct Response..... B

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
82.6	36.8

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
77.3	16.0

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 46

Difficulty Index..... 48

Discrimination Index..... 43

Equivalent Value of Pearson's r61

Equivalent Value of Fisher's z71

- Item # 32 The process by which heat and energy are released in living things is (a) assimilation; (b) secretion; (c) respiration (d) digestion.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
108	27	143	61	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
95	61	150	23	11

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
42.0	44.1

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
22.7	25.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 24

Difficulty Index..... 35

Discrimination Index..... -2

Equivalent Value of Pearson's r..... -.04

Equivalent Value of Fisher's z..... -.04

- Item # 33 Growth is a characteristic of all living things. However, a snowball rolling down the side of a snow-covered hill, grows. The snowball is not alive because (a) it grows from within; (b) it grows by addition to the outside; (c) it will melt in the sun; (d) it is not able to move from place to place.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
0	277	36	26	1

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
3	254	50	24	9

Correct Response..... B

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
81.5	74.7

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
76.0	66.7

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 72

Difficulty Index..... 62

Discrimination Index..... 7

Equivalent Value of Pearson's r..... .12

Equivalent Value of Fisher's z..... .12

- Item #34 The process by which insoluble nutrients are changed to soluble substances is known as (a) assimilation; (b) growth; (c) oxidation; (d) digestion.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
24	8	19	289	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
75	23	107	111	24

Correct Response..... D

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
85.0	32.7

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
80.0	10.7

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 44

Difficulty Index..... 48

Discrimination Index..... 51

Equivalent Value of Pearson's r..... .69

Equivalent Value of Fisher's z..... .85

Item # 35 A characteristic of animals, but not of most plants is (a) respiration (b) reproduction; (c) motion; (d) locomotion.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
0	8	23	209	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
40	35	81	178	6

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
91.0	52.4

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
88.0	36.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 64

Difficulty Index..... 56

Discrimination Index..... 37

Equivalent Value of Pearson's r..... .55

Equivalent Value of Fisher's z..... .61

- Item # 36 Living things, chiefly animals, produce special substances to carry on their activities. These substances are called (a) gases; (b) secretions; (c) carbohydrates; (d) excretions.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
11	286	33	8	2

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
80	72	127	45	16

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
84.2	21.2

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
78.7	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 32-

Difficulty Index..... 45

Discrimination Index..... 73+

Equivalent Value of Pearson's r..... .84+

Equivalent Value of Fisher's z..... 1.21+

Item # 37 The animals in a balanced aquarium receive, from the plants, both food and (a) energy; (b) oxygen; (c) carbon dioxide; (d) nitrogen.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
1	329	4	6	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
54	205	48	25	8

Correct Response..... B

Per Cent of Examinees in Each Group With The Correct Response

High	Low
96.7	60.3

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
96.0	46.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 76

Difficulty Index..... 62

Discrimination Index..... 45

Equivalent Value of Pearson's r..... .63

Equivalent Value of Fisher's z..... .74

Item # 38 Respiration in plants and animals (a) is identical; (b) is opposite; (c) releases oxygen; (d) is a building up process.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
118	195	3	23	1

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
57	122	53	92	16

Correct Response..... A

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
34.7	16.8

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
13.3	0.0

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 6-

Difficulty Index..... 19

Discrimination Index..... 29+

Equivalent Value of Pearson's r..... .45

Equivalent Value of Fisher's z..... .48+

Item # 39 An important use of roots is (a) absorption; (b) assimilation; (c) food-making; (d) transpiration.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
319	7	7	7	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
179	11	88	51	11

Correct Response..... A

Per Cent of Examinees in Each Group With The
Correct Response

High	Low
93.8	52.6

Per Cent of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
92.0	37.3

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 67

Difficulty Index..... 58

Discrimination Index..... 43

Equivalent Value of Pearson's r..... .61

Equivalent Value of Fisher's z..... .71

Item # 40 The turning of leaves toward the light is called (a) geotropism; (b) response; (c) phototropism; (d) irritability.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
14	16	302	8	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
39	127	144	21	9

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
88.8	42.2

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
85.3	22.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 55

Difficulty Index..... 52

Discrimination Index..... 44

Equivalent Value of Pearson's r..... .62

Equivalent Value of Fisher's z..... .73

Item # 41 The building up and breaking down of protoplasm is known as (a) respiration; (b) growth; (c) metabolism; (d) transpiration.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
7	72	240	19	2

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
23	61	174	57	25

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
70.6	51.2

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
60.0	34.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 47

Difficulty Index..... 49

Discrimination Index..... 16

Equivalent Value of Pearson's r..... .26

Equivalent Value of Fisher's z..... .27

Item #42 Tropisms are most like (a) voluntary acts;
 (b) reflexes; (c) conditioned reflexes;
 (d) habits.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
12	279	40	6	3

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
58	92	93	69	28

Correct Response..... B

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
82.1	27.0

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
76.0	2.7

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 34

Difficulty Index..... 45

Discrimination Index..... 62

Equivalent Value of Pearson's r..... .77

Equivalent Value of Fisher's z..... 1.03

Item # 43 A life process which is not usually performed by animal cells is (a) growth; (b) excretion; (c) assimilation; (d) photosynthesis.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
1	3	4	332	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
23	30	57	214	16

Correct Response..... D

Per Cent of Examinees in Each Group With The Correct Response

High	Low
97.7	63.0

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
97.3	50.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 78

Difficulty Index..... 63

Discrimination Index..... 46

Equivalent Value of Pearson's r..... .64

Equivalent Value of Fisher's z..... .76

Item #44 Habits and conditioned reflexes are alike in that both (a) are learned responses; (b) are inherited; (c) appear only in dogs; (d) appear only in man

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
332	3	1	4	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
223	63	9	25	20

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
97.7	65.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
97.3	54.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 80

Difficulty Index..... 65

Discrimination Index..... 43

Equivalent Value of Pearson's r..... .61

Equivalent Value of Fisher's z..... .71

Item # 45 Absorption of a substance through a membrane is termed (a) diffusion; (b) osmosis; (c) catabolism; (d) erosion.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
60	279	1	0	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
83	202	24	10	25

Correct Response..... B

Per Cent of Examinees in Each Group With The Correct Response

High	Low
82.1	59.5

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
76.0	46.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 62

Difficulty Index..... 56

Discrimination Index..... 20

Equivalent Value of Pearson's r..... .32

Equivalent Value of Fisher's z..... .33

Item # 46 When eggs develop normally without being fertilized by spermatozoa, the process is known as (a) gametogenesis; (b) metamorphosis; (c) incubation; (d) parthenogenesis.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
64	8	19	243	4

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
68	77	90	70	35

Correct Response..... D

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
71.6	20.6

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
62.7	0.0

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 25-

Difficulty Index..... 40

Discrimination Index..... 63+

Equivalent Value of Pearson's r..... .78

Equivalent Value of Fisher's z..... 1.05

Item #47 Oxygen enters the leaf of a plant through the (a) stomates; (b) lenticels; (c) xylem; (d) veins.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
291	35	4	10	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
140	57	41	78	24

Correct Response..... A

Per Cent of Examinees in Each Group With The Correct Response

High	Low
85.6	41.2

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
81.3	21.3

Per Cent of Examinees Who Know the Correct Answer To Each Item.....	51
Difficulty Index.....	51
Discrimination Index.....	42
Equivalent Value of Pearson's r.....	.60
Equivalent Value of Fisher's z.....	.69

Item # 48 Transfer of pollen from anther to stigma of a flower is called (a) pollination; (b) maturation; (c) fertilization; (d) germination.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
327	0	10	3	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
248	9	41	23	19

Correct Response..... A

Per Cent of Examinees in Each Group With The Correct Response

High	Low
96.2	73.0

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
94.7	64.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 82

Difficulty Index..... 68

Discrimination Index..... 32

Equivalent Value of Pearson's r..... .48

Equivalent Value of Fisher's z..... .53

Item # 49 Nitrogenous wastes are excreted mainly by means of the (a) lungs; (b) stomach; (c) kidneys; (d) liver.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
63	3	267	7	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
68	36	162	47	27

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
78.6	47.6

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
72.0	30.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 52

Difficulty Index..... 51

Discrimination Index..... 26

Equivalent Value of Pearson's r40

Equivalent Value of Fisher's z43

Item # 50 Seedless oranges are propagated by (a) hybridization; (b) grafting; (c) hydroponics; (d) fission.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
133	195	9	1	2

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
108	130	33	36	33

Correct Response..... B

Per Cent of Examinees in Each Group With The
Correct Response

High	Low
57.4	38.2

Per Cent of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
42.7	17.3

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 29

Difficulty Index..... 39

Discrimination Index..... 19

Equivalent Value of Pearson's r31

Equivalent Value of Fisher's z32

Item #51 The part of the human body in which bile is stored is the (a) liver; (b) duodenum; (c) pancreas; (d) gall bladder.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
107	1	4	228	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
139	16	70	106	9

Correct Response..... D

Per Cent of Examinees in Each Group With The Correct Response

High	Low
67.1	31.2

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
56.0	8.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 29

Difficulty Index..... 40

Discrimination Index..... 38

Equivalent Value of Pearson's r..... .56

Equivalent Value of Fisher's z..... .63

Item # 52 The word "joint" is most closely associated with (a) bones; (b) muscles; (c) nerves; (d) skin.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
334	4	1	1	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
301	26	4	5	4

Correct Response..... A

Per Cent of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
98.3	88.5

Per Cent of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
97.3	85.3

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 92

Difficulty Index..... 78

Discrimination Index..... 21

Equivalent Value of Pearson's r..... .34

Equivalent Value of Fisher's z..... .35

Item #53 The digestion of food occurs mostly in the
 (a) mouth; (b) stomach; (c) small intestine;
 (d) large intestine.

Responses for Each Item in the Highest 27 Per Cent
 Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
2	61	273	4	0

Responses for Each Item in the Lowest 27 Per Cent
 Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
16	135	145	37	7

Correct Response..... C

Per Cent of Examinees in Each Group With The
 Correct Response

<u>High</u>	<u>Low</u>
80.3	42.7

Per Cent of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

<u>High</u>	<u>Low</u>
73.3	24.0

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 48

Difficulty Index..... 49

Discrimination Index..... 32

Equivalent Value of Pearson's r..... .48

Equivalent Value of Fisher's z..... .53

Item # 54 Assuming that the instrument works properly in each case, we would be least apt to hear a bell, which was placed in (a) water; (b) oil; (c) a vacuum; (d) sawdust.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
13	17	296	13	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
95	54	128	49	14

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
87.0	37.7

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
82.7	17.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 50

Difficulty Index..... 50

Discrimination Index..... 47

Equivalent Value of Pearson's r..... .65

Equivalent Value of Fisher's z..... .78

Item # 55 A secretion that digests both proteins and carbohydrates is (a) saliva; (b) pancreatic juice; (c) bile; (d) pepsin.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
24	208	22	85	1

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
73	93	27	132	15

Correct Response..... B

Per Cent of Examinees in Each Group With The
Correct Response

High	Low
61.2	27.4

Per Cent of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
48.0	2.7

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 21

Difficulty Index..... 36

Discrimination Index..... 46

Equivalent Value of Pearson's r..... .64

Equivalent Value of Fisher's z..... .76

Item # 56 Before food can be used to nourish protoplasm, it must be acted upon by (a) mastication; (b) saliva; (c) enzymes; (d) hydrochloric acid.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
7	1	316	16	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
18	60	216	32	14

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
93.0	60.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
90.7	48.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 72

Difficulty Index..... 61

Discrimination Index..... 35

Equivalent Value of Pearson's r..... .52

Equivalent Value of Fisher's z..... .58

Item #57 The red pigment which gives blood its color is (a) hematin; (b) fibrinogen; (c) lymph; (d) globulin.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
155	16	4	164	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
47	46	55	174	18

Correct Response..... A

Per Cent of Examinees in Each Group With The Correct Response

High	Low
45.6	13.8

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
28.0	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 11-

Difficulty Index..... 28

Discrimination Index..... 43+

Equivalent Value of Pearson's r..... .61

Equivalent Value of Fisher's z..... .71

Item #58 The pancreas secretes a hormone known as
 (a) prolactin; (b) thyroxine; (c) adrenalin;
 (d) insulin.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
28	9	17	285	1

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
33	42	86	163	16

Correct Response..... D

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
83.8	48.0

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
78.7	30.7

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 56

Difficulty Index..... 53

Discrimination Index..... 32

Equivalent Value of Pearson's r..... .48

Equivalent Value of Fisher's z..... .53

Item # 59 The backward flow of blood in the veins is prevented by (a) the heartbeat; (b) muscles; (c) lymphatics; (d) valves.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
17	13	1	309	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
70	9	29	219	13

Correct Response..... D

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
91.0	64.5

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
88.0	53.3

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 72

Difficulty Index..... 61

Discrimination Index..... 27

Equivalent Value of Pearson's r..... .41

Equivalent Value of Fisher's z..... .44

Item #60 When blood passes through the kidneys, it loses (a) carbon dioxide; (b) red blood cells; (c) white blood cells; (d) urea.

Responses for Each Item in the Highest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
8	15	4	311	2

Responses for Each Item in the Lowest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
83	35	26	180	16

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

<u>High</u>	<u>Low</u>
91.6	53.0

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

<u>High</u>	<u>Low</u>
89.3	37.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 65

Difficulty Index..... 57

Discrimination Index..... 38

Equivalent Value of Pearson's r..... .56

Equivalent Value of Fisher's z..... .63

Item # 61 The threads that are part of a blood clot are made of (a) globulin; (b) fibrin; (c) lymph; (d) platelets.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
8	265	8	59	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
41	130	34	117	18

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
78.0	38.3

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
70.7	17.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 43

Difficulty Index..... 47

Discrimination Index..... 37

Equivalent Value of Pearson's r..... .55

Equivalent Value of Fisher's z..... .61

Item #62 Painting is often caused by defective
 (a) respiration; (b) digestion (c) metabolism;
 (d) circulation.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
45	3	9	282	1

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
62	6	23	238	11

Correct Response..... D

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
83.0	70.0

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
77.3	60.0

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 69

Difficulty Index..... 60

Discrimination Index..... 12

Equivalent Value of Pearson's r..... .20

Equivalent Value of Fisher's z..... .20

Item # 63 The muscular wall that aids us in breathing is the (a) broncus; (b) epiglottis; (c) larynx; (d) diaphragm.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
2	1	2	336	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
40	22	36	227	15

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
98.9	66.8

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
98.7	56.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 83

Difficulty Index..... 66

Discrimination Index..... 52

Equivalent Value of Pearson's r..... .70

Equivalent Value of Fisher's z..... .87

Item # 64 Eskimos eat a large quantity of fatty foods because these foods (a) are cheaper; (b) produce more calories; (c) are easy to obtain; (d) require little preparation.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
0	269	63	8	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
4	178	118	27	13

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
79.1	52.3

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
72.0	36.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 54

Difficulty Index..... 52

Discrimination Index..... 23

Equivalent Value of Pearson's r..... .36

Equivalent Value of Fisher's z..... .38

Item #65 Exercise increases the rate of breathing because it causes in the blood, an increase of (a) oxygen; (b) nitrogen; (c) carbon dioxide; (d) hydrogen.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
27	5	307	1	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
155	29	116	14	26

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
90.3	34.1

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
86.7	12.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 49

Difficulty Index..... 50

Discrimination Index..... 55

Equivalent Value of Pearson's r..... .72

Equivalent Value of Fisher's z..... .91

Item #66 The human embryo, before it is born, obtains its food and oxygen through the (a) nucleus; (b) ovaries; (c) placenta; (d) yolk.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
2	23	289	26	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
42	101	102	71	24

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
85.0	30.0

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
80.0	6.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 41

Difficulty Index..... 47

Discrimination Index..... 56

Equivalent Value of Pearson's r..... .73

Equivalent Value of Fisher's z..... .93

Item #67 Compared to an equal volume of inhaled gas,
 a volume of exhaled gas contains less
 (a) oxygen; (b) nitrogen; (c) carbon dioxide;
 (d) hydrogen.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
327	1	12	0	0

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
166	35	86	24	29

Correct Response..... A

Per Cents of Examinees in Each Group With The
 Correct Response

<u>High</u>	<u>Low</u>
96.2	48.8

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

<u>High</u>	<u>Low</u>
94.7	32.0

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 68

Difficulty Index..... 58

Discrimination Index..... 52

Equivalent Value of Pearson's r..... .70

Equivalent Value of Fisher's z..... .87

Item #68 Blood platelets contain a substance which is necessary for (a) blood clotting; (b) respiration; (c) metabolism; (d) ingestion.

Responses for Each Item in the Highest 27 Per Cent
Choice

A	B	C	D	Omitted
319	10	10	0	1

Responses for Each Item in the Lowest 27 Per Cent
Choice

A	B	C	D	Omitted
231	36	42	10	21

Correct Response..... A

Per Cents of Examinees in Each Group With The
Correct Response

High	Low
93.8	68.0

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

High	Low
92.0	57.3

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 76

Difficulty Index..... 64

Discrimination Index..... 30

Equivalent Value of Pearson's r..... .46

Equivalent Value of Fisher's z..... .50

- Item #69 The contraction of the pupil of the human eye, when exposed to strong light, is an example of (a) phototropism; (b) plexus; (c) reflex; (d) synapse.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
57	8	266	6	3

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
70	23	193	34	20

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
78.3	56.8

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
70.7	42.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 57

Difficulty Index..... 54

Discrimination Index..... 18

Equivalent Value of Pearson's r..... .29

Equivalent Value of Fisher's z..... .30

Item # 70 Poisons from disease producing bacteria are counteracted by (a) antitoxins; (b) fibrinogen; (c) germicides; (d) white blood cells.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
220	0	1	118	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
122	14	28	156	20

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
64.7	35.9

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
53.3	14.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 33

Difficulty Index..... 41

Discrimination Index..... 27

Equivalent Value of Pearson's r..... .41

Equivalent Value of Fisher's z..... .44

Item # 71 The part of the brain which is used for thinking is the (a) cerebrum; (b) cerebellum; (c) pineal body; (d) medulla.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
269	52	0	18	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
164	88	9	58	21

Correct Response..... A

Per Cent of Examinees in Each Group With The Correct Response

High	Low
79.2	48.2

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
72.0	30.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 52

Difficulty Index..... 51

Discrimination Index..... 26

Equivalent Value of Pearson's r..... .40

Equivalent Value of Fisher's z..... .43

Item #72 The cause of night blindness is (a) eyestrain; (b) a virus; (c) a bacterium; (d) a vitamin deficiency.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
13	4	2	321	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
88	27	14	198	13

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
94.5	58.2

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
93.3	44.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 72

Difficulty Index..... 60

Discrimination Index..... 40

Equivalent Value of Pearson's r..... .58

Equivalent Value of Fisher's z..... .66

- Item # 73 Obeying traffic lights for most people is
 (a) a reflex; (b) a tropism; (c) an instinct;
 (d) a habit.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
26	3	12	299	0

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
62	14	44	212	8

Correct Response..... D

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
88.0	62.4

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
84.0	49.3

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 68

Difficulty Index..... 59

Discrimination Index..... 25

Equivalent Value of Pearson's r..... .39

Equivalent Value of Fisher's z..... .41

Item #74 In normal vision, the part of the eye, on which light focuses, is the (a) cornea; (b) lens; (c) retina; (d) humor.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
11	43	284	2	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
81	118	115	12	14

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
83.6	33.9

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
78.7	12.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 44

Difficulty Index..... 48

Discrimination Index..... 49

Equivalent Value of Pearson's r..... .67

Equivalent Value of Fisher's z..... .81

Item # 75 Abnormal height in a young person is usually due to improper functioning of the (a) adrenal gland; (b) pancreas; (c) pituitary gland; (d) thymus gland.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
13	2	296	28	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
65	8	189	58	20

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
87.1	55.6

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
82.7	41.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 63

Difficulty Index..... 56

Discrimination Index..... 29

Equivalent Value of Pearson's r..... .45

Equivalent Value of Fisher's z..... .48

Item #76 Chemical substances used to destroy insects are called (a) emulsions; (b) insecticides; (c) powders; (d) germicides.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
0	333	0	7	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
16	244	28	37	15

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
98.0	71.8

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
97.3	62.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 83

Difficulty Index..... 68

Discrimination Index..... 39

Equivalent Value of Pearson's r..... .57

Equivalent Value of Fisher's z..... .65

Item #77 Organic matter may be returned to the soil by the use of (a) crop residues; (b) green-manure crops; (c) manure from animals; (d) all of these.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
5	16	50	269	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
32	23	73	190	22

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
79.2	55.9

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
72.0	41.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 57

Difficulty Index..... 54

Discrimination Index..... 20

Equivalent Value of Pearson's r..... .32

Equivalent Value of Fisher's z..... .33

Item #78 The purpose of contour plowing is to
 (a) discourage insects; (b) beautify the
 farm; (c) save the topsoil; (d) control
 weeds.

Responses for Each Item in the Highest 27 Per Cent
 Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
0	0	340	0	0

Responses for Each Item in the Lowest 27 Per Cent
 Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
17	7	242	54	20

Correct Response..... C

Per Cents of Examinees in Each Group With The
 Correct Response

<u>High</u>	<u>Low</u>
100.0	71.2

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

<u>High</u>	<u>Low</u>
100.0	61.3

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 85+

Difficulty Index..... 68

Discrimination Index..... 50

Equivalent Value of Pearson's r..... .68

Equivalent Value of Fisher's z..... .83

- Item # 79 In 1906, the federal government protected the deer in Kaibab National Forest against any type of killing. At first the number of deer increased, but then gradually decreased. This decrease was because (a) hunters ignored the law; (b) the food supply was becoming exhausted; (c) the deer could not be protected against wild animals; (d) the deer fought with each other.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
7	304	25	4	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
51	200	55	17	17

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
89.4	58.8

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
85.3	45.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 66

Difficulty Index..... 58

Discrimination Index..... 29

Equivalent Value of Pearson's r..... .45

Equivalent Value of Fisher's z..... .48

Item # 80 An animal that was once threatened with extinction in this country, but is now increasing in number is the (a) bison; (b) squirrel; (c) coyote; (d) passenger pigeon.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
308	10	10	12	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
142	64	33	78	23

Correct Response..... A

Per Cents of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
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90.6	41.8
------	------

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
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88.0	22.7
------	------

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 57

Difficulty Index..... 53

Discrimination Index..... 47

Equivalent Value of Pearson's r..... .65

Equivalent Value of Fisher's z..... .78

Item #81 An insect which is considered valuable is the (a) cutworm (b) termite; (c) ladybird beetle; (d) locust.

Responses for Each Item in the Highest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
32	0	300	7	1

Responses for Each Item in the Lowest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
73	4	190	45	28

Correct Response.....C

Per Cents of Examinees in Each Group With The Correct Response

<u>High</u>	<u>Low</u>
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88.3	55.9
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Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

<u>High</u>	<u>Low</u>
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84.0	41.3
------	------

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 64

Difficulty Index..... 57

Discrimination Index..... 30

Equivalent Value of Pearson's r..... .46

Equivalent Value of Fisher's z..... .50

Item # 82 The greatest destruction in forests is caused by (a) lichens; (b) insects; (c) beavers; (d) fires.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
2	19	1	318	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
6	17	6	304	7

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
93.6	89.4

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
92.0	85.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 89

Difficulty Index..... 76

Discrimination Index..... 9

Equivalent Value of Pearson's r..... .15

Equivalent Value of Fisher's z..... .15

Item # 83 Fish hatcheries are places where fish are (a) prepared to be used as food; (b) cared for during the winter; (c) artificially propogated; (d) studied in their natural environment.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
6	10	306	18	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
58	43	164	57	18

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
90.0	48.3

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
86.7	30.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 61

Difficulty Index..... 55

Discrimination Index..... 40

Equivalent Value of Pearson's r..... .58

Equivalent Value of Fisher's z..... .66

Item #84 One species of tree which has been almost entirely destroyed by a parasitic blight is the (a) birch; (b) oak; (c) chestnut; (d) ash.

Responses for Each Item in the Highest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
53	24	183	72	8

Responses for Each Item in the Lowest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
88	50	76	99	27

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

<u>High</u>	<u>Low</u>
53.8	22.3

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

<u>High</u>	<u>Low</u>
38.7	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 15-

Difficulty Index..... 32

Discrimination Index..... 50+

Equivalent Value of Pearson's r..... .68+

Equivalent Value of Fisher's z..... .83+

Item # 85 The organic matter in soil is called
 (a) humus; (b) silt; (c) loam; (d) clay.

Responses for Each Item in the Highest 27 Per Cent
 Choice

A	B	C	D	Omitted
295	10	32	1	2

Responses for Each Item in the Lowest 27 Per Cent
 Choice

A	B	C	D	Omitted
147	52	67	50	24

Correct Response..... A

Per Cents of Examinees in Each Group With The
 Correct Response

High	Low
86.8	43.2

Per Cents of Examinees in Each Group With The
 Correct Response After Correction for Chance
 Success

High	Low
82.7	24.0

Per Cent of Examinees Who Know the Correct Answer
 To Each Item..... 54

Difficulty Index..... 52

Discrimination Index..... 41

Equivalent Value of Pearson's r..... .59

Equivalent Value of Fisher's z..... .68

- Item # 86 Soil erosion is not likely to be caused by
(a) high mountains; (b) weeds; (c) desert
region; (d) heavy rains.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
11	296	21	12	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
47	156	51	70	16

Correct Response..... B

Per Cents of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
87.1	45.8

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
82.7	28.0

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 56

Difficulty Index..... 53

Discrimination Index..... 38

Equivalent Value of Pearson's r..... .56

Equivalent Value of Fisher's z..... .63

Item # 87 The type of soil which is best able to hold water is a (a) sandy soil; (b) clay soil; (c) mixture of sand and clay; (d) loamy soil.

Responses for Each Item in the Highest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
14	39	21	253	3

Responses for Each Item in the Lowest 27 Per Cent Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
56	48	93	119	24

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

<u>High</u>	<u>Low</u>
11.5	14.1

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

<u>High</u>	<u>Low</u>
0.0	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 00

Difficulty Index..... 0

Discrimination Index..... 0

Equivalent Value of Pearson's r..... .00

Equivalent Value of Fisher's z..... .00

Item #88 The drainage of swamps tends to (a) increase wildlife; (b) prevent floods; (c) destroy the balance in the water cycle; (d) prevent dust storms.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
84	77	174	2	3

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
97	94	108	8	33

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
51.2	31.8

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
34.7	9.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 21

Difficulty Index..... 34

Discrimination Index..... 23

Equivalent Value of Pearson's r..... .36

Equivalent Value of Fisher's z..... .38

Item # 89 The Tennessee Valley Authority is directly concerned with (a) flood control; (b) control of soil erosion; (c) reforestation; (d) all of these.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
144	11	2	180	3

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
90	58	20	143	29

Correct Response..... D

Per Cents of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
52.9	42.1

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
37.3	22.7

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 30

Difficulty Index..... 39

Discrimination Index..... 10

Equivalent Value of Pearson's r..... .17

Equivalent Value of Fisher's z..... .17

Item #90 Soil conservation is not aided by (a) addition of soil nutrients; (b) formation of gullies; (c) crop rotation; (d) contour plowing.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
15	322	0	3	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
46	185	48	30	31

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High Low

94.7 54.4

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High Low

93.3 38.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 69

Difficulty Index..... 59

Discrimination Index..... 43

Equivalent Value of Pearson's r..... .61

Equivalent Value of Fisher's z..... .71

Item #91 Many wild flowers are protected by law and must not be picked. This is because these flowers (a) are poisonous; (b) cause allergies; (c) are becoming extinct; (d) furnish food and shelter to birds.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
1	0	292	47	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
14	17	200	84	25

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
13.8	24.7

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
0.0	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 00

Difficulty Index..... 0

Discrimination Index..... 0

Equivalent Value of Pearson's r..... .00

Equivalent Value of Fisher's z..... .00

Item #92 In the spring, a farmer burned the grass around his farm to get rid of the weeds. That summer, his farm was deluged with insects. This probably (a) was because the insects were better able to find food; (b) was because the insects were brought to the surface by the fire; (c) was because the fire destroyed the nest of birds; (d) had no connection with the fire.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
14	25	139	159	3

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
45	108	37	124	26

Correct Response..... C

Per Cent of Examinees in Each Group With The Correct Response

High	Low
40.8	10.9

Per Cent of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
21.3	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 09-

Difficulty Index..... 24

Discrimination Index..... 37+

Equivalent Value of Pearson's r..... .55+

Equivalent Value of Fisher's z..... .61+

Item # 93 A bird which is considered a pest is the
(a) barn owl; (b) seagull; (c) English
sparrow; (d) quail.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
44	21	266	9	0

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
122	30	136	27	25

Correct Response..... C

Per Cent of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
78.3	40.0

Per Cent of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
70.7	20.0

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 45

Difficulty Index..... 48

Discrimination Index..... 35

Equivalent Value of Pearson's r..... .52

Equivalent Value of Fisher's z..... .58

Item # 94 The balance of nature has been most often upset by (a) wind; (b) floods; (c) insects; (d) man.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
0	10	5	325	0

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
15	86	27	183	29

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
95.7	53.8

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
94.7	38.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 71

Difficulty Index..... 59

Discrimination Index..... 47

Equivalent Value of Pearson's r..... .65

Equivalent Value of Fisher's z..... .78

Item # 95 Floods and soil erosion are most apt to result from (a) crop rotation; (b) strip cropping; (c) deforestation; (d) terracing.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
0	12	320	7	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
25	69	163	49	34

Correct Response..... C

Per Cents of Examinees in Each Group With The Correct Response

High	Low
94.2	48.0

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
92.0	30.7

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 64

Difficulty Index..... 56

Discrimination Index..... 47

Equivalent Value of Pearson's r..... .65

Equivalent Value of Fisher's z..... .78

Item # 96 Japanese beetles are more of a pest in this country than in Japan, because in this country (a) food is more plentiful; (b) there are fewer natural enemies; (c) the climate is more suitable; (d) the government has not tried to eradicate them.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
21	304	13	1	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
77	126	71	37	29

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
89.4	37.1

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
85.3	16.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 51

Difficulty Index..... 51

Discrimination Index..... 50

Equivalent Value of Pearson's r..... .68

Equivalent Value of Fisher's z..... .83

- Item #97 In 1886, Pennsylvania paid people who killed hawks and barn owls. The loss in fruit and grain crops which resulted was probably due to (a) a lack of pollination; (b) an increase in field mice; (c) weather conditions; (d) all of these factors.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
16	305	6	12	1

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
58	116	40	93	33

Correct Response..... B

Per Cents of Examinees in Each Group With The Correct Response

High	Low
89.8	34.1

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
86.7	12.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 49

Difficulty Index..... 50

Discrimination Index..... 55

Equivalent Value of Pearson's r..... .72

Equivalent Value of Fisher's z..... .91

Item # 98 If you were to give a talk on the conservation of lumber, which of the following recommendations should you not make? (a) use small pieces of lumber whenever they are suitable; (b) use the best available lumber for the purpose; (c) coat lumber that is to be placed in the ground with a suitable paint or chemical; (d) never use plywood as a substitute for other types of lumber.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
55	50	65	163	7

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
74	52	79	90	45

Correct Response..... D

Per Cents of Examinees in Each Group With The Correct Response

High	Low
47.9	26.4

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
30.7	1.3

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 12

Difficulty Index..... 30

Discrimination Index..... 45

Equivalent Value of Pearson's r63

Equivalent Value of Fisher's z74

Item #99 Compost is used (a) to improve soil fertility; (b) to destroy bacteria; (c) to prevent soil erosion; (d) as an aid to crop rotation.

Responses for Each Item in the Highest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
294	18	6	15	7

Responses for Each Item in the Lowest 27 Per Cent
Choice

<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>Omitted</u>
122	40	46	65	67

Correct Response..... A

Per Cents of Examinees in Each Group With The
Correct Response

<u>High</u>	<u>Low</u>
86.5	35.9

Per Cents of Examinees in Each Group With The
Correct Response After Correction for Chance
Success

<u>High</u>	<u>Low</u>
82.7	14.7

Per Cent of Examinees Who Know the Correct Answer
To Each Item..... 49

Difficulty Index..... 50

Discrimination Index..... 48

Equivalent Value of Pearson's r..... .66

Equivalent Value of Fisher's z..... .79

Item #100 In crop rotation, which of the following is usually included? (a) legumes; (b) cotton; (c) corn; (d) oats.

Responses for Each Item in the Highest 27 Per Cent Choice

A	B	C	D	Omitted
272	12	26	28	2

Responses for Each Item in the Lowest 27 Per Cent Choice

A	B	C	D	Omitted
68	36	107	88	41

Correct Response..... A

Per Cents of Examinees in Each Group With The Correct Response

High	Low
80.0	20.0

Per Cents of Examinees in Each Group With The Correct Response After Correction for Chance Success

High	Low
73.3	0.0

Per Cent of Examinees Who Know the Correct Answer To Each Item..... 29-

Difficulty Index..... 43

Discrimination Index..... 70+

Equivalent Value of Pearson's r..... .82+

Equivalent Value of Fisher's z..... 1.16+

7. A Review of 13 High School Biology Texts

It was hoped that one of the results of this study would be that it would serve as an influential factor in the construction of future biology texts. Publishers and textbook authors are anxious to give teachers what they need and what they want. It was hoped that this study would point out some of the needs for textbook revisions. Therefore, it seemed desirable to determine the amount of coverage given to those areas of biology most frequently named as most important. The texts which were reviewed are all being used in a number of high schools at the present time. Also, all of the texts used have been published since January of 1950. It is probably safe to assume that the books which have been reviewed account for over 90 per cent of recent sales of high school biology texts. Since no real purpose would be served, the title of the texts will be omitted. In reviewing the texts, a count was made of the number of pages which were given to those areas named as most important by selected high school biology teachers. The results are presented in Table 13.

Table 13. The Number of Pages Given, in Each of 13 Recently Published Texts, to the Four Areas of Biology Which Were Most Often Named as Most Important.

Book	Pages in Body of the Book	Approximate Number of Pages Given To:			
		Biological Principles	Essential Life Processes	Human Physiology	Conser- vation
(1)	(2)	(3)	(4)	(5)	(6)
1...	579	0	1	79	10
2...	758	0	0	117	41
3...	313	0	0	78	18
4...	701	0	4	87	90
5...	752	14	0	33	63
6...	430	0	0	110	34
7...	540	12	11	66	37
8...	616	0	1	49	38
9...	676	0	23	123	25
10...	397	0	2	69	10
11...	713	0	10	76	43
12...	401	0	6	53	20
13...	467	0	5	55	30

It can be seen from the table that there are only two texts with pages given to biological principles. However, it would be erroneous indeed and most unjust to conclude that the authors of the other 11 texts have disregarded biological principles. It merely points out that the authors of only two texts have seen fit to devote special emphasis to this particular phase of biology. Unquestionably, biological principles may be gleaned from all of the texts, but it is far better to use headings, rather than require teachers and pupils to search for these principles.

Much the same things may be said in regard to the area of essential life processes. While four texts have not mentioned them at all per se, they certainly are discussed throughout the body of the text in relation to particular plants and animals.

8. A Review of Seven Standardized Biology Tests

If the areas named by selected biology teachers as most important are truly most important, then we should hope that test constructors would give emphasis to them. A review of seven tests determined the amount of emphasis which was given to each of the four named areas. While some of the tests which were reviewed are quite old, they are useful in that we can compare them with the more recent tests. The number of published tests is small. None has been published since 1950. Again, since all but two tests are over 10 years old, and since no useful purpose would be served, the names of the tests are not given. The results of this review are given in Table 14.

Table 14. The Number of Items in Each of Seven Standardized Biology Tests which Test for a Knowledge of One of the Four Areas of Biology which were Most Often Named as Most Important

Publi- cation Year	Number of Test Items	Number of Items Which Test for Knowledge Of:			
		Biological Principles	Essential Life Processes	Human Physiology	Conserva- tion
(1)	(2)	(3)	(4)	(5)	(6)
1924..	112	8	10	4	2
1929..	230	7	30	2	8
1937..	105	7	7	5	0
1939..	118	1	7	9	2
1945..	137	69	11	9	1
1949..	89	10	9	11	2
1950..	75	30	19	5	14

While some of the tests seemed to place undue emphasis on structural biology and on nomenclature, this was not true of all. The test which was published in 1945, for example, devoted an entire section to biological principles. In this case, however, the area of conservation was greatly neglected. By looking at Table 14, one may come to two conclusions. There is a real need for more tests in biology. Also, tests in the future should be so designed as to be certain that proper emphasis is given to the most important areas.

CHAPTER V

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDY

1. Summary

The problem.-- Biology occupies a very important place in most high school curricula. More high school students take biology than take any other science course. It is more and more becoming a required rather than an optional course.

However, biology is a small word which embraces a very large field of knowledge. The field is so large that it is impossible to even consider covering it in a single high school course. The teacher, then, is faced with the problem of determining the material that should be included and the material which should be emphasized.

To determine the biological areas that are most important for high school pupils, it seemed best to ask those who are closest to the problem, the teachers, themselves.

This was done by means of two surveys. In the first survey, selected teacher-members of the N.A.B.T. located throughout the United States were given absolute freedom and were asked to name the one most important and the one least important area of biology. It was felt that by asking teachers to name only one most important area and only one

least important area, great thought and very careful selection would result. Any faults that were inherent in this method of survey were corrected in the second survey, when a list of areas was supplied to each teacher. The results were tabulated and the same teachers were then given a list from which they chose the three most important and the three least important biological areas. The results were then tabulated.

The second major part of the problem was an attempt to get an indication of the extent to which high school pupils had learned the four areas, determined to be the most important.

The first survey.-- In order that this survey might have meaning, it was felt that there should be at least 500 teachers taking part. To get this number of replies, letters were sent to 2000 members of the National Association of Biology Teachers. These teachers were asked to name the area of biology which they considered most important and the area which they considered least important. These teachers were not given a list nor was the word "area" defined. This was done deliberately so as not to limit in any way their thinking on the problem.

There were 931 who replied, and these represented all sections of the country. From these replies, 795 were used

in determining the most important areas. The others were discarded for various reasons. Of the 931 replies, 829 were used in determining the least important areas. Again, the others were discarded for various reasons.

The results were tabulated, and a list of 24 areas was made from a list of 30 areas most often named as most important. The other six were not used because they were too inclusive, in terms of testing material and textbook material.

The ten areas that were most often named as most important, in their order of frequency are: human biology; conservation; human physiology; ecology; health and hygiene; physiology (general); genetics; human anatomy; essential life processes; and biology applied to humans. The areas of human biology and biology applied to humans were two of the six areas that were not used for the second survey because they were so inclusive.

The second survey.-- The list of the 24 areas most often named as most important was sent to each of the 793 teachers who had indicated that they would be willing to do further work on the study. They were asked to choose, from this list, the three areas which they considered most important and the three areas which they considered least important.

Five hundred and twenty-seven replies were received. Fifty of these were not usable because the reply cards were not correctly filled out. The results were tabulated. The areas were then placed in order according to the number of times that they were named most important. The areas were also placed in order according to the number of times that they were named as least important. In this survey, the four areas that were named most often as most important were named least often as least important.^{1/} In the areas named as most important, there was a definite breaking point after the fifth area, health and hygiene. Since in many schools, this is offered as a course separate from general biology, there would be a definite disadvantage to including this as one of the areas of the test. The four areas then, for which the test had to be devised were: Essential life processes; biological principles; conservation of natural resources; and human physiology.

Construction of the test.-- For a number of reasons, it was deemed best to have all of the items of the multiple-choice type. Also, after holding a number of time trials, it was felt that 100 items could be answered in the allotted time. Therefore, it became necessary to construct 25 items for each of the four areas.

^{1/}See p. 38.

The material for which the items were intended to test was taken from a number of high school biology texts.

Distribution and administration of the test.-- Letters were sent to 100 teachers asking if they would be willing to give the test to one of their classes. Seventy-seven replied in the affirmative, and 50 of these were chosen on the basis of the greatest possible geographical distribution.

Thirty copies of the test were sent to each of these 50 teachers. It was explained that the test was divided into four sections of 25 items each, and the teachers were asked to allow 9 minutes for each group of 25 items. The teachers were also asked to indicate any items which they felt were not teachable; i. e., items in which the difficulty level of the material was too high for high school pupils.

Results of the test.-- Of the 50 sets of tests that were distributed, two were received too late to be administered, and two were not returned until the following fall and so were not included. Forty-six sets, with a total of 1260 tests and with a national distribution, were corrected and included in the study.

It was found that the average $\frac{1}{2}$ per cent of those who were assumed to know the correct answers to the items on 1/An arithmetical average.

biological principles was 54; to the items on essential life processes, it was 51; to the items on human physiology, it was 47; and to the items on conservation, it was 47. The average of these four figures is slightly less than 50 per cent. This points out that on the average, approximately 50 per cent of the examinees could be assumed to know the answers to each item. At first glance, this per cent might seem adequate. Indeed, it would be adequate if the test were on just any or on all areas of biology. However, the test was concerned only with the four areas of biology which had been most often named as most important. Also, no teacher had claimed that the material for any one of the items was too difficult to be taught to high school pupils. With these facts in mind, we can see that the per cents appear to be far too low.

Review of textbooks.-- Of the 13 texts which were reviewed, only two devoted special emphasis to the area of biological principles. Four of the 13 texts gave no discussion of the essential life process, per se, and only three of the books devoted 10 or more pages to such a discussion. These findings should not be construed to mean that most authors have overlooked these areas. In all cases, biological principles and essential life processes can be gleaned from the text, but in many cases this is left to the teacher or to the pupil.

The number of pages devoted to human physiology varied among the texts from 33 to 123. Unlike the cases of the two previously mentioned areas, the findings here speak out boldly and clearly. For such an important area, there is indeed a wide variation in coverage from one text to another.

In the area of conservation, we have a variation from 10 pages to 90 pages. Here again we have a wide variation in coverage.

Review of standardized tests.-- Only seven tests were reviewed because there have been so few standardized biology tests published. None has been published since 1950 (information as of 1958).

In one test, slightly more than 50 per cent of the items were devoted to biological principles. In another test 40 per cent of the items were in this area. There was then a sharp drop in another test to 11 per cent of the items being given to biological principles. The number of items testing this area went down for one test to less than 1 per cent.

In the area of essential life processes, one test used slightly more than 40 per cent of the items, while the others ranged from just under 6 per cent to just over 10 per cent.

In the area of human physiology, the number of items ranged from eight tenths of 1 per cent to 12 per cent, with only one test having over 8 per cent.

In the area of conservation, one test devoted nearly 19 per cent of the items. The number of items for this area on the other tests ranged from zero to just over 3 per cent.

2. Conclusions

The first survey.-- In this survey, the selected teachers were not given a list from which to choose the most important and the least important areas. While this method was used so that the thinking of the teacher might not be limited, it also served to point up the wide variety of opinions among biology teachers. There was a total of 64 areas of biology named as most important and 46 of these were named by teachers giving but one answer. Since by definition there cannot be 64 or even 46 "most important" areas, this diversity gives a reason for a need of a study of this type.

The second survey.-- Here it is interesting to note that the area of "essential life processes" was chosen first, whereas in the first survey, it was chosen ninth. Even more startling is the fact that the area of "biological principles" finished in twenty-fourth place in the first survey and in second place in this survey. These observations

suggest that these two areas were overlooked by a number of teachers in the first survey, but having had them pointed out, the teachers were willing to revise their former position. The change in position of these two areas also proved a definite need for this second survey. However, the unreliability of the teachers' choice is not in question because in this second survey, the four areas which were named most often as most important were named least often as least important.

The test.-- On the average, only about 50 per cent of the examinees could be assumed to know the answers to each item. It is fair to question whether or not this was satisfactory. If the test were on just any or on all areas of biology, we might have little reason for concern. However, this was not the case. The test concerned only the four areas of biology which had been most often named as most important. Further, no teacher had claimed that the material for any of the items was too difficult for high school pupils.

In light of these considerations, we have cause to be greatly concerned. If this is the extent to which all high school pupils know this material, then far too little emphasis is being placed on these areas.

Textbooks.-- Most of the texts have meager coverage of the areas of "biological principles" and "essential life processes". In light of the stated importance of these areas, they probably should be given a much greater coverage. The task of searching for and pulling of this material from the content ought not be left to the pupil. It must clearly stand out so that it becomes impossible for pupil or teacher to overlook it.

There is a great variation in the amount of coverage of the areas of "human physiology" and "conservation". It is evident, that while all authors think these areas are important, there is some question as to the opinions on the extent of their importance.

Standardized tests.-- The value of a standardized biology test is certainly to be questioned when less than 1 per cent of the items test for a knowledge of biological principles. Such was the case with one of the tests which were reviewed.

3. Suggestions for Further Study

A determination of the extent of emphasis to be placed on each area.-- While this study has made a determination of the important areas of biology, it has in no way begun to search the question of degrees of importance. While the degree of importance will of necessity vary somewhat from

one location to another and from one group to another, some generalities can be made. It would be especially helpful for the beginning teacher to know approximately how long he should devote to each area.

Writing a course of study for the important areas.--

A course of study which listed the methods and materials for teaching the important areas of biology would be most worthwhile. It would, of course, have to be capable of adaptation to a variety of situations, but it could be written with this point in mind.

Reviewing textbooks to determine possible changes.--

It is hoped that textbook authors who are not at present placing a great deal of emphasis on these important areas of biology, will do so in the future. A study could be made 10 years hence to determine whether or not this has happened.

Writing standardized tests.-- Since no standardized test for high-school biology has been written since 1950, a real need exists at the present time. These tests should be written so that most of the questions are concerned with the most important areas of biology.

APPENDICES

APPENDIX A
TEACHERS' REACTION TO THE TEST

Of those teachers who received one or more copies of the test, 20 sent letters in which there was some criticism of the test.

In nine of the letters, comments were made on the test as a whole, and none of the items was singled out for individual criticism. In four instances, the teacher made comments on the whole test and also on some of the individual items in the test. In the seven remaining cases, individual items were picked out for criticism, but there were no generalized comments included.

There were 36 items that were commented on or criticized. Of these, 26 were mentioned by only one teacher. In a number of these cases, the teacher felt that more than one answer was possible. In others the teacher felt that the wording was ambiguous or unfamiliar. In two cases, the items are criticized as being too easy. This particular teacher felt that items Number 24^{1/} and Number 90^{2/} were

1/Item 24. If a species of animal life were to suddenly lose the ability to reproduce, as a direct result (a) the animals would all die; (b) the species would become extinct; (c) both of these things would happen; (d) neither of these things would happen.

2/Item 90. Soil conservation is not aided by (a) addition of soil nutrients; (b) formation of gullies; (c) crop rotation; (d) contour plowing.

"....so easy they would not function as measuring devices in most high school classes". It is interesting to note that from his class of 30 pupils, 15 answered Number 24 incorrectly and eight answered Number 90 incorrectly.

Comment or criticism was made by two of the teachers on six items in the test. The first was item Number 16.^{1/} One teacher felt that the word "develop" should be used in place of "come into existence". The other teacher said that he could not decide on an answer, but that choice (b) seemed the most logical.

The second item criticized by two teachers was item Number 21.^{2/} One teacher felt that it should be prefaced by the phrase, "to the best of knowledge". The second teacher questioned the "authenticity" of the item.^{3/}

The third item criticized by two teachers was item Number 33.^{4/} The first teacher claimed that he didn't "see

^{1/}Item 16. Mosquitoes come into existence from (a) stagnant water; (b) eggs; (c) decaying food; (d) nitrogen.

^{2/}Item 21. The fact that dinosaurs are now extinct indicates that (a) they were too big; (b) they were not suited to survive the changing conditions of the earth; (c) there was not enough food; (d) they fought with each other.

^{3/}For authenticity of items, see p. 41.

^{4/}Item 33. Growth is a characteristic of all living things. However, a snowball, rolling down the side of a snow-covered hill, grows. The snowball is not alive because (a) it grows from within; (b) it grows by addition to the outside; (c) it will melt in the sun; (d) it is not able to move from place to place.

the point of the question". The second teacher merely named it as one of the five items which were criticized during class discussion.

The fourth item criticized by two teachers was item Number 45.^{1/} Again, one teacher named it as having been criticized during class discussion. The other teacher suggested the possibility of the word "passage" rather than the word "absorption".

The fifth item criticized by two teachers was item Number 58.^{2/} The first teacher suggested the inclusion of "Isles of Langerhans". The second teacher said that the word "prolactin" is unfamiliar to high school biology students.

The sixth item criticized by two teachers was item Number 86.^{3/} One of the teachers said that he was confused by the item. The other teacher stated that "heavy rains" and "high mountains" were not comparable ideas.

There were two items that were criticized by three

1/Item 45. Absorption of a substance through a membrane is termed (a) diffusion; (b) osmosis; (c) catabolism; (d) erosion.

2/Item 58. The pancreas secretes a hormone known as (a) prolactin; (b) thyroxine; (c) adrenalin; (d) insulin.

3/Item 86. Soil erosion is not likely to be caused by (a) high mountains; (b) weeds; (c) desert region; (d) heavy rains.

teachers. The first was item Number 23.^{1/} The first teacher asked the question: "Will students think of nitrogen as nitrates?". The second teacher felt that "humidity" would have been a better and less obvious answer than "nitrogen". The third teacher claimed that the nitrogen in the atmosphere would be a correct answer, but that the nitrogen in sodium nitrate of the soil would be incorrect.

The second item criticized by three teachers was item Number 57.^{2/} The first teacher said that some of his students were confused by the word "hematin". He explains further that he understands that it "...is the more acceptable form of hemoglobin". The other two teachers also had the same criticism.

There were two items that were criticized by five teachers. The first was item Number 6.^{3/} One teacher claimed that the answer was obtainable by elimination of three of the choices. Another teacher said that it was one of four items which were not clear to some of the students.

1/Item 23. Which one of the following factors would be least apt to explain the geographic distribution of plants and animals? (a) heat; (b) light; (c) nitrogen; (d) pressure.

2/Item 57. The red pigment which gives blood its color is (a) hematin; (b) fibrinogen; (c) lymph; (d) globulin.

3/Item 6. When we exercise, we breathe faster because (a) we are tired; (b) we need energy; (c) there is less oxygen in the air; (d) there is less carbon dioxide in the air.

The remaining three teachers claimed that the correct answer was not among the choices since we actually breathe faster not because we need energy, but rather because of an excess amount of carbon dioxide in the blood.

The second item criticized by five teachers was item Number 10.^{1/} Two of these teachers felt that more than one answer was possible. Another felt that the choices were too similar and that the distinctions were too finely drawn. Another teacher stated that in his opinion, the item was too broad in the scope of the answers. Another teacher merely stated that he did not think it was a good question.

Of the 36 items which received comment or criticism only three items had the same criticism by more than one teacher. The three items which had the same criticism by more than one teacher are worthy of further consideration and are discussed in the three following paragraphs.

The first of these was item Number 6.^{2/} Three teachers claimed that the correct answer was not among the choices. It is true that breathing is controlled by the medulla, and

1/Item 10. A knowledge of chemistry is important in the study of biology, because (a) living things are made up of chemicals; (b) living things are dependent upon chemicals; (c) life processes involve chemical change; (d) a biologist should have a knowledge of the other sciences.

2/Item 6. When we exercise, we breathe faster because (a) we are tired; (b) we need energy; (c) there is less oxygen in the air; (d) there is less carbon dioxide in the air.

this in turn is stimulated by the carbon dioxide in the blood. However, when we exercise, we increase the carbon dioxide in the blood, thus bringing about increased breathing. This results in more oxygen being brought into the body. This in turn will react with the carbohydrates of the body to produce energy. Thus, in fact, the cause for increased breathing is indirectly a need for energy. It is interesting to note that 51.8 per cent of the lowest 27 per cent of those tested answered this item correctly and 84.5 per cent of the highest 27 per cent of those tested answered the item correctly.

Item Number 10^{1/} received identical criticism by two teachers. The criticism was that more than one answer was possible. Of the 340 students who obtained the highest test scores, 227 marked choice (c); 80 marked choice (a); 21 marked choice (b); 11 marked choice (d); and one left the item unanswered. There was an approximately equal distribution among the three wrong choices in this item for the 340 students who obtained the lowest test scores. This would seem to indicate that choice (a) of the item was too close to the truth and that, in fact, the distinction between choice (a) and choice (c) was not clear.

1/Item 10. A knowledge of chemistry is important in the study of biology, because (a) living things are made up of chemicals; (b) living things are dependent upon chemicals; (c) life processes involve chemical change; (d) a biologist should have a knowledge of the other sciences.

In item Number 57,^{1/} the criticism was for the use of the word "hematin". While these three teachers admitted the word to be perfectly proper, they felt that it was unfamiliar to high school students. The point is well made. Most high school biology texts make no mention of the word. There is, however, wide mention of the terms of the other three choices in the item. Familiarity with these three choices would, of course, lead to the correct answer.

Here, it is most important to point out that no teacher felt that the material for any one of the items was too difficult to be taught to high school students. This fact will be discussed further in a later chapter.

As was previously stated, some of the comments on the test as a whole were favorable, while others were not. A number of these comments seem worthy of mention.

One teacher wrote that the test "...hit the nail on the head on general principles". He went on to state that he was astounded and ashamed that many of his students had not done better in the test. He also wrote that he will try to incorporate much of the material of the test into his teaching for next year.

Another teacher felt that there should have been a series of questions of graded difficulty to challenge the

1/Item 57. The red pigment which gives blood its color is (a) hematin; (b) fibrinogen; (c) lymph; (d) globulin.

better students. He also wrote that the test did not cover detailed factual knowledge and vocabulary and specific knowledge of living organisms and their habits. It should be noted that this process was not intended. The very nature of the test rules out the inclusion of items on detailed facts.

Another teacher sent "congratulations on the fine test" which the author had formulated. This teacher went on to write that she thought it was "a wonderful piece of work".

One teacher said that: "The test appears suitable for the level of the students."

A teacher wrote that this is "...a very nice test" and "...a good job of testing biology". However, she felt that her students tend to do poorly on objective tests in their hurry to be finished first.

Another teacher said that she liked "...the organization of the testing material". She felt that this was "...a good test for the pupil who can do abstract thinking". However, she also was of the opinion that there was "an over-emphasis on vocabulary".

Another teacher wrote to say that many of his students had finished the test before the allotted time had elapsed.

One teacher wrote that when she had reviewed the results of her class on the test, she was not impressed by what she

had taught them.

Another teacher said that the majority of her students had finished the test in less than 25 minutes.

A teacher wrote that he did "...not believe there was any part of the examination that was too difficult for high school biology students". He further stated that after examining it, he believes "...it is a good test" and that it "...covers the areas adequately".

Another teacher wrote that: "The boys and girls had no difficulty in completing the 100 questions in the time allowed."

Another teacher wrote that his pupils thought the test was difficult, but that it seemed adequate to him.

APPENDIX B

Dear Teacher:

It is generally recognized by biology teachers that there is not enough time to sufficiently cover all of the units suggested in courses of study and in textbooks. If the amount of material to be covered can be reduced to include only the most important areas, one of the many problems in the teaching of biology will be resolved.

As partial fulfillment of the requirements for a doctorate degree at Boston University, I am conducting a study in order to discover the most important and also the least important areas of biology as determined by an opinion survey of biology teachers throughout the country. I also plan to construct a test to measure achievement in the most important areas of biology. Any help that you are willing to give will be deeply appreciated. On the enclosed postcard, will you please state:

1. The area of biology that you consider most important.
2. The area of biology that you consider least important.
3. Whether or not you would be interested in having the results of this study mailed to you.
4. Your name and address.
5. Whether or not you would be willing to be of further assistance in this study. This would require:
 - a. Choosing the three most important areas and the three least important areas in regard to the present educational needs of pupils from a list of about twenty areas. I shall supply the list of these areas.
 - b. Picking the three best and the three worst items in a test of the four most important areas of biology.

I thank you again for any help that you might give.

Sincerely yours,

1. The area of most importance:

2. The area of least importance:

3. Would you be interested in the results of the study?
Yes..... No.....

4. Would you be willing to do further work on this study?
Yes..... No.....

5. Your name

Address

.....

CHARLESTOWN HIGH SCHOOL
Monument Square
Charlestown 29, Mass.

204

Dear Teacher:

During the early part of March 1954, I wrote to you and asked for your assistance in the conducting of an opinion survey of biology teachers in order to determine the most important areas of Biology. I want to thank you for the help that you have given so far, and I especially want to express my gratitude to you for indicating that you would be willing to do further work on this study. I have tabulated the replies which I received, and a list of the twenty-four most named areas is given below.

I. Will you please choose the three areas that you consider the most important of these twenty-four areas and place the letters, which are before these areas, in the spaces designated for them on the enclosed postcard.

II. Will you please then choose the three areas that you consider the least important of these twenty-four areas and place the letters, which are before these areas, in the spaces designated for them on the enclosed postcard.

Note: The List Is In Alphabetical Order

- A. Anatomy of plants and animals without emphasis on man
- B. Biological principles
- C. Conservation of natural resources
- D. Conservation without emphasis on natural resources
- E. Disease
- F. Ecologic relations to man
- G. Ecology without emphasis on man
- H. Economic significance of Biology
- I. Embryology
- K. Entomology
- L. Essential life processes
- M. Evolution
- N. Foods and nutrition
- P. Genetics of plants and animals without emphasis on man
- Q. Genetics of the human
- R. Health and hygiene
- S. Human anatomy
- T. Human physiology
- U. Human reproduction
- V. Kinds of living things
- W. Nature study
- X. Physiology of plants and animals without emphasis on man
- Y. Protoplasm and the cell
- Z. Reproduction of plants and animals without emphasis on man

I thank you again for the great assistance which you are giving to this endeavor.

Sincerely yours,

John A. Tyrrell

Most important areas:

Least important areas:.....

Your name

Address

.....

Dear Teacher,

In reply to a questionnaire, which was sent to you in March of 1956, you chose "Biological Principles" as one of the three most important areas of biology, from a supplied list of twenty-four areas.

I have constructed a test in the area of "Biological Principles" and I want to be sure that the items have face validity, that is, that they really test for a knowledge of "Biological Principles". Listed below are five sample test items and also a statement of the principle being tested. Would you be so kind as to look these over and then fill out the enclosed postcard and return it to me.

Principle: There are processes that go on within an organism, which are essential to its continued existence.

Item: Which one of the following life processes is not essential to the existence of the individual? (a) respiration; (b) reproduction; (c) secretion; (d) absorption.

Principle: Oxygen combines with other elements producing heat and energy.

Item: When we exercise, we breathe faster because (a) we are tired; (b) we need energy; (c) there is less oxygen in the air; (d) there is less carbon dioxide in the air.

Principle: All organisms must be adjusted to the environmental factors, in order to survive in the struggle for existence.

Item: The fact that the European corn borer is widespread in the United States indicates that (a) it is a pest; (b) it cannot be controlled; (c) it has adjusted to the environment; (d) it is not a harmful insect.

Principle: All life comes from previously existing life and reproduces its own kind.

Item: Mosquitoes come into existence from (a) stagnant water; (b) eggs; (c) decaying food; (d) all of these.

Principle: All living organisms have similar life functions.

Item: A man is most like an ape in his (a) size; (b) life processes; (c) shape; (d) habits.

I wish to thank you for the great assistance which you have given. I assure you that it is deeply appreciated.

Sincerely yours,



In your opinion, do the items test for
knowledge of biological principles?

Yes _____ No _____

Comments (if any) _____

Name _____

CHARLESTOWN HIGH SCHOOL
MONUMENT SQUARE
CHARLESTOWN 29, MASS.

Dear Teacher:

During the past two years, I have twice asked for your assistance in the conducting of an opinion survey of biology teachers in order to determine the most important areas of biology.

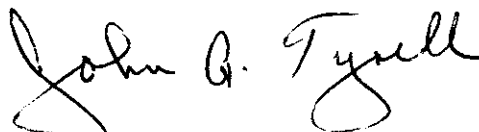
All of the replies have been tabulated and the four most named areas are:

- a) Essential Life Processes
- b) Biological Principles
- c) Conservation of Natural Resources
- d) Human Physiology

I have constructed a test in these four areas of biology. As a final part of my study, this test must be given to 50 biology classes. If 30 copies of this test were sent to you some time in May, could you find the time to give it to one of your biology classes. The test will require about 35 minutes to administer and all correcting will be done by me. The purpose of the test is to give an indication on a country-wide basis of the knowledge of students in these four areas of biology.

You have already been overly generous with your time and effort and it is with great hesitation that I ask you to help me this third and final time.

Sincerely yours,



P.S. I have enclosed a self-addressed postcard on which you may send your reply.

Will you be able to give the tests in May?

Yes _____ No _____

Name _____

Address _____

CHARLESTOWN HIGH SCHOOL
Monument Square
Charlestown 29, Mass.

Dear Teacher:

Enclosed is the set of 30 tests, which you so kindly agreed to give to one of your classes. The test consists of 100 items, which can be broken down in the following way:

#1 - #25.....Biological Principles
#26 - #50.....Essential Life Processes
#51 - #75.....Human Physiology
#76 - #100.....Conservation

To prevent a pupil from spending too much time on any one group of questions, will you please allow 9 minutes for each group of 25 questions. If a pupil finishes one group of questions before 9 minutes have elapsed, he should be allowed to continue on with the next group.

It would certainly prove most valuable to this study if you could supply the I. Q. and/or results of any standard biology tests for each of your students, taking this test. This could be written in over the heading on the front page of the test.

Also, if you feel that any of the items on the test are not teachable (i.e. the difficulty level of the material is too high for high school pupils) would you please indicate this on a piece of paper and enclose it with the tests, when you return them. Any other comments or criticisms of the test would also be most welcome.

Be assured that your very great effort is most deeply appreciated.

Sincerely,


John A. Tyrell

Name _____ Sex _____ Age _____ Grade _____

School _____ Course: College _____
Non-College _____

Directions:

In each of the following items, choose the word or phrase which best completes the sentence or which best answers the question. Place the letter, which is before the word or phrase, on the line provided at the right of each item. Work as quickly and as accurately as you can.

1. The strongest indication that evolution has occurred is (a) fossil records; (b) uplifting of mountains; (c) sinking of land; (d) geographic isolation. 1. _____
2. When identical twins do not do equally well in school, it is probably because (a) they were born with different capacities; (b) there is a difference in the size of their brains; (c) there is a difference in the size of their bodies; (d) there is somewhat of a difference in their environment. 2. _____
3. For their food supply, all living things are dependent upon (a) nucleoplasm; (b) chlorophyll; (c) chromatin; (d) cytoplasm 3. _____
4. The fact that new kinds of living things have come into existence is best explained by (a) the mutation theory; (b) the theory of acquired traits; (c) the theory of overproduction; (d) creation. 4. _____
5. Heredity determiners are (a) genes; (b) nuclei; (c) nucleoli; (d) centrosomes. 5. _____
6. When we exercise, we breathe faster because (a) we are tired; (b) we need energy; (c) there is less oxygen in the air; (d) there is less carbon dioxide in the air. 6. _____
7. The term evolution means that (a) life came from non-life; (b) we have uncovered fossils; (c) living things are constantly changing; (d) man descended from the ape. 7. _____
8. The ultimate source of the energy of all living things is (a) food; (b) the sun; (c) the soil; (d) green plants. 8. _____
9. The basic unit of plant and animal structure is the (a) tissue; (b) cell; (c) eggs; (d) nucleus. 9. _____
10. A knowledge of chemistry is important in the study of biology, because (a) living things are made up of chemicals; (b) living things are dependent upon chemicals; (c) life processes involve chemical change; (d) a biologist should have a knowledge of the other sciences. 10. _____
11. The basic substance of all life is (a) the nucleus; (b) the nucleolus; (c) the cell; (d) protoplasm. 11. _____

- 12. In plant and animal life, whenever the structure of an organism becomes more complex, then there is always an increase in (a) the size of the organism; (b) the needs of the organism; (c) the division of labor within the organism; (d) the number of offspring produced by the organism. 12. _____
- 13. The crow, the English sparrow, and the starling occur over a very wide area because (a) they produce great numbers of offspring; (b) they are able to vary their diets and living conditions; (c) they require very little food; (d) they are protected by law. 13. _____
- 14. The fact that the European corn borer is widespread in the United States indicates that (a) it is a pest; (b) it has adjusted to the environment; (c) it cannot be controlled; (d) it is not a harmful insect. 14. _____
- 15. In the human, there is a building up of protoplasm (a) only when the person is young; (b) only when the person is eating; (c) only when the person is sleeping; (d) during the entire life of the person. 15. _____
- 16. Mosquitoes come into existence from (a) stagnant water; (b) eggs; (c) decaying food; (d) all of these. 16. _____
- 17. If all green plants were to suddenly die, the gas that would soon disappear is (a) oxygen; (b) carbon monoxide; (c) carbon dioxide; (d) nitrogen. 17. _____
- 18. Certain bacteria can resist adverse conditions by (a) growing in colonies; (b) producing carbon dioxide; (c) protective coloration; (d) forming spores. 18. _____
- 19. A man is most likely an ape in his (a) size; (b) life processes; (c) shape; (d) habits. 19. _____
- 20. Protein food is essential because (a) it contains nitrogen, which is found in protoplasm; (b) it is a good energy food; (c) it contains oxygen, which is essential to protoplasm; (d) it is found in all meat. 20. _____
- 21. The fact that dinosaurs are now extinct indicates that (a) they were too big; (b) they were not suited to survive the changing conditions of the earth; (c) there was not enough food; (d) they fought with each other. 21. _____
- 22. The clam has a hard shell, in order that it may (a) burrow in the mud; (b) be protected against enemies; (c) get food; (d) not be affected by cold water. 22. _____
- 23. Which one of the following factors would be least apt to explain the geographic distribution of plants and animals? (a) heat; (b) light; (c) nitrogen; (d) pressure. 23. _____
- 24. If a species of animal life were to suddenly lose the ability to reproduce, as a direct result (a) the animals would all die; (b) the species would become extinct; (c) both of these things would happen; (d) neither of these things would happen. 24. _____

25. An aquarium having both plants and animals is a good example of (a) balance in the world of life; (b) pond life; (c) marine life; (d) how to care for living things. 25. _____
26. For the food making process green plants do not need (a) carbon dioxide; (b) oxygen; (c) water; (d) light. 26. _____
27. A life process most likely to be associated with the lungs and skin is (a) digestion; (b) absorption; (c) excretion; (d) secretion. 27. _____
28. Fission is a type of (a) excretion; (b) absorption; (c) assimilation; (d) reproduction. 28. _____
29. When a male cell unites with a female cell to produce the young; the reproduction is termed (a) parthenogenesis; (b) sexual; (c) asexual; (d) dioecious. 29. _____
30. Ingestion is a process which occurs (a) in all plants and no animals; (b) in all animals and no plants; (c) in all plants and some animals; (d) in all animals and some plants. 30. _____
31. Which of the following life processes is not essential to the existence of the individual (a) respiration; (b) reproduction; (c) secretion; (d) absorption. 31. _____
32. The process by which heat and energy are released in living things is (a) assimilation; (b) secretion; (c) respiration; (d) digestion. 32. _____
33. Growth is a characteristic of all living things. However a snowball, rolling down the side of a snow-covered hill, grows. The snowball is not alive because (a) it grows from within; (b) it grows by addition to the outside; (c) it will melt in the sun; (d) it is not able to move from place to place. 33. _____
34. The process by which insoluble nutrients are changed to soluble substances is known as (a) assimilation; (b) growth; (c) oxidation; (d) digestion. 34. _____
35. A characteristic of animals, but not of most plants is (a) respiration; (b) reproduction; (c) motion; (d) locomotion. 35. _____
36. Living things, chiefly animals, produce special substances to carry on their activities. These substances are called (a) gases; (b) secretions; (c) carbohydrates; (d) excretions. 36. _____
37. The animals in a balanced aquarium receive, from the plants, both food and (a) energy; (b) oxygen; (c) carbon dioxide; (d) nitrogen. 37. _____
38. Respiration in plants and animals (a) is identical; (b) is opposite; (c) releases oxygen; (d) is a building up process. 38. _____

39. An important use of roots is (a) absorption; (b) assimilation; (c) food-making; (d) transpiration. 39. _____
40. The turning of leaves toward the light is called (a) geotropism; (b) response; (c) phototropism; (d) irritability. 40. _____
41. The building up and breaking down of protoplasm is known as (a) respiration; (b) growth; (c) metabolism; (d) transpiration. 41. _____
42. Tropisms are most like (a) voluntary acts; (b) reflexes; (c) conditioned reflexes; (d) habits. 42. _____
43. A life process which is not usually performed by animal cells is (a) growth; (b) excretion; (c) assimilation; (d) photosynthesis. 43. _____
44. Habits and conditioned reflexes are alike in that both (a) are learned responses; (b) are inherited; (c) appear only in dogs; (d) appear only in man. 44. _____
45. Absorption of a substance through a membrane is termed (a) diffusion; (b) osmosis; (c) catabolism; (d) erosion. 45. _____
46. When eggs develop normally without being fertilized by spermatozoa, the process is known as (a) gametogenesis; (b) metamorphosis; (c) incubation; (d) parthenogenesis. 46. _____
47. Oxygen enters the leaf of a plant through the (a) stomates; (b) lenticels; (c) xylem; (d) veins. 47. _____
48. Transfer of pollen from anther to stigma of a flower is called (a) pollination; (b) maturation; (c) fertilization; (d) germination. 48. _____
49. Nitrogenous wastes are excreted mainly by means of the (a) lungs; (b) stomach; (c) kidneys; (d) liver. 49. _____
50. Seedless oranges are propagated by (a) hybridization; (b) grafting; (c) hydroponics; (d) fission. 50. _____
51. The part of the human body in which bile is stored is the (a) liver; (b) duodenum; (c) pancreas; (d) gall bladder. 51. _____
52. The word "joint" is most closely associated with (a) bones; (b) muscles; (c) nerves; (d) skin. 52. _____
53. The digestion of food occurs mostly in the (a) mouth; (b) stomach; (c) small intestine; (d) large intestine. 53. _____
54. Assuming that the instrument works properly in each case, we would be least apt to hear a bell, which was placed in (a) water; (b) oil; (c) a vacuum; (d) sawdust. 54. _____
55. A secretion that digests both proteins and carbohydrates is (a) saliva; (b) pancreatic juice; (c) bile; (d) pepsin. 55. _____

56. Before food can be used to nourish protoplasm, it must be acted upon by (a) mastication; (b) saliva; (c) enzymes; (d) hydrochloric acid. 56. _____
57. The red pigment which gives blood its color is (a) hematin; (b) fibrinogen; (c) lymph; (d) globulin. 57. _____
58. The pancreas secretes a hormone known as (a) prolactin; (b) thyroxine; (c) adrenalin; (d) insulin. 58. _____
59. The backward flow of blood in the veins is prevented by (a) the heartbeat; (b) muscles; (c) lymphatics; (d) valves. 59. _____
60. When blood passes through the kidneys, it loses (a) carbon dioxide; (b) red blood cells; (c) white blood cells; (d) urea. 60. _____
61. The threads that are part of a blood clot are made of (a) globulin; (b) fibrin; (c) lymph; (d) platelets. 61. _____
62. Fainting is often caused by defective (a) respiration; (b) digestion; (c) metabolism; (d) circulation. 62. _____
63. The muscular wall that aids us in breathing is the (a) broncus; (b) epiglottis; (c) larynx; (d) diaphragm. 63. _____
64. Eskimos eat a large quantity of fatty foods because these foods (a) are cheaper; (b) produce more calories; (c) are easy to obtain; (d) require little preparation. 64. _____
65. Exercise increases the rate of breathing because it causes in the blood, an increase of (a) oxygen; (b) nitrogen; (c) carbon dioxide; (d) hydrogen. 65. _____
66. The human embryo, before it is born, obtains its food and oxygen through the (a) nucleus; (b) ovaries; (c) placenta; (d) yolk. 66. _____
67. Compared to an equal volume of inhaled gas, a volume of exhaled gas contains less (a) oxygen; (b) nitrogen; (c) carbon dioxide; (d) hydrogen. 67. _____
68. Blood platelets contain a substance which is necessary for (a) blood clotting; (b) respiration; (c) metabolism; (d) ingestion. 68. _____
69. The contraction of the pupil of the human eye, when exposed to strong light, is an example of (a) phototropism; (b) plexus; (c) reflex; (d) synapse. 69. _____
70. Poisons from disease producing bacteria are counteracted by (a) antitoxins; (b) fibrinogen; (c) germicides; (d) white blood cells. 70. _____
71. The part of the brain which is used for thinking is the (a) cerebrum; (b) cerebellum; (c) pineal body; (d) medulla. 71. _____
72. The cause of night blindness is (a) eyestrain; (b) a virus; (c) a bacterium; (d) a vitamin deficiency. 72. _____

73. Obeying traffic lights for most people is (a) a reflex; (b) a tropism; (c) an instinct; (d) a habit. 73. _____
74. In normal vision, the part of the eye, on which light focuses, is the (a) cornea; (b) lens; (c) retina; (d) vitreous humor. 74. _____
75. Abnormal height in a young person is usually due to improper functioning of the (a) adrenal gland; (b) pancreas; (c) pituitary gland; (d) thymus gland. 75. _____
76. Chemical substances used to destroy insects are called (a) emulsions; (b) insecticides; (c) powders; (d) germicides. 76. _____
77. Organic matter may be returned to the soil by the use of (a) crop residues; (b) green-manure crops; (c) manure from animals; (d) all of these. 77. _____
78. The purpose of contour plowing is to (a) discourage insects; (b) beautify the farm; (c) save the topsoil; (d) control weeds. 78. _____
79. In 1906, the federal government protected the deer in Kaibab National Forest against any type of killing. At first the number of deer increased, but then gradually decreased. This decrease was because (a) hunters ignored the law; (b) the food supply was becoming exhausted; (c) the deer could not be protected against wild animals; (d) the deer fought with each other. 79. _____
80. An animal that was once threatened with extinction in this country, but is now increasing in number is the (a) bison; (b) squirrel; (c) coyote; (d) passenger pigeon. 80. _____
81. An insect which is considered valuable is the (a) cutworm; (b) termite; (c) ladybird beetle; (d) locust. 81. _____
82. The greatest destruction in forests is caused by (a) lichens; (b) insects; (c) beavers; (d) fires. 82. _____
83. Fish hatcheries are places where fish are (a) prepared to be used as food; (b) cared for during the winter; (c) artificially propagated; (d) studied in their natural environment. 83. _____
84. One species of tree which has been almost entirely destroyed by a parasitic blight is the (a) birch; (b) oak; (c) chestnut; (d) ash. 84. _____
85. The organic matter in soil is called (a) humus; (b) silt; (c) loam; (d) clay. 85. _____
86. Soil erosion is not likely to be caused by (a) high mountains; (b) weeds; (c) desert region; (d) heavy rains. 86. _____
87. The type of soil which is best able to hold water is a (a) sandy soil; (b) clay soil; (c) mixture of sand and clay; (d) loamy soil. 87. _____

88. The drainage of swamps tends to (a) increase wildlife; (b) prevent floods; (c) destroy the balance in the water cycle; (d) prevent dust storms. 88. _____
89. The Tennessee Valley Authority is directly concerned with (a) flood control; (b) control of soil erosion; (c) reforestation; (d) all of these. 89. _____
90. Soil conservation is not aided by (a) addition of soil nutrients; (b) formation of gullies; (c) crop rotation; (d) contour plowing. 90. _____
91. Many wild flowers are protected by law and must not be picked. This is because these flowers (a) are poisonous; (b) cause allergies; (c) are becoming extinct; (d) furnish food and shelter to birds. 91. _____
92. In the spring, a farmer burned the grass around his farm to get rid of the weeds. That summer, his farm was deluged with insects. This probably (a) was because the insects were better able to find food; (b) was because the insects were brought to the surface by the fire; (c) was because the fire destroyed the nest of birds; (d) had no connection with the fire. 92. _____
93. A bird which is considered a pest is the (a) barn owl; (b) seagull; (c) English sparrow; (d) quail. 93. _____
94. The balance of nature has been most often upset by (a) wind; (b) floods; (c) insects; (d) men. 94. _____
95. Floods and soil erosion are most apt to result from (a) crop rotation; (b) strip cropping; (c) deforestation; (d) terracing. 95. _____
96. Japanese beetles are more of a pest in this country than in Japan, because in this country (a) food is more plentiful; (b) there are fewer natural enemies; (c) the climate is more suitable; (d) the government has not tried to eradicate them. 96. _____
97. In 1886, Pennsylvania paid people who killed hawks and barn owls. The loss in fruit and grain crops which resulted was probably due to (a) a lack of pollination; (b) an increase in field mice; (c) weather conditions; (d) all of these factors. 97. _____
98. If you were to give a talk on the conservation of lumber, which of the following recommendations should you not make? (a) use small pieces of lumber whenever they are suitable; (b) use the best available lumber for the purpose; (c) coat lumber that is to be placed in the ground with a suitable paint or chemical; (d) never use plywood as a substitute for other types of lumber. 98. _____
99. Compost is used (a) to improve soil fertility; (b) to destroy bacteria; (c) to prevent soil erosion; (d) as an aid to crop rotation. 99. _____
100. In crop rotation, which of the following is usually included? (a) legumes; (b) cotton; (c) corn; (d) oats. 100. _____

CHARLESTOWN HIGH SCHOOL

MONUMENT SQUARE

Charlestown 29, Mass.

Dear Teacher,

I would like to thank you for your generous co-operation in agreeing to give a biology test to one of your classes. Letters were sent to 100 teachers, asking for their assistance in this regard. The response was overwhelming and because of this, it was possible to obtain an excellent geographical distribution.

It was on this basis that your name was removed from the list of those to give the test. Since you are an educator, you readily understand the importance of geographical distribution in a study of this nature.

However, I am enclosing a copy of the test and would be most grateful for any comments that you would care to make.

The test consists of 100 items, which can be broken down in the following way:

#1-#25-----Biological Principles
 #26-#50-----Essential Life Processes
 #51-#75-----Human Physiology
 #76-#100-----Conservation

Be assured that the work that you have done in behalf of this study is most deeply appreciated.

Sincerely,

John A. Tyrell
 John A. Tyrell



BOSTON PUBLIC SCHOOLS
CHARLESTOWN HIGH SCHOOL

MONUMENT SQUARE
CHARLESTOWN 29, MASSACHUSETTS

219

LOUIS R. WELCH
HEAD MASTER

September 27, 1956

Dear Sir:

I am in the process of making a survey of high school biology textbooks and would be most grateful for your assistance.

Would you send me a list of any high school biology textbooks which you have published since and including 1950.

Also, for each book, could you give me the approximate coverage (by number of pages) for each of the four following topics?

1. Essential life processes.
2. Biological principles.
3. Conservation of natural resources.
4. Human physiology.

If it is impossible to fulfill this latter request, would it be possible to send an examination copy of the book or books.

Also, if possible, could you give me the approximate number of schools in which your text is being used.

Be assured that your help in this rather arduous undertaking is most deeply appreciated.

Sincerely yours,

John A. Tyrell
John A. Tyrell

JAT:CH

BIBLIOGRAPHY

BIBLIOGRAPHY

1. Anderson, Kenneth E., "Summary of the Relative Achievements of the Objectives of Secondary School Science, in a Representative Sampling of Fifty-Six Minnesota Schools," Science Education (December, 1949), 33:323-329.
2. Baker, Arthur O., and Lewis H. Mills, Dynamic Biology Today. Rand McNally and Co., New York, 1953.
3. Bingham, N. Eldred, and Joe Young West, "Aims and Purposes of Science Teaching," Review of Educational Research (October, 1948), 18:297-314.
4. Bullington, Robert A., "What's New in the Teaching of Biology," School Science and Mathematics (April, 1954), 54:253-255.
5. Caldwell, Otis W., and Florence Weller, "High School Biology Content as Judged by Thirty College Biologists," School Science and Mathematics (April, 1932), 32:411-424.
6. Charles, Brother H., Biology. The Bruce Publishing Company, Milwaukee, 1956.
7. Clark, Sayles B., and J. Albert Mould, Biology for Today. Cambridge Book Company, New York, 1956.
8. Curtis, Francis D., "Some Practical Suggestions for the Teaching of Biology," School Science and Mathematics (February, 1951), 51:95-104.
9. Davis, Frederick B., Item Analysis Chart, Cooperative Test Service of the American Council on Education, New York, 1944.
10. Davis, Frederick B., Item Analysis Data: Their Computation, Interpretation and Use in Test Construction. Graduate School of Education, Harvard University, Cambridge, 1949.

11. Dodge, Ruth A., Elements of Biology. Allyn and Bacon, Inc., New York, 1955.
12. Eisman, Louis, and Charles Tanzer, Biology and Human Progress. Prentice Hall, Inc., New York, 1953.
13. Fan, Chung-Teh, Item Analysis Table. Educational Testing Service, Princeton, New Jersey, 1952.
14. Fenton, Carroll L., and Paul E. Kambly, Basic Biology for High Schools. The Macmillan Company, New York, 1953.
15. Fitzpatrick, F. L., and S. R. Powers, Cooperative Biology Test (Revised Series Form N). Cooperative Testing Service, New York, 1937.
16. Fitzpatrick, Fred, "Trends in High School Biology," The Bulletin of the National Association of Secondary School Principals (January, 1953), 37:56-67.
17. Fitzpatrick, Frederick L., and Vivian Edmiston, "Teaching of Science in Senior High School and Junior College," Review of Educational Research (October, 1942), 12:412-424.
18. Fried, Alexander A., High Points in Biology. College Entrance Book Company, New York, 1952.
19. Galbreath, J. W., "A Suggested List of Principles for Biology at the Tenth Grade Level," The American Biology Teacher (December, 1942), 5:69-70.
20. Grant, Charlotte L., "Can A Single Course in the Biological Sciences Fill the Dual Objectives of General Education and Training of Future Specialists." School Science and Mathematics (April, 1953), 53:287-290.
21. Grant, Charlotte L., H. Keith Cady, and Nathan A. Neal, High School Biology. McGraw-Hill Book Company, Inc., New York, 1952.
22. Guilford, J. P., Fundamental Statistics in Psychology and Education. McGraw-Hill Book Company, Inc., New York, 1950.

23. Guilford, J. P., Fundamental Statistics in Psychology and Education. McGraw-Hill Book Co., Inc., New York, 1956.
24. Hanes, G. M., and H. E. Benz, Hanes-Benz Biology Test Form A. C. A. Gregory Company, Cincinnati, Ohio, 1939.
25. Heiss, Elwood D., Ellsworth S. Obourn, and Charles W. Hoffman, Modern Science Teaching. The Macmillan Company, New York, 1950.
26. Henry, Nelson B. (Editor), "The Content of Methods of Senior High School Science - The Course in High School Biology," Chapter XIII, in Science Education in American Schools, Part I, The Forty-sixth Yearbook, National Society for the Study of Education. The University of Chicago Press, Chicago, 1947.
27. Hintz, Melvin A., "A Modern Biology Program For The High School," The American Biology Teacher (November, 1940), 3:48-51.
28. Hoff, Arthur G., Secondary School Science Teaching. The Blakiston Company, Philadelphia, 1950.
29. Horst, Paul, "Item Selection by Means of a Maximizing Function," Psychometrika, (December 1936) Volume 1, Number 4.
30. Hunter, George W., and H. J. Edward Ahrens, "The Present Status of Science Objectives in the Secondary Schools of California," Science Education (December, 1947), 31:287-295.
31. Hunter, George W., and Leroy Spore, "The Objectives of Science in the Secondary Schools of the United States," School Science and Mathematics (October, 1943), 43:633-647.
32. Hunter, Mabel R., "Adapting the Study of Biology to the Ability and the Needs of Slow-Learning Pupils," School Science and Mathematics (June, 1947), 47:544-548.

33. Isenbarger, Katharine Ulrich (Editorial Chairman), A Half Century of Science and Mathematics Teaching. Central Association of Science and Mathematics Teachers, Inc., Oak Park, Illinois, 1950.
34. Kambly, Paul E., Cooperative Biology Test, Revised Series, Form Y. Educational Testing Service, New York, 1948.
35. Kelley, Truman L., "The Selection of Upper and Lower Groups for the Validation of Test Items," Journal of Educational Psychology (January, 1939), 30:17-24.
36. Kirkpatrick, James J., and Edward E. Cureton, "Simplified Tables for Item Analysis," Educational and Psychological Measurement (Winter, 1954), 14:709-714.
37. Klinge, Paul, "Is Biology A Science Course," School Science and Mathematics (May, 1950), 50:379-383.
38. Kroeber, Elsbeth, and Walter H. Wolff, Adventures with Animals and Plants. D. C. Heath and Company, Boston, 1950.
39. Lovely, Charles V., Topics Suitable for Developing Understandings of Biological Principles in Senior High School, Unpublished Master's Thesis. Boston University, 1947.
40. Lowry, Nelson S., "Biology and Physical Science for Ninth and Tenth Grade Students," Science Education (March, 1951), 35:71-73.
41. Lurensky, Maurice L., A Determination of the Applications of the Principles of Biology Found in Four Textbooks of Biology for the Senior High School, Unpublished Master's Thesis. Boston University, Boston, 1947.
42. McAtee, Veva, "Is Biology a Science or a Fad," School Science and Mathematics (March, 1946), 46:206-208.
43. McFadden, M. G., "Recent Trends in the Teaching of Biology and Some Recommendations Relative to the Development of a Course of Study," Science Education (February, 1950), 34:47-51.

44. McKibben, Margaret, "The Present Status of General Objectives in the Teaching of Secondary Biology," Science Education (April, 1947), 31:171-175.
45. McMenamain, Joseph P., "A Change for High School Botany," The Science Teacher (April, 1949), 16:84,96-99.
46. Martin, W. Edgar, "A Determination of the Principles of the Biological Sciences of Importance for General Education," Science Education (March, 1945), 29:100-105.
47. Martin, W. Edgar, The Teaching of General Biology in the Public Schools of the United States, Bulletin, 1952, Number 9, Federal Security Agency, Office of Education, Washington, D. C.
48. Meder, Elsa M., "The Science Curriculum," Review of Educational Research (October, 1951), 21:249-263.
49. Miller, D. F., "A Summary of Part of the Questionnaire Sent to Teachers of Biological Sciences in Secondary Schools," The American Biology Teacher (April, 1941), 3:221-227.
50. Miller, Jesse V., "Biology - 1949 Model," The American Biology Teacher (April, 1949), 11:101-104.
51. Moon, Truman J., Paul B. Mann, and James H. Otto, Modern Biology. Henry Holt and Company, New York. 1956.
52. Morse, Stanley W., "High School Science Experience of 506 Non-Science Curricula College Students," Science Education (March, 1950), 34:117-126.
53. Nelson, Clarence H., Nelson Biology Test, Form AM. World Book Company, New York, 1950.
54. Noll, Victor H., The Teaching of Science in Elementary and Secondary Schools. Longmans, Green and Company, New York, 1939.
55. Powers, Samuel R., and David J. Blick, "Teaching of Science in Senior High School and Junior College," Review of Educational Research (October, 1945), 15:301-309.

56. Presson, John M., and Leroy A. King, Presson Biology Test. World Book Company, New York, 1929.
57. Read, John G., Measuring with a Non-Verbal Picture Test, the Ability to Recognize and Classify some Objects and Situations Associated with the Physical Science Environment, Unpublished Doctoral Dissertation. Boston University, Boston, Massachusetts, 1954.
58. Richardson, M. W., and Dorothy C. Adkins, "A Rapid Method of Selecting Test Items," Journal of Educational Psychology, 1939, 29:547-552.
59. Riddle, Oscar, "Amount and Nature of Biology Teaching in Secondary Schools," The American Biology Teacher (January, 1942), 4:120-123;150-159;184-192.
60. Riddle, Oscar, "Preliminary Impressions and Facts from a Questionnaire on Secondary School Biology," The American Biology Teacher (February, 1941), 3:151-159.
61. Ruch, Giles M., and Leo H. Cossmann, Ruch-Cossmann Biology Test-Form A. World Book Company, New York, 1924.
62. Sanders, Edwin R., Practical Biology. D. Van Nostrand Company, Inc., New York, 1947.
63. Schneck, John W., "The Practical Value of Certain Topics in a Course in Biology," School Science and Mathematics (April, 1946), 46:318-322.
64. Shoop, John E., "Why Teach Biology," School Science and Mathematics (December, 1941), 41:818-821.
65. Smith, Ella Thea, Exploring Biology. Harcourt, Brace and Company, New York, 1954.
66. Stanfield, J. Fisher, "General Education, General Biology, and Plant Science," School and Society (June, 1951), 73:401-405.
67. Thorndike, Robert L., Personnell Selection. John Wiley and Sons, Inc., New York, 1949.
68. Trowbridge, Helen, "How To Strengthen the Teaching of High School Biology," School Science and Mathematics (June, 1943), 43:563-566.

69. United States Armed Forces Institute, Examination in Biology - High School Level, Form SCG-1-B-4. The American Council on Education, New York, 1945.
70. Vance, B. B., and D. F. Miller, Biology For You. J. B. Lippincott Company, New York, 1954.
71. Washton, Nathan S., "A Syllabus in Biology for General Education," Science Education (March, 1951), 35:84-92.
72. Washton, Nathan S., "A Syllabus in Biology for General Education II," Science Education (October, 1952), 36:227-237.
73. Weckstein, A. M., and Benjamin DeLeon, Graphic Survey of Biology. Oxford Book Company, New York, 1956.
74. Wells, Harrington, Secondary Science Education. McGraw-Hill Book Company, Inc., New York, 1952.
75. Weltzin, Elmer M., The Content of Biology in High School Texts, Unpublished Master's Thesis. State University of Iowa, Iowa City, 1933.
76. Whitaker, Prevo L., "Problems of Biology in General Education," School Science and Mathematics (April, 1949), 49:289-295.