AN EVALUATION OF CERTAIN COURSE CONTENT IN RELATION TO UNDERSTANDING OF PRINCIPLES IN A BIOLOGICAL SCIENCE COURSE

By

James McFarland Elliott

A THESIS

Submitted to the School of Graduate Studies of Michigan State College of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

Department of Education

1953

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Approved Milosh Muntyan

James McFarland Elliott

THESIS ABSTRACT

The purpose of this study was (1) to obtain an evaluation of the content of the Biological Science Lecture Syllabus in relation to an understanding of principles presented in the course and (2) to derive from these data certain inferences and generalizations having implications for a) the objectives of Biological Science, b) the "minimum essentials" concept as it relates to Biological Science, c) the revision of the Biological Science Lecture Syllabus and the Study Guide for Biological Science, d) the examination program in Biological Science, and e) the preparation of laboratory studies in Biological Science.

A five-place rating scale was employed in obtaining the evaluation of syllabus content. The staff of the Department of Biological Science served as the "jury of expert respondents". The arithmetic mean of the ratings which each item received was calculated and assigned to the item as an index value indicating the degree of contribution toward an understanding of the related principle. The items related to each principle were arranged in a frequency distribution on the basis of index values. Reliability of the rating instrument was determined by the retake method. The product-moment coefficient of correlation between the two sets of mean scores for the units of the rating scale marked a second time were .86 and .75. The t-test revealed both coefficients of correlation to be significant at the 1 per cent level of confidence.

Based upon an analysis of the frequency distribution of items of syllabus content arranged in terms of index values, it was concluded that the syllabus contains information which contributes in varying degree toward an understanding of the principles presented in the study guide. Furthermore, the staff of the Department of Biological Science, acting collectively, was able to identify the elements of course content in the order of the importance of contribution toward an understanding of related principles.

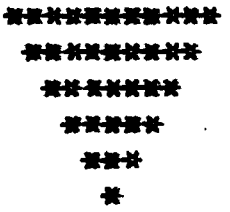
The lecture syllabus does not treat adequately, by comparison, all of the principles presented in the study guide. Therefore, if equitable treatment of principles is a desired feature of the syllabus, the results of this study indicate areas where revision is needed and also provide information bearing on the general nature of the necessary changes.

The content of the syllabus does not adequately contribute toward attainment of the course objective "to acquire knowledge of some of the basic laws (principles) of biology" if it is assumed that this contribution must take the form of adequate contribution by syllabus content toward an understanding of the principles presented in the study guide.

Until a revision of course material is accomplished the evaluation of syllabus content obtained as a result of this study should be employed as a basis for the investigation of the "minimum essentials" concept as it related to Biological Science and as a basis for the preparation of examinations and laboratory studies for use in the biological science course.

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The author wishes to extend an expression of appreciation to Dr. Milosh Muntyan, chairman, and to his entire guidance committee. The sincere co-operation of the writer's own colleagues, who spent many hours executing the rating instruments employed in this study, is gratefully acknowledged.



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CHAPTER I

CHAPTER I

THE BACKGROUND OF THE PROBLEM

INTRODUCTION

Role of facts in course organization. It seems to be generally agreed that the sciences have a definite contribution to make toward the objectives of general education.[1] For the most part there is agreement as to the nature of the contribution, at least to the extent that uniformity of expressed objectives can be considered as evidence of such agreement.

Examination of objectives for biological science courses designed especially for general education purposes reveals that the factual elements have not been overlooked. However, almost invariably the phrasing of the objectives tends to place emphasis on fundamental principles and concepts. It is characteristic of expressed objectives for general education science courses that the factual elements of the course are embodied within the meaning of such an objective as, for example, "To become acquainted with some of the more important facts of science."[2]

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[1] E. J. McGrath, Editor. Science in General Education. Dubuque, Iowa. William C. Brown Company. 1948. p. 89.

[2] W. C. Van Deventer, Chairman, Committee on Research in Junior College Science, National Association for Research in Science Teaching, Trends and problems in general education college science courses. Science Education, 33:89. April 1949.

It is not the intent here to undertake the development of a case against the emphasis which major principles and concepts have received in relation to the development of objectives for programs of general studies. Neither is it to be proposed that the intensity with which they have been treated be reduced. What is to be suggested, however, is that the desire to produce breadth of scope in general education has resulted to a considerable degree in the failure of factual content to receive the attention which it deserves. The term "factual content" is used here to refer to course content included within the meaning of the four senses in which "fact" may be used, as differentiated by Cohen and Nagel.[3] These four senses in which "fact" may be used are as follows:

1. "Fact" may be used to refer to certain discriminated elements in sense perception.
2. The term "fact" may be used to denote certain propositions which interpret what is derived by sense experience.
3. Propositions which assert an invariable sequence or conjunction of characters may be within the meaning of "fact".
4. "Fact" may be used to denote those things existing in space or time together with the relations between them, in virtue of which a proposition is true.

Throughout this study the term "fact" will be used in accord with the above statements.

General education courses are designed specifically to implement the objectives of general education programs. They are intended to serve as vehicles of progress toward understanding of certain fundamental

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[3]Morris R. Cohen and Ernest Nagel, An Introduction to Logic and the Scientific Method, New York, Harcourt, Brace and Company, 1934. p. 217.

principles and concepts which have been drawn from the areas to which a given course pertains. It is logical to assume that principles and concepts selected for emphasis should bear a contributory relationship both to over-all objectives of the program and the objectives of the course of which they are a part. Thus, it is relatively easy to establish the relationship between bread principles and concepts of a designated course and the objectives, both over-all and specific, of a general studies program. Indeed, there seems to be general recognition of the desirability of defining this relationship more specifically.[4] Will not extension of the same logic help to establish the relationship between principles and concepts of an area on the one hand and its factual content on the other? Certainly, knowledge of fundamental facts of an area of learning form the basis for an understanding of the broader aspects of the area. Because this is true, the selection of factual content for general education merits as much consideration and emphasis as does the selection of principles, concepts and generalizations.

Attention should be called to the fact that the phrase Knowledge of fundamental facts of an area and not Knowledge of the fundamental facts of an area was used in the foregoing passage. The former phraseology was employed specifically to avoid the inference that the point of view from which this study was undertaken was that only certain basic facts from an area of study are capable of contributing toward an understanding of related principles and concepts. The view here is in

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[4]Nathan S. Washton, "A Syllabus in Biology for General Education," Science Education, 35:86. March, 1951.

accord with the statement in Cooperation in General Education[5] to the effect that more than one set of content can be used to attain the objectives of general education. For the same reasons, more than one set of factual material can contribute to an understanding of principles. The plea is to be made, however, that attention should be given to selection and organization of factual content so that there is created in every course an orderly procession of factual material, each component of which contributes meaningfully toward understanding of major principles and concepts.

It is not to be inferred that every item of factual material worthy of inclusion in a course of study must be capable of standing alone as a contribution toward the elucidation of the principles, concepts, and generalizations central to the area. Indeed, in many instances an item of factual information may appear as mere minutia when viewed out of context, yet its role may be vital in completing the mosaic upon which understanding rests.

It is also desirable to remember that regardless of how important a fact may appear when examined in isolation, justification for emphasizing it in the teaching and testing program should be found. The basic reason for emphasizing any fact in instructional procedures should arise from the contribution which the fact in question makes toward an understanding of the broader aspects of the course. If the factual content

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[5]American Council on Education, Executive Committee on the Cooperative Study in General Education, Cooperation in General Education. Washington: American Council on Education. 1947. p. 212.

of a course does not measure up when judged by this criterion, yet continues to receive instructional emphasis, the indictment that facts are being taught as isolated phenomena can hardly be avoided.

> Factual information should be taught or learned only when it contributed to the understanding of something. Were the acquisition of specific items of information thus always made subordinate, there would not be any question of learning too much factual information, or of learning useless information, or information that cannot be applied.[6]

Thus, the solution seems to lie not in the addition of more facts but in the attempt to identify and incorporate within course structure only those significant facts which will contribute toward desired understandings.

The belief has been expressed that it should be possible, through analysis of course structure, to determine the approximate degree of contribution toward understanding made by certain kinds of facts. To accomplish this would involve a detailed evaluation of factual content in terms of criteria derived from principles, concepts, and generalizations presented in the course. The results would be a determination of levels of contribution made by different facts toward understanding of a related principle. Analogous to this view factual content is visualized as a series of concentric circles around a central core of fundamental or basic ideas, principles, and generalizations which form the nucleus of course organization. The innermost circle is conceived as representing the factual elements making the most vital contribution toward understanding of core materials. Moving outward, the second circle represents

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[6]James B. Stroud, Psychology in Education. New York, Longmans Green and Company, Inc. 1946. p. 206.

the factual material related to both the factual content of the first order and to the core material, but the contribution which it makes is not deemed quite as significant to achievement of desired outcomes as that made by the material occupying the first orbit. Thus, following this analogy, it should be possible to establish a sort of heirarchy of supporting factual material about the central elements of a course.

As presented, this scheme is suggestive of the modern concept of the structure of the atom. Recognizing this, it is most tempting to carry the analogy even further by pointing out the parallels that may be drawn regarding the outermost orbits of both.

It must be admitted that such a conceptualization as has been suggested contains dangerous overtones. Such a pattern of course organization could lead to overemphasis on the transmission of factual knowledge with the consequent encouragement of rote learning. Stereotyped presentation of material and general devitalization of classroom experiences might be concomitants of an attempt to put the scheme into operation. But cannot these and other undesirable practices occur under any plan of course structure?

Basically, what has been suggested here is that the factual aspects of a course of study should be brought into proper focus in the light of fundamental principles and concepts which have been selected to enhance attainment of objectives. It is maintained that principles can be taught only through the medium of facts and that the student learns and arrives at understanding of principles through a process of synthesis of facts. It is true that the factual raw materials of understandings

may be presented in various ways. For example, situations may be created in which the student discovers the facts for himself, as in the problem solving approach. The question of importance here is not how the student gets facts. The concern should be with which facts he gets and with the use he makes of them.

As further evidence of the relationship between facts and principles, it is of interest to note the following definitions of principles that have been offered by various workers.

A principle has been defined by Washton[7] as a comprehensive generalization of interrelated facts pertaining to natural phenomena. He also states that a principle is scientifically true within the limitations stated or exceptions noted and that it can be verified by observation and/or experimentation.

Russell[8] defines a principle as follows:

> A principle recrystallizes specific judgements into terms having general application. Thus, if a specific situation can be referred to as a principle or associated with one, there results great economy of thought. It becomes unnecessary to form new opinions or to exercise new judgments. The establishment of a principle, then, becomes a means of relating large numbers of meanings and adjusting novel facts as they arise.

Martin[9] defines a principle as a comprehensive generalization of interrelated facts, objects, and/or events that must be scientifically

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[7] Nathan S. Washton, op. cit., p. 85.

[8] Charles Russell, Teaching for Tomorrow. New York: Prentice-Hall Inc., 1937, p. 145.

[9] W. Edgar Martin, "A Determination of the Principles of the Biological Sciences of Importance for General Education", Science Education, 29:101, March, 1945.

true with few exceptions. Observation or experimentation should determine its true value.

Bergman[10] has said that a principle is a scientifically true generalization which characterizes a fundamental process or structure, a mode of behavior, or a property pertaining to natural phenomena.

Lawson[11] has defined a principle as a relationship or generalization that is supported by such a wealth of data that its truth is very highly probable. It is also noted that a principle is supported by so many observations or facts that the possibility of the discovery of any facts that disprove it is remote.

Heineman[12] describes a principle as a statement of relationship, frequently causal in nature, between two facts.

All of these definitions, in one way or another, convey the idea that principles are derived from facts, that the formulation of a principle is the expression of an interrelationship of facts. It therefore seems logical that the process of teaching for understanding and application of principles would involve treatment of the basic facts upon which a given principle rests.

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[10] George J. Bergman, "Determination of Principles of Entomology for General Education", Science Education, 31:24, February, 1947.

[11] Chester A. Lawson, Biological Science Lecture Syllabus with Readings, East Lansing, Michigan: Michigan State College Press, 1951. p. 3.

[12] Ailsie M. Heineman, "A Study of General Science Textbooks", General Science Quarterly, 8:11, November, 1928.

If it is granted that factual material provides the basis for the teaching-learning situation and if it is accepted that more than one set of factual material can contribute toward the goals of instruction, it becomes impossible to escape the implication that the selection of factual content must be exercised by someone involved in the teaching-learning process. As most courses are presented the "someone" who usually makes the selection is the instructor. Frequently, it is not until examination day that the students discover the facts that the instructor considered important. Would it not be more consistent if basic organization of the course were carried one step farther in the beginning and the fundamental factual content were identified immediately following the determination of significant objectives, concepts, and principles?

The literature pertaining to the organization of courses in biological science for general education purposes indicates that the problem of selection of principles has received considerable attention. Little mention is made, however, concerning the selection of fundamental facts upon which the principles are based. It is this interstitial zone, delimited by objectives on one side and principles and concepts on the other, that is occupied by the factual elements of course content. Any attempt to develop broad courses in a general education program must involve examination of the content of this interstitial region in search of facts with which to buttress the generalizations with which they deal.

Origin of the problem. The general education program at Michigan State College was introduced in 1945. The Basic College, responsible

for the program, was established as a separate administrative unit composed of seven different departments. The seven departments were: Biological Science, Physical Science, Social Science, Effective Living, History of Civilization, Literature and Fine Arts, and Written and Spoken English. According to the committee recommendations resulting in the establishment of the general education program at Michigan State College, the function of the Basic College is "to provide students with a sound foundation on which to build an intelligent interest in personal, family, vocational, social, and civic problems, a better understanding of these problems, and a greater ability to cope with them....Students whose training may eventually become highly specialized need this foundation of general educational experience that each may have a greater appreciation of the relationship of his special field to the needs of society as a whole."[13]

The Department of Biological Science[14] was created in the process of establishing the Basic College as the vehicle for the general education program at Michigan State College.

The biological science course occupies an entire academic year of three terms. The designations 121, 122 and 123 are used to identify the first, second and third terms respectively. The three term sequence is

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[13]"Report of Committee appointed 'For Study and Recommendations' Concerning Basic Education at Michigan State College." Unpublished report, Michigan State College, 1944.

[14]In the process of reorganization of the Basic College in 1952, the number of departments was reduced to four. The Biological Science Department was dissolved. Virtually the entire staff of the former Department of Biological Science now comprises the Department of Natural Science.

not comprised of three separate courses, but constitutes one year of work in the area with considerable continuity between terms.

Students attend two one-hour lecture meetings and one two-hour laboratory period each week. Each term of the course is valued at three credits; the entire sequence at nine credits. It is possible for the student to receive credit by means of passing a comprehensive examination in lieu of taking certain terms of the course in class. Additional explanation of this point will be presented below in connection with comment on the testing program.

All three terms of the course have been offered each term of the academic year. Students may begin the sequence any term during the year including the summer session.

The average number of students enrolled in the course for the two year period, 1950 to 1952, was approximately twenty-eight hundred. Two-thirds of these were in normal sequence; that is, they were in Basic 121 in the Fall, Basic 122 in Winter and Basic 123 in Spring term.

Throughout the period of this investigation the staff of the department consisted of twenty-two full-time members. The majority of the staff were teaching through the respective terms in normal sequence in keeping with the distribution of student load. Each term during which these ratings were made, six or seven instructors were teaching out of sequence. This number was required to staff Basic 122 and Basic 123 in the Fall, Basic 121 and Basic 123 in Winter and Basic 121 and Basic 122 in Spring term.

Within the interval in which this investigation was conducted it was departmental policy for a given instructor to teach both laboratory and lecture classes. Schedules were arranged in such a way that several laboratory classes were correlated with specific lecture hours and instructors were assigned correlated sections. Thus, students had the same instructor in both lecture and laboratory classes. Teaching assistants within any of the various meanings of the term were not employed during the period that this study was in progress.

Each instructor was responsible for evaluation procedures in his own classes while this study was in progress. At the conclusion of each term the student receives a laboratory-lecture grade as determined by his instructor. This grade constitutes 50 per cent of the final grade. The remaining 50 per cent of the term grade is derived from performance on a departmental comprehensive examination.

The comprehensive examination is taken by all students completing a particular term of the course. There is a separate examination for each of the three terms. Not only does the comprehensive examination provide the criterion for determining 50 per cent of the term grade but it also provides a means whereby qualified students may receive credit for certain terms of the course without taking the actual work in class. Pertinent to the latter function of the comprehensive examination is the fact that examinations covering successive terms of work are "cumulative and increasingly comprehensive". This is understood to mean that the comprehensive examination covering the first term of the course contains only first term material while the examination on the second

term has selected first term material integrated into its structure. Examinations on the third term of the course include materials from both previous terms or work.

A student who achieves a grade of A for the first term of the course is eligible to apply for permission to take the second term comprehensive at the end of his first term of work or he may apply for permission to take both second and third term examinations. Should he pass these examinations with a grade of B or better he receives credit for these terms of work on the basis of his examination grade alone. The grade he receives is the same as his letter grade on the examination. A student in second term may be granted permission to write the third term comprehensive in event he has a B-plus average for the first two terms with no grade less than B. If a student receives special permission to take the comprehensive examination covering any term of the course and does not achieve a grade of B or better he must take the term of work in class before repeating the examination.

The Board of Examiners, a department of the Basic College, is jointly responsible with the departments comprising the Basic College for the preparation of comprehensive examinations. As experts in testing and evaluation procedures the members of the Board of Examiners assume the burden of technical problems concerned with preparation of comprehensive examinations. The departmental contribution is made through a committee operating under the joint chairmanship of a representative of the Board of Examiners and a department member. The remainder of the committee is composed of regular instructors. The duty of the

departmental examination committee is to write examination questions and to edit questions written by both the representative of the Board of Examiners and other committee members. All comprehensive tests must be approved by the committee before the final forms of the tests are published.

In the process of course organization and development certain principles, deemed significant to general education, were selected and included in the course. These principles are clearly indicated either in the Guide for Laboratory Studies in Biological Science[15] or in the Study Guide for Biological Science.[16] They are thus available for the use of all concerned, staff, examiners and students alike. These are the principles about which the course is built. It is upon the understanding and application of these principles that the students are tested. They might be termed "minimum essential principles".

The situation is not as clear regarding factual aspects of the course. The objectives of the course[17] mention the acquisition of factual material as one of the desired outcomes. An inspection of the Biological Science Lecture Syllabus[18] appears to justify the conclusion that much

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[15]Staff of the Department of Biological Science, "Guide for Laboratory Studies in Biological Science". East Lansing, Michigan: Michigan State College Press. 1951. p. 5.

[16]Study Guide Committee, "Study Guide for Biological Science". East Lansing, Michigan: Michigan State College Press. 1951.

[17]Education Committee, "Objectives for Biological Science", Unpublished report, Department of Biological Science, Michigan State College, 1946.

[18]Chester A. Lawson, loc. cit.

more factual material is included than is actually needed for the formulation of adequate understandings of the principles presented in the course. This creates the problem of selection on the part of the student. Which facts should be mastered to insure an understanding of the principles? For the solution, the student will look to the instructor for guidance.

An analysis of the comprehensive examinations shows that factual items constitute thirty to sixty percent of the examinations. This implies the problem of selection by the examination committee. Which facts should be included in the examination? Which facts form the basis for an understanding of the principles of the course?

In teaching it is the policy to emphasize principles. Principles are usually explained in terms of the facts upon which they are based. Which facts should be emphasized in explaining the principles? This suggests the problem of selection on the part of the instructor. The instructor knows that the comprehensive examinations contain factual material. A conscientious effort must be made to aid the students in mastery of enough of the material so that they will not be at a disadvantage when competing with the students of other instructors. What is the basis for the selection of factual material to be emphasized by the instructor? This selective process can be performed only in terms of the application of individual criteria to the vast body of factual material at hand. Different instructors do not apply the same criteria with the result that different facts are selected for emphasis in the various classes. Because one instructor emphasizes one factual aspect

of a given principle and another may emphasize a different factual aspect of the same principle, there can be little agreement between the two as to what factual elements should be included on the examination. An impasse is the result.

Generally all instructors are in agreement that factual material should receive a measure of emphasis in teaching and testing. All are more or less in agreement that a student should demonstrate mastery of certain "fundamental biological facts" before being allowed to leave the course with a satisfactory mark. However, upon raising the question as to which facts should be emphasized in teaching, little agreement can be obtained. In the past, attempts by the staff to identify factual material that could validly be included in the departmental examinations have resulted in generalizations of little specific value to the examiners.

Recognition of this problem on the part of members of the term-end examination committee came largely as a result of experiences connected with the routine functions of the committee. It was the policy of the examination committee to work closely with the twenty to twenty-five individual staff members comprising the department. All items were submitted to the staff for criticism and were subsequently revised in the light of such criticism before inclusion in an actual test. Reaction of staff members over the period of years provided a basis for definition of the problem situation upon which this study is based.

THE PROBLEM

Statement of the Problem. It was the purpose of this study (1) to obtain from the staff of the Department of Biological Science an evaluation of the content of the Biological Science Lecture Syllabus relative to an understanding of principles presented in the course and (2) to derive from these data certain inferences and generalizations having implications for a) the objectives of Biological Science, b) the "minimum essentials" concept as it relates to Biological Science, c) the revision of the Biological Science Lecture Syllabus[19] and the Study Guide for Biological Science,[20] d) the examination program in Biological Science, and e) the preparation of laboratory studies for Biological Science.

Delimitation of the problem. This study was limited to an investigation of the relationship between the factual information in the lecture syllabus and the principles appearing in the study guide. This limitation was imposed because of the specificity with which the principles in the study guide were identified with corresponding areas of factual information in the syllabus.

The content of the Biological Science Lecture Syllabus[21] used in this study was not validated against outside criteria. The fact that the syllabus and study guide were official departmental publications required of all students was presumed to be sufficient evidence that the contents of the two volumes had received prior validation.

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[19]Chester A. Lawson, loc. cit.

[20]Study Guide Committee, loc. cit.

[21]Chester A. Lawson, loc. cit.

Participation in this study was limited to the staff of the Department of Biological Science because it was felt that the judgments of the individuals actually responsible for the preparation and presentation of the course were, in the final analysis, the ones of real significance.

Importance of the problem. Stroud[22] has pointed out that unless we can learn to teach more effectively, a thorough, well rounded, useful knowledge of facts can be acquired only at the expense of teaching fewer facts. The suggestion to limit the amount of factual material in a course carries with it the implication of selection. Only those facts should be emphasized which meet certain criteria. In a course dedicated to the teaching of major concepts and principles, the criterion for inclusion of factual material should be based upon the contribution which knowledge of the facts makes toward understanding of the principles or concepts to which they are related. This investigation was undertaken in an effort to measure the factual content of the biological science lecture syllabus against this general criterion. If this objective can be attained the results of this study should prove useful in the following capacities.

1. The results of this study could provide the basis for subsequent revisions of the Biological Science Lecture Syllabus.[23]
2. The results of this analysis would offer a unique reference

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[22]Stroud, loc. cit.

[23]Chester A. Lawson, loc. cit.

for use in conjunction with the present methods of planning and constructing examinations in Biological Science.

3. This study should make available information pertinent to the departmental grading policy. The contribution in this area should prove particularly significant in regard to grading policies based on the "passing grade concept"[24] since this study deals to some extent with the identification of "minimum essentials".[25]
4. The results of this study could contribute toward the preparation of laboratory studies involving methods of science.
5. The information resulting from this study might be utilized as an aid in the planning of teaching procedures such as lectures, discussions and visual aids programs.
6. Other colleges and universities using the Biological Science Lecture Syllabus[26] and/or the Guide for Laboratory Studies in Biological Science[27] should be informed of this study and the results should be available to them.[28]

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[24]Herbert E. Hawkes, E. F. Lindquist, and C. R. Mann, The Construction and Use of Achievement Examinations, New York: Houghton Mifflin Company, 1936. p. 36.

[25]Ibid.

[26]Chester A. Lawson, Biological Science Lecture Syllabus with Readings", East Lansing, Michigan: Michigan State College Press, 1951.

[27]Staff of the Department of Biological Science, loc. cit.

[28]According to information supplied by the Michigan State College Press 10 institutions were using the laboratory guide and 3 were using the syllabus during the Fall of 1952.

Basic assumptions of this study. The following are the basic assumptions pertinent to this investigation.

1. Facts form the basis for teaching and understanding of specific principles.
2. When a limited number of facts is employed in teaching a specific principle certain facts are more important than others in contributing toward an understanding of the principle.
3. When a limited number of facts is employed in teaching a specific principle certain facts are essential to an understanding of the principle.
4. The principles appearing in the Study Guide for Biological Science[29] are the principles emphasized by the staff in teaching and testing and by the students in their study.
5. The judgments of the staff in executing the rating device used in this study were valid.
6. The fact that the syllabus and study guide were official departmental publications was presumed to be evidence of the validity of over-all content.

ORGANIZATION OF REMAINDER OF THE THESIS

In Chapter II a review of literature related to certain aspects of the problem is presented. The first area of the chapter deals with studies selected for the purpose of illustrating the changing role of

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[29]Study Guide Committee, loc. cit.

facts in course objectives. The concluding portion of this chapter presents a review of studies on selection of certain course content.

Chapter III explains the procedures employed in this investigation. The phases described are: construction of the rating instrument, administration of the instrument, analysis of evaluations, and determination of reliability of the instrument.

Chapter IV briefly describes the method of presenting the results of this study but is principally concerned with inferences and generalizations derived from the data.

In Chapter V the study is summarized, conclusions are formulated and educational implications, both specific and general, are considered. The chapter concludes with further problems suggested by the study.

CHAPTER II

CHAPTER II

REVIEW OF RESEARCH RELATED TO THE PROBLEM

Bullington,[1] on the basis of a nation-wide survey of 150 general education science courses, made the recommendation that before content is selected course objectives should be determined that are in full agreement with the philosophy of general education and with the policies of the school. Course content should then be selected in terms of these objectives. The value of this recommendation is evident, since in practice there should be some structured procedure for the selection of content, component by component, in terms of the objectives. It would be difficult to select the entire content of a course on any other than a step by step basis and regardless of the plan of selection employed, some criteria must be utilized in the process.

Examination of the literature discloses the nature of the procedures that have been utilized as a means of insuring that the course content is consistent with over-all objectives. The methods employed vary in detail but examination discloses a common factor in the entire group of studies. The common element in the studies reviewed here is the recognition by the investigators that it is desirable to select principles, concepts, and generalizations in terms of criteria provided

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[1]Robert Adrian Bullington, "Subject Matter Content of General Education Science Courses", Science Education, 36:285-292, December, 1952.

by course objectives. The view supported here is that the next logical step in course construction is to select facts according to criteria derived from the principles to be presented in the course. This must be done before it can be expected that the factual content will be logically related to the objectives of the course. The extent of common thought on this point may appear to be exaggerated because most of the studies mentioned here deal with selection of principles and not all general education courses, are "principles" courses. Nevertheless, it is true that such courses are frequently encountered in general education programs.[2] Even when other types of courses are employed, the logic of justifying content in terms of objectives is no less sound than when applied to the construction of a "principles" course.

Because there is logic in the general practice of looking to objectives to provide criteria for the selection of immediately subordinate course components, it may be anticipated that principles and concepts, once selected, should logically provide criteria governing selection of course content of lesser stature. In other words, extension of the same logic employed in selection of the principles dictates that the justification for the inclusion of factual material in a course should arise from the principles and concepts presented. Furthermore, logic requires that the facts selected contribute toward an understanding of the principles and concepts. Because of the fundamentally simple nature of the relationships outlined above, it is reasonable to expect

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[2] Ibid., p. 286.

that reports of studies dealing with the selection of factual content in terms of principles could be discovered. Such is not the case. Thorough search has failed to reveal studies dealing specifically with the problem of selection, or evaluation, of factual content in terms of criteria derived from stated principles, concepts, and generalizations. It was recognized before this study was undertaken that there was this dearth of related material.

Therefore, in the absence of other studies parallel in nature to the present study, reference will be made to the literature pertaining to the following points:

1. Studies showing the evolution of the role of facts in expressed objectives for general education science courses.
2. Studies on the selection of principles for general education science courses in which techniques similar to those used in this investigation were employed.

Review of studies illustrating the role of facts in expressed objectives of general education science courses. Because of the prominent role accorded factual material in this investigation, it is probable that the impression will be created that factual content has been treated out of proper perspective relative to the other elements of the course. Since it is true that in courses designed to serve the purposes of general education facts can be overemphasized, there is justification for suspecting that any study devoted to the factual aspects of a course will be received with marked skepticism in many quarters. Thus, it should

be emphasized again that this study is an attempt to bring the factual components of the course in biological science into proper focus with respect to principles, generalizations, and concepts presented in the course. Furthermore, there is a trend toward bringing content into proper adjustment with other facets of course structure which constitutes an historical parallel to the development of the general education point of view in course construction. The different light in which facts are regarded may constitute the major point of difference between general education science courses and those designed primarily for the preparation of specialists.

The movement toward casting factual material into a role subsidiary to the attainment of other course outcomes is nowhere better illustrated than in the literature pertaining to course objectives. Reference to the representative studies from the past two decades reviewed below should not only reveal the changing emphasis on factual content but also the pattern of the change should be relatively clear.

Sequential examination of studies on objectives should also provide support for the contention that although informational objectives may no longer receive principal emphasis, the task of bringing facts into the proper support of other objectives has emerged as a major problem. Therefore, it is reasonable to believe that the selection of factual content is more difficult now that facts are expected to make some contribution toward total outcome.

Brief reference will be made to selected studies on objectives for the purpose of developing the following points:

a. That the emphasis on facts as mentioned in stated course objectives has changed in the past 20 years and that the pattern of the change can be detected.

b. That the present phraseology of stated objectives implies a factual content that is subsidiary to the attainment of the objectives and that a consequence of this is that factual content is currently more difficult to select.

Several studies have involved the submission of lists of objectives to various groups for rating. In 1931 Berner[3] reported a study in which 25 students in a graduate course in Education at the University of Wisconsin were asked to collect lists of objectives from textbooks, courses of study and periodicals. The objectives were then classified according to knowledges, abilities, habits, appreciations, attitudes, purposes, ideals, and interest. In all, 57 distinct objectives were stated. The class members were then asked to rank each of the objectives by placing them into five groups. Each objective then received, as its score, the sum of the ratings given by the class. The objectives ranked highest by the class were: the habit of scientific thinking, a scientific attitude, and knowledge which will give insight into the nature and organization of the enrivonment, making it an organized whole instead of a number of disjointed parts. This report is mentioned here for two reasons. First, the technique is basically comparable to the procedure employed in the present study and, second, the study mentions acquisition of knowledge as a worthy objective of science instruction, but qualifies the kind of knowledge and the purpose it is to serve,

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[3]L. M. Berner and others, "Objectives of Science Teaching", School Science and Mathematics, 31:550-557, May, 1931.

that is, knowledge which will give insight into the nature and organization of the environment. This suggests that the particular "knowledges" expected to contribute to understanding of the environment would have to be related to aspects of the environment.

In 1932 Beauchamp[4] conducted an investigation based on an analysis of stated objectives of science courses aimed at determining frequency of mention of the various types of objectives. Included in the 160 courses studied were 45 courses in biology. For courses in biology, the objectives most frequently mentioned were: to acquire knowledge that will produce a better understanding of our environment, to acquire knowledge that will lead to more healthful living, to appreciate nature, to acquire knowledge for worthy use of leisure time, and to acquire knowledge of principles of biology. In four of the objectives mentioned above reference is made to the acquisition of knowledge intended to contribute toward specific outcomes. In the last objective, to acquire knowledge of principles of biology, the association of factual material with objectives is unmistakable. In all five of the objectives the problem of selection of factual content is implicit.

A report on questionnaires from 68 respondent collegiate institutions teaching science courses of generalized nature was published by Winokur[5] in 1936. Biological science, physical science and combination

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[4]Wilber L. Beauchamp, Instruction in Science. U. S. Office of Education Bulletin, 1932, No. 17, Monograph No. 22. Washington: Government Printing Office. 1933. pp. 9-14.

[5]Morris Winokur, "A Survey of Generalized Science Courses in Institutions of Higher Education", Science Education, 20:132-140, October, 1936.

courses were covered by the study. The questionnaire contained the request that the objectives of the courses be given. The frequency of each type of objective listed was then tabulated. The portion of the results that are of significance for the present study is the fact that 54 of the respondents gave "to teach knowledge of the subject matter of the course" as one of the objectives. Burmester[6] says, in reference to the results of this study, "It would appear that in 1936 even in those colleges courses which are supposedly for the general student the major emphasis was on the subject matter of science". Whether or not the major emphasis was on subject matter during 1936, or in any other year, is relatively unimportant from the standpoint of the present study. It is of importance here to point out that when, at any time, instructional emphasis is on factual content there is the concomitant problem of selection of facts. Where progress toward course objectives other than the informational type is desired, the factual content of the course will condition attainment of these objectives. Therefore, those responsible for the selection of factual content should do so in terms of criteria which give recognition to other objectives.

In 1938 Hard and Jean[7] reported a survey of general education science courses in colleges dealing with the identification of objectives. In the questionnaire employed the recipients were asked to indicate the

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[6]Mary Alice Burmester, "A Synthesis and Evaluation of Objectives for Biological Science in the Basic College of Michigan State College". Unpublished master's thesis, Michigan State College, 1948, p. 18.

[7]H. O. Hard and F. C. Jean, "Natural Science Survey Courses in Colleges", Science Education, 22:294-299, November, 1938.

principle objectives of their course in accord with the following key:

1. The acquirement of pure science facts.
2. The acquirement of generalized understandings.
3. The acquirement of skill in valid and reliable thinking.
4. The acquirement of socially acceptable scientific attitudes.

Of 209 questionnaires submitted 84 percent were returned. The first objective was checked by 35.5 percent of the respondents and 93.1 percent indicated the second objective as the most important. Apparently some of the respondents, unable to choose between facts and understandings, marked both 1 and 2. This indicates the difficulties involved in attempting to separate facts and understandings. Such indecisive behavior may be attributed to the artificiality of attempting a clear-cut separation of the two. It would be more realistic to consider facts and understandings as mutually related factors.

Noll,[8] in 1939, reported a study of objectives of science teaching which was considerably more comprehensive than most similar studies. In this study a list of objectives was compiled from a total of 130 sources such as textbooks, committee reports, articles, and periodicals. The objectives thus obtained were then arranged into categories as follows: knowledges, abilities, habits, appreciations, attitudes, and interest.

The findings pertaining to "knowledges", together with the comments on this point, are of the most interest in relation to the present study. Of all categories of objectives, at all levels of instruction, the

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[8]Victor H. Noll, The Teaching of Science in Elementary and Secondary Schools. New York: Longmans, Green and Company, 1938. pp. 5-21.

principle emphasis was found to be on "knowledge". The greatest emphasis was at the senior high school level where 51.5 percent of all objectives listed were in the "knowledges" area. Noll[9] does not believe that knowledge of facts should be an aim of science but that this kind of knowledge is a prerequisite to the attainment of the true aims of science. These "true aims" are presumed to be such objectives as understanding of nature and its organization, an appreciation of its complexity and orderliness, and so on. This constitutes recognition of the foundational role played by facts in the process of gaining understandings. Certainly, when knowledge of facts is considered to be prerequisite to certain specific understandings, the nature of the understandings desired should play a decisive role in the identification of the factual precursors. Noll[10] also makes a plea for teachers to learn to think of the purposes of their work in terms of changes to be brought about in the thinking and behavior of the pupils rather than in terms of the transmission of facts only. What is desired is a change of emphasis from the attempt to transmit <u>mere</u> facts to trying to teach understandings for which <u>certain</u> facts are prerequisite. The view is not that facts should be eliminated, but that they should be recognized in their proper perspective as subsidiary to understandings. Therefore, it seems that the factual content of a course should be selected in terms of the understandings desired. This is the position supported here and it is also the one from which this study was undertaken.

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[9] <u>Loc. cit.</u>

[10] Noll, <u>op. cit.</u>, p. 11.

In 1938, a questionnaire on science teaching practices was sent to 100 selected specialists in the field of secondary school science teaching by the Committee on Secondary School Science of the National Association for Research in Science Teaching.[11] The questionnaire was comprised of nine main divisions, one of which dealt with the objectives of secondary school science. The 71 respondents rated the objectives on a five point scale ranging from great importance, number one, to unimportant, number five. Provision was made for indicating complete disagreement with the objective by checking space X. Failure to understand the meaning of an objective called for checking space Y. On this scale the items relating to the scientific attitude were given the highest ratings. Examples of objectives in this category are: an objective attitude toward facts, an understanding of cause and effect relationships, freedom from superstition, and a willingness to suspend judgment. The major objective given second highest rating was "the ability to think scientifically." Third place was awarded to "mastery of fundamental knowledges."

It is interesting to note that, once again, the phraseology employed in expressing the objective awarded first rank is suggestive of the factual basis of the scientific attitude. The third place objective, mastery of fundamental knowledges, leaves some doubt as to its meaning, because it may be questioned how fundamental knowledges can be identified. The obtained ratings offer evidence that, at the time of the study,

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[11] "Report of Committee on Secondary School Science of the National Association for Research in Science Teaching", Science Education, 22: 223-233, October, 1938.

there was awareness of the desirability of relating factual aspects to other course objectives.

In 1943, Hunter and Spore[12] reported a study dealing with evaluations of objectives in which rating scales were used. In this study 30 objectives were rated as teachers thought they were being taught, not as they thought they should be taught. The respondents represented 655 schools. The data were analyzed separately for junior and senior high school. At both levels the objective which received the highest rating was "understanding the environment." Rather than undertake any subtle means of relating this objective to its obviously factual basis, it seems appropriate to question how the environment can be understood without factual information about it. It appears that "understanding the environment" is an example of one of the "true aims of science" the attainment of which depends on prerequisite facts.

In a monograph, Science in General Education, published in 1948, McGrath[13] summarized materials contributed by 21 colleges and universities. Four possible objectives for non-science major students who take general education science courses were mentioned. These may be listed as follows:

1. To understand and learn to use the method of science.

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[12]George W. Hunter and Leroy Spore, "The Objectives of Science in the Secondary Schools of the United States", School Science and Mathematics, 43:633-647, October, 1943.

[13]Earl J. McGrath, Editor. Science in General Education, Dubuque, Iowa: Wm. C. Brown and Company, 1948.

2. To become acquainted with some of the more important facts of science.

3. To become aware of the social implications of science.

4. To appreciate the historical development of science.

The second objective has definite implications for the problem of selection of facts for inclusion in any course which attempts to meet that objective. Not only would it be necessary to identify the more important facts of science but, consistent with current thinking in curriculum construction, it would be necessary to select from among these facts those which contribute toward the attainment of the other objectives.

In 1949,[14] Geer reported the results of a study of objectives for three survey courses in Physics at the University of Southern California. At the beginning of the semester 150 students were asked to list the objectives which they considered important for the course. A wide divergence was represented in the opinions of the student respondents. Hundreds of objectives were listed, which the investigator categorized by a process of rewording and classification into 21 major objectives. These were returned to the students with instructions to mark each, according to the emphasis he believed it should receive. One hundred and twenty-one responses were used in the final results.

The method employed by the investigator in arriving at a relative evaluation of the objectives was to accord "very high" a numerical value

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[14] Willard Geer, "Objectives Students Seek in Physics Survey Courses", Science Education, 33:152-155, March, 1949.

of "4", "high" a value of "3", etc. The mean numerical score was then computed and the objectives arranged in rank order accordingly.

The objective receiving highest rank, with a mean score of 3.38, was "general knowledge". The second place mean score of 2.79 was awarded to "understanding how mechanical and electrical devices around us work". Third position was given to "understanding fundamental laws and principles". The results of this study indicate that the "knowledge" type of objective is still uppermost in the minds of the students. Inspection of the objectives also leads to the conclusion that it would be virtually impossible to devise a teaching program designed to meet any of the first three objectives without considering the problem of selection of factual content since the basic criteria for inclusion of factual content rest in the objectives.

In addressing a meeting of the science teachers of South Carolina in 1950, Baker[15] outlined specific objectives for a program of science teaching. The following stands out in its obvious reference to the problems of selection of factual content for programs of science education.

> The sciences should give the student a body of accurate, reliable and useful knowledge--knowledge which will enable him to distinguish fact from superstition, education from propoganda.[16]

In summarizing the studies on objectives the following points seem justified:

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[15]Woolford B. Baker, "Science Teaching and the World of Tomorrow", Science Education, 34:7-15, February, 1950.

[16]Ibid., p. 11.

1. To the extent that stated objectives may be taken as indicative of educational practice, there seems to be a definite trend away from placing primary emphasis on the transmission of facts as an objective of generalized science courses.

2. There appears to be a well established movement toward the practice of attempting to teach certain factual material selected for the purpose of contributing toward the attainment of other objectives.

3. Increased prevalence of the point of view expressed in Item 2 above does not mean that facts are coming to be considered as incidental to learning; that is, something to be tolerated until they can be eliminated at the earliest opportunity. On the contrary, contemporary objectives suggest a factual content derived through a process of selection growing out of the realization that all of the facts can never be covered in one course and that some facts <u>are</u> more important than others in contributing toward attainment of concomitant objectives.

4. The results of studies on frequency of mention of objectives indicate that the teaching of knowledge remains as the objective most frequently mentioned by all classes of respondents; students, classroom teachers, and college and university specialists in the teaching of science. These findings tend to corroborate the statements in Item 3 above in that they constitute evidence that acquisition of knowledge as an objective of instruction has not disappeared from the educational scene.

5. It is perhaps of general significance to note that the categories of respondents listed in Item 4 above (students, classroom teachers,

university specialists) appear in the order of their increasing tendency to qualify the role of facts as course objectives. Twenty years ago the college or university specialists probably would have been the only group to restrict the role of facts as course objectives but at the present time it can be expected that most classroom teachers will react approximately the same way. However, even now, relatively few students, in a free response situation, will place restrictions on the part played by facts in course objectives. This clearly indicates the time lag that occurs in the dissemination of ideas. The fact that students continue to award first place to the acquisition of facts as an unqualified objective of instruction probably accounts for much of the student resistance encountered in presenting general education courses where the principal emphasis is on non-informational types of objectives.

6. The phraseology of contemporary objectives for general education science courses indicates that factual content is expected to contribute toward attainment of many non-informational objectives. This point of view may be contrasted with that represented by the type of traditional introductory science course where the primary emphasis is on providing an introduction to a specialized field. From the latter point of view, facts are important because teaching is directed toward the training of future scientists. Facts are no less important in the science course designed for general education purposes but they must be selected on a different basis and restricted in number. Because of the restrictions and qualifications arising, for the most part, from the desire to meet non-informational objectives, it is the contention here that the

selection of factual content for general education science courses is a more rigorous process than would be the case if only informational objectives were involved.

Review of studies on course content employing the "expert jury technique" of evaluation. A number of studies have been reported in the past decade dealing, in general, with the identification of principles desirable for inclusion in the various types of science courses designed specifically for general education purposes. These studies have dealt with the problem of selection of principles at both the senior high school and junior college level. To a considerable extent, the common concern of the investigators has been with obtaining relative evaluations of principles in terms of the criteria or objectives of general education. The evident concern over the problem of selection of principles that are in harmony with objectives of general education does not, in itself, constitute an indictment, even though it restricts the investigations to a pattern. Actually, the concentration on selection of principles indicates a general recognition of at a least one facet of the over-all problem of course construction.

Another major aspect of the problem of course construction concerns the selection of course content that will be effectively subsidiary to the principles, once the principles have been selected. If it is logical to assume that principles should be selected in terms of course objectives, it seems equally logical to assume that the content of the course that is subordinate to the principles should be selected in terms of the principles.

Thorough search failed to reveal a single study in which it was undertaken to select or evaluate course content in terms of principles. With certain exceptions, to be specifically noted later in this chapter, the investigators seem to have been content once they had considered the problem of selection of principles.

The reason for mentioning the studies which will be reviewed below is because of interest in the techniques of evaluation employed. What may be called the "jury technique" of obtaining evaluations has apparently become an accepted practice in educational research. As a device for securing evaluations of individual items the "jury technique" offers many advantages, chief among them being that evaluations obtained by this method are valid within the limits imposed by the qualifications of the jurors.

Among the earlier studies in the field of science education in which the expert jury was employed for purposes of selecting course content was one reported by Wise[17] in 1941. The investigator was concerned with determination of the major principles of Physics, Chemistry and Geology which are of importance for general education. The jury method was utilized in four phases of the investigation. First, a jury of three was employed in sorting out duplicate principles from a composite master list of principles. Following this operation, the head of the Department of Physics of the University of Michigan served as a jury of one to check the surviving principles against the criterion, "It must be true without

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[17]Harold E. Wise, "The Major Principles of Physics, Chemistry and Geology of Importance for General Education." Science Education, 25: 371-379, December, 1941.

exception or within limitations specifically stated". The third resort to the jury technique was made when the revised group of principles was submitted to a jury composed of a specialist in each of the three respective fields involved. This final submission was for the purpose of determining accuracy of statement and content of the principles. Applications were then assigned to each principle in the composite list and the applications were checked again by a jury of four specialists. In this way a master list of 272 principles together with 3,153 applications assigned to 246 of the principles was obtained. No conclusions based on this study alone were presented in the report since it was pointed out that the conclusions from this study were later synthesized with those from eleven earlier studies for the purpose of obtaining composite conclusions.

In 1945 Martin[18] reported on a study which promises to become a pioneer educational report of this type. The study was done for the purpose of determining the principles of the biological sciences which are of importance for general education. The major problem was broken down into three sub-problems. The first was to determine the important generalizations of the biological sciences which occur in (1) textbooks prepared for survey courses in the natural sciences at the junior college level of the public schools, (2) in textbooks prepared for use in courses in biology at the secondary level, and (3) in a survey series of the

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[18] W. Edgar Martin, "A Determination of the Principles of the Biological Sciences of Importance for General Education", Science Education, 29:100-105, March, 1945.

biological sciences prepared for the general reader. A second sub-problem was to determine the generalizations of the biological sciences that appear in the lists of scientific principles in published reports and in readily available unpublished reports of research studies. The third sub-problem was to determine what are the important major generalizations, or principles, of the biological sciences. The jury technique was employed in two of the three sub-problems.

In the first sub-problem a committee of three staff members of the School of Education of the University of Michigan served to provide the means of selecting three junior college textbooks, three high-school biology textbooks and a four volume survey series of the biological sciences to serve as a source of principles.

The jury method was involved in sub-problem three to the extent that subject matter specialists, one from the Department of Zoology and the other from the Department of Botany of the University of Michigan, were asked to improve and refine the ststements of principles wherever necessary and possible.

Finally, a list of 100 major principles was prepared on the basis of the aggregate of the ranks which each had received in the three evaluations. The 100 principles were listed in order of their decreasing value. Since the time of their publication, these principles have been mentioned or utilized in almost every study dealing with the identification or evaluations of principles.[19]

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[19] M. G. McFadden, "Proposed Integration of Biology Workbook and Study Materials with Specially Designed Reading Procedures for the Course", Science Education, 33:156, March, 1949.

Also in 1945, Keeslar[20] reported on the preparation of an original list of elements of the scientific method and the results of submission of this list in questionnaire form to a jury of 22 research scientists at the University of Michigan. The reactions of this jury of experts to each element in the list were tabulated and a relative numerical value based on a 200 point scale was obtained for each element. Using the score received by each item on the established scale, all items falling below a score of 170 were eliminated from the list. The 42 remaining items were checked for ambiguity of expression and for errors by three specialists in the teaching of science. The list, in final form, consisted of 10 major and 17 minor elements of the scientific method, set forth in the sequence in which they might be expected to occur in the solution of a scientific problem involving all 10 major steps. The purpose of submitting the list to the 22 experts was to obtain a validation of the entries. Considerable evidence was presented to indicate that this was true; that is, that the opinions of the jury were valid.

Bergman[21,22] published the results of a study in 1947 in which he

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[20]Oreon Keeslar, "Contributions of Instructional Films to the Teaching of High School Science", Unpublished doctoral dissertation, University of Michigan, 1945. Reported in Keeslar, Oreon, "Objectives of Instruction in Science", Science Education, 29:212-216, October, 1945.

[21]George J. Bergman, "Determination of the Principles of Entomology of Significance for General Education. I", Science Education, 31:23-32, February, 1947.

[22]George J. Bergman, "Determination of the Principles of Entomology of Significance for General Education. II", Science Education, 31:144-157, March, 1947.

attempted to determine the principles of entomology that have significance for general education. Essentially, the procedure was based on analyses of books, pamphlets, bulletins, and research articles as sources of the principles. The jury method of evaluation was employed in several instances. The heads of departments of entomology in nine colleges and universities served as jurors in deciding which textbooks and reference books used in teaching the fundamentals of entomology were to be employed as sources of tentative principles. Eleven outstanding entomologists holding positions either as heads of entomology departments, as professors of entomology, or as entomologists with the United States Department of Agriculture served as critical jurors with respect to the 46 principles of entomology gathered from the forementioned sources. A third jury composed of twelve chairmen of high school biology departments was employed in evaluating the desirability of selected high school textbooks as sources of biological principles against which the principles of entomology could be checked. In all, three separate juries were employed for the purpose of evaluating principles, or sources of principles. In all instances those selected for jury duty presented certain qualifications by virtue of training, experience, or both, which served to justify the critical role into which they were fitted.

In 1949, Miles[23] reported another study on the determination of principles. The purpose of the initial portion of this investigation

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[23]Vaden W. Miles, "A Determination of Principles and Experiments for an Integrated Course of Physical Science for High School. I", Science Education, 33:147-152, March, 1949.

was to determine the relative importance of the principles of physical science which are desirable for inclusion in an integrated course of physical science for senior high school.

Miles[24] used Wise's[25] list of 272 principles of physical science and prepared a rating type of questionnaire which he submitted to five specialists in the teaching of science, each of whom was well qualified in terms of experience and subject matter training. The specialists were given specific instructions for evaluating each principle in regard to its desirability for inclusion in an integrated course in physical science for senior high school. The rating key employed read as follows:

> Please write E, D or U at the left of each principle to indicate, respectively, whether you consider it to be
> (1) essential (E) for inclusion in an integrated course of physical science for senior high school,
> (2) merely desirable (D) if time permits its inclusion, or
> (3) undesirable (U) in such a course because it is too abstract or difficult.

On the basis of independent marking, each principle was assigned a numerical value which was the sum of the five individual evaluations of that principle. A scale was used in which each "essential" designation was arbitrarily assigned a value of +3; each "desirable" rating was given a value of +2; and each "undesirable" rating was valued at -2. All values received by each principle were added algebraically to give the sum. The principles were then arranged in descending order of values.

In 1951, Washton[26] reported on a project concerned with "the production of a syllabus in biology for general education, based upon

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[24]Miles, loc. cit.

[25]Wise, loc. cit.

[26]Nathan S. Washton, "A Syllabus in Biology for General Education. I", Science Education, 35:84-91, March, 1951.

previous investigations and current judgments secured from various leaders in the area of general education and in the biological sciences".[27] In the process of carrying out this project, three problems were investigated. These problems were:

What are the criteria or guiding principles for general education?

What are the significant principles of biology?

What principles of biology have important applications to specific purposes of general education?

In seeking solutions to the first problem a tentative list of criteria for general education was prepared from several reports and studies. The tentative list was then submitted, in questionnaire form, to 25 leaders in the area of general education for the purpose of obtaining their responses and comments. Replies were received from 18 of these specialists. They were unanimous in their acceptance of 13 criteria but suggested that 3 more be added. This was done, making a total of 16 criteria determined on the basis of jury opinion.

In determining the principles of biology, Washton[28] started with Martin's[29] 100 major principles and, on the advice of a committee of four subject matter specialists, reduced the number of these principles to 42 through a process of deletion and combination. The 42 remaining principles were then subjected to the scrutiny of a group of three experienced teachers and two laymen, who evaluated the principles in

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[27] Ibid., p. 84.

[28] Washton, loc. cit.

[29] Martin, loc. cit.

terms of their suitability as objectives of instruction in general education. This operation provided the basis for the solution of the third problem.

The final procedure, preceding actual construction of the syllabus, was to seek the judgment of 30 experienced teachers as to which of the principles of biology they considered most important, important or unimportant to the criteria of general education. On the basis of the twenty-five replies received, those principles designated as "most important" and "important" were included in the syllabus together with the criterion of general education to which they relate.

The following passage quoted from Washton's[30] work is also pertinent to the present problem.

> Students learn principles more efficiently than a vast array of isolated facts....Facts become more significant when they are employed in the processes of deductive and inductive reasoning to enable individuals to understand principles and generalizations.[31]

This appears to embody the basic idea behind the present investigation. The principles selected for Biological Science were accompanied by a great number of facts, some directly related to the principles, some indirectly related, and others unrelated to them. The present study is an attempt to bring together principles and related facts within the framework of an established course.

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[30]Washton, loc. cit.

[31]Nathan S. Washton, "A Syllabus in Biology for General Education. II", Science Education, 36:227, October, 1952.

A study reported by Smith,[32] in 1951, was concerned with the determination of principles for inclusion in general science at the junior high school level. Because of the similarity of procedures which he employed to those used in the present study brief mention will be accorded the work here. The jury used in this study consisted of four individuals experienced in the field of general science. They evaluated 304 principles on the basis of the following three point scale:

+3 = highly desirable
+2 = desirable
-2 = undesirable

All scores accorded a given principle were added, giving due cognizance to the sign. Thus, one value was obtained which indicated the importance of the principle as judged by the four evaluators. The principles were then listed in descending order of relative importance.

One of the most recent studies, reported by Irish,[33] in 1953, was undertaken for the purpose of selecting and organizing, from periodical sources, materials on soil conservation suitable for inclusion in high school science courses for general education.

The initial step was the preparation of a tentative outline of the various "phases" or "aspects" of soil conservation, which was to serve as a criterion in locating and identifying conservation materials in

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[32]Herbert F. A. Smith, "A Determination of Principles Desirable for a Course of General Science at the Junior High School Level", Science Education, 35:279-284, December, 1951.

[33]E. Eugene Irish, "A Determination of Materials Dealing with Soil Conservation and Suitable for Integration into Courses of High School Science for General Education", Science Education, 37:84-99, March, 1953.

newspapers and magazines. The tentative outline of "phases" was then submitted for evaluation to a group of three authorities, all of whom were professors in the School of Forestry and Conservation of the University of Michigan. The validated list of "aspects of conservation" was then used as the basis for choosing from selected publications "knowledges of conservation" which were further combined into "major phases" of soil conservation.

The "major phases" of conservation were then rated by a jury of five specialists in the teaching of science. Complete directions for making the ratings were given in the rating device in which the following key was used:

Please give each aspect one of the following values.

a. Is essential for inclusion in one of more high school courses of science. (value +2)
b. Has some positive value for inclusion in such courses. (value +1)
c. Is neither well suited nor poorly suited for inclusion in courses of high school science. (value 0)
d. Is poorly suited rather than well suited for inclusion in such courses. (value -1)
e. Is totally unsuited for inclusion in any high school science course. (value -2)

The values assigned to each of the 49 "major phases" of soil conservation by the jurors were added giving the algebraic sum. The algebraic sum of all five ratings given each "major phase" was considered as indicative of the general desirability of the "major phase" for inclusion in a high school science course.

Because of an additional step at this point in the survey, the work of Irish[34] relates more closely to the present investigation than do

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[34] Loc. cit.

some of the other studies mentioned here. After the determination of the relative desirability of the "major phases" of conservation, an attempt was made to relate the desirable "major phases" of conservation to corresponding principles of the physical and biological sciences. This was done by arbitrarily assigning each "major phase" to the one principle to which it made the most apparent contribution. This operation resulted in a list of the principles of the physical and biological sciences in which each principle was followed by the related "major phases" of conservation. The assignment of "major phases" to corresponding principles was checked for accuracy by two of the specialists from the original jury.

Summary of studies employing the "expert jury technique" of evaluation. In summary, the following statements seem to be warranted regarding the use of the method of the "expert jury".

1. The utilization of the "jury of experts" has apparently become a well established procedure in educational research.

2. In problems concerned with the selection of course content the "jury method" has been applied most frequently in the process of obtaining relative evaluations of principles, concepts and generalizations suitable for inclusion in general education science courses.

3. All studies on the determination of content reviewed here were based on doctoral investigations. None of the studies were made with reference to any specific existing course. Therefore, the studies tend to be generalized in approach.

4. The evaluations obtained by the "jury method" are valid provided the jurors possess suitable qualifications by virtue of training and experience, and provided that the criteria upon which the ratings are to be made are clearly understood.

5. The "jury method", since it is relatively new, undoubtedly needs refinement. However, even in its present form it provides a procedure for securing a concensus upon which decisions may be based.

6. There is general recognition, on the part of the investigators, that the principles presented in a course should be selected in accord with criteria provided by the objectives of the course.

CHAPTER III

CHAPTER III

METHODS OF PROCEDURE

The procedures to be discussed in this chapter are: (1) construction of the rating instrument, (2) administration of the instrument, (3) methods of analysis and (4) determination of reliability of the instrument. Each of these phases will be presented consecutively.

Construction of the rating instrument. Basically the problem of this study was to obtain from the staff of the Department of Biological Science a collective evaluation of the factual material contained in the Biological Science Lecture Syllabus.[1] The specific criteria upon which the evaluations were based were derived from the relationship between the Biological Science Lecture Syllabus[2] and Study Guide for Biological Science.[3] Each student in the course is required to obtain both volumes. In the study guide, the objectives and major biological principles of each course area, as well as a related page assignment in the syllabus,[4]

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[1]Chester A. Lawson, Biological Science Lecture Syllabus with Readings. East Lansing, Michigan: Michigan State College Press, 1951.

[2]Loc. cit.

[3]Study Guide Committee, Study Guide for Biological Science. East Lansing, Michigan: Michigan State College Press. 1951.

[4]Henceforth in this study the Biological Science Lecture Syllabus and the Study Guide for Biological Science will be referred to respectively as the syllabus and the study guide.

are presented. Criteria for evaluating the factual material of the syllabus were founded upon the assumption that if a student studied a syllabus assignment he could obtain a factual basis for understanding of principles included in the area.

Thus, the desire was to create a rating instrument which would present the entire factual content of the lecture syllabus against a background of related principles in such a way that each participant could be asked in substance, "To what extent, if any, does this particular fact contribute toward an understanding of the related principle?".

In an effort to achieve this objective a rating device was constructed which followed the organizational pattern of the study guide. A separate section of the rating instrument was prepared for each area of the course[5] indicated in the study guide. Because Area II of the study guide does not include a syllabus assignment, no rating device was prepared for this area. Presented in Table I is a summary of the titles of areas covered by each section of the rating instrument together with the length of the instrument in terms of both pages and items. Also shown in Table I is the page assignment from the lecture syllabus for each area.

With the exception of the first unit, each section of the rating scale was prefaced with identical instructions. The instructions for the first unit will be described separately later in this section. It was also considered necessary to include in each unit of the rating

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[5]See appendix.

scale the specific objectives of the area. If the objectives had been omitted, it seemed likely that some of the raters might have referred to the objectives as they were making judgments while others might not have done so. Thus, it appeared wise to insure that all individuals participating in the ratings read the area objectives along with other instructions immediately prior to making the actual ratings.

The principal consideration influencing the choice of a scoring key was the specific nature of the ratings desired. The rating key shown below was employed in all of the units of the questionnaire used in this investigation except in the questionnaire for Area I. In this area special conditions made it necessary to use a modified form of the scoring key shown below.

Mark space 1 if you believe that knowledge of the fact is essential to an understanding of the principle.
Mark space 2 if you believe that knowledge of the fact is quite important to an understanding of the principle.
Mark space 3 if you believe that knowledge of the fact is of average importance to an understanding of the principle.
Mark space 4 if you believe that knowledge of the fact is relatively unimportant to an understanding of the principle.
Mark space 5 if you believe that knowledge of the fact is unrelated to an understanding of the principle.

The answer sheet used in this study was the International Business Machines, Form 1008. This form was selected because, even though each sheet is numbered to accommodate only one-hundred and fifty items, re-numbering of additional sheets for instruments of greater length was possible.

TABLE I

AREAS COVERED BY INSTRUMENTS, LENGTH OF INSTRUMENTS IN PAGES AND ITEMS TOGETHER WITH PORTION OF SYLLABUS UPON WHICH EACH INSTRUMENT WAS BASED

Number of Area	Title of Area	Length in Pages (Exclusive of Instructions)	Length Item
I	The Scientific Approach to Problems	3.5	60
II	The Kinds of Living Things		
III	Characteristics Common to All Living Things	5	91
IV	Transformation of Solar Energy: Photosynthesis	7	129
V, Unit 1	Utilization of Matter and Energy: Foods and Digestion	5.5	114
V, Unit 2	Utilization of Matter and Energy: Organ Systems	11	209
V, Unit 3	Utilization of Matter and Energy: Cells and the Internal Environment	8.5	159
VI, Unit 1	Coordination and Adjustment: Nervous Coordination	7.5	159
VI, Unit 2	Coordination and Adjustment: Chemical Coordination	4	97
VII, Unit 1	Maintenance of the Species: Reproduction and Development	16	217
VII, Unit 2	Maintenance of the Species: Heredity	12.5	225
VIII, Unit 1	Interrelationships: The Organism and Its Environment	21.5	376
VIII, Unit 2	Interrelationships: Populations and Conservation	5	76
IX	Evolution	23	427
Total Pages Exclusive of Instructions		130	
Total Number of Items			2339

TABLE I

COVERED BY INSTRUMENTS, LENGTH OF INSTRUMENTS IN PAGES AND ITEMS TOGETHER WITH PORTION OF SYLLABUS UPON WHICH EACH INSTRUMENT WAS BASED

ıtle of Area	Length in Pages (Exclusive of Instructions)	Length in Items	Syllabus Assignment Upon Which Questionnaire was Based
roach to Problems	3.5	60	1-5
ıg Things			No Syllabus Assignment
mmon to All Living Things	5	91	5-14
Solar Energy:	7	129	15-17
ter and Energy: on	5.5	114	17-21, 31-33
ter and Energy:	11	209	33-42, 55-63
ter and Energy: ernal Environment	8.5	159	42-55
djustment: ion	7.5	159	63-73
djustment: tion	4	97	73-77
Species: Development	16	217	78-104
Species:	12.5	225	104-138
: Its Environment	21.5	376	139-175
: onservation	5	76	176-216
	23	427	217-293
uctions	130		

Analysis of the categories in the rating key shows that the first category is entirely different from the other four. When a given factual item was assigned to this position the raters were thus deeming it an "essential fact," knowledge of which "is essential to an understanding of the related principle." Category five can be considered the antithesis of the first position. Fifth place was selected as the repository of factual items which, in the judgment of the raters, were so remote from the principle with which they appeared as to make them unrelated. Occuring between the two extreme positions, categories two, three, and four can be thought of as representing relative degrees of contribution toward an understanding of a given principle. It is of singular importance to note that when an assignment was made to any of the first four categories the raters were admitting that the item being evaluated was related to the principle with which it appeared and, by selecting from the first four possibilities, the degree of that relationship was being estimated.

The entire content of the syllabus assignment for a given area appears in the questionnaire for that area. None of the factual content of the syllabus was omitted during the process of preparation of the questionnaires. Selection of content was considered to be the prerogative of the jurors. Therefore, omission of any of the syllabus content from the rating instrument would have constituted encroachment on the province of the raters. The judgment of all syllabus content was thus left to the participants.

Because no principles were listed for Area I in the study guide, specific objectives for Area I were utilized in the construction of the rating scale for this area. Because of this variation, different instructions were necessary. The following directions and scoring key were used for Area I only.

> It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact from Area I of the syllabus is to be evaluated in terms of the contribution which you believe it makes toward attainment of the specific objectives of Area I. The specific objectives for Area I were taken from the Study Guide for Biological Science. The statements to be evaluated were taken from the syllabus. Will you rate each fact or statement according to the following key?
>
> Mark space 1 if you believe that knowledge of the fact is essential to attainment of the objectives.
> Mark space 2 if you believe that knowledge of the fact is quite important to attainment of the objectives.
> Mark space 3 if you believe that knowledge of the fact is of average importance to attainment of the objectives.
> Mark space 4 if you believe that knowledge of the fact is relatively unimportant to attainment of the objectives.
> Mark space 5 if you believe that knowledge of the fact is unrelated to the attainment of the objectives.

THE SPECIFIC OBJECTIVES OF AREA I

1. To understand the objectives of general education.
2. To understand the place of biological science in a general education program.
3. To realize the significance of scientific methods in effective living.

Administration of the instrument. The twenty-two individuals comprising the Department of Biological Science served as the "jury of experts" used in this study. Participation was limited to members of

the department for a number of reasons. Each individual in the department was thoroughly familiar with course structure, organization, and testing policies. Each of the jurors had taught at least three years in the department. Average tenure as full time workers in general education programs was approximately six years. Among the raters, 70.4 per cent held doctorates in biological science or related areas.[6] The remainder were nearing completion of the requirements for the degree.

The personnel of the Department of Biological Science, at the time these ratings were made, was practically the same group responsible for the initial preparation of the Biological Science material evaluated in this study. Therefore, a "jury of experts" composed of these individuals should be expected to render judgments exceeding in validity those of any other group.

There are at least two additional considerations which support the policy of having limited participation in the study to members of the department involved. In the first place, the objective was to secure the evaluation in terms of criteria provided in the rating instrument. It was felt that outsiders would have had a strong tendency to evaluate the principles themselves, instead of limiting their evaluation to the internal relationships of the course. Basic to the decision to use department members as evaluators, was the assumption that principles contained in the course represented the concensus of the group. To the extent that this assumption is valid the jury used in this study should

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[6] "Annual Report of the Basic College, 1951-52," Michigan State College, East Lansing, Michigan.

have been little influenced in their ratings because of subtle disagreement with course principles.

Finally, an important consideration in favor of having requested only department members to participate in this study grew out of the length of the project which participants were asked to carry out. As indicated previously, thirteen separate units or sections of the questionnaire were prepared. These units ranged in length from three to twenty-four typewritten pages, the last requiring a total of 427 separate evaluations. While no check was made to determine the actual time required of any individual to complete the entire set of questionnaires, on the basis of random interviews it is safe to assume that many hours of work went into the operation. In anticipation of the time that would be required, it was recognized from the beginning that the successful completion of this study would depend to a considerable degree upon establishing and maintaining an unusually effective rapport with those individuals who were asked to contribute to the project. As a result of this conviction, the members of the teaching staff of the Department of Biological Science were selected as the group most likely to give wholehearted support to the endeavor.

Throughout the study all units of the rating scale were distributed personally to each rater. When the first unit was delivered, each individual was carefully informed as to what he was being asked to do and his cooperation was requested. During the initial contact, however, the investigator did not interpret the written instructions contained in the questionnaire. It was felt that the instructions were sufficiently clear.

The participants were not informed as to the total length of the evaluative instrument they were being asked to execute. The feeling was that advanced knowledge of the magnitude of the task would temper the enthusiasm of even the most cooperative. Acting on this belief, the policy throughout was to collect completed units of the questionnaire from each individual and at the same time supply additional units to be marked. This resulted in a very close check on the progress of individual raters. At the same time each was allowed to proceed at his own speed unburdened by any knowledge of how much work remained to be done.

The first units of the rating instrument were distributed in October, 1951, and the last units were completed in June, 1952. This represents a much longer time for the completion of the questionnaires than was anticipated. In retrospect, however, the time required appears to be minimal consistent with the preservation of rapport.

Methods of analysis. It should be clearly understood that what was desired for purposes of this study was a collective evaluation of the materials under scrutiny. It was of no interest, in itself, how an individual evaluator rated a given factual item but it was of utmost concern how the group as a whole reacted to the item in question. Not only was the group reaction of primary concern but it was desired to obtain a means of ranking the items in terms of collective ratings. This is but another way of stating that a relative evaluation of factual content was to be achieved if possible.

As a means of facilitating such a comparison it was considered necessary to employ an index number into which the twenty-two separate ratings which each item received could be translated. By means of this number the group evaluation of one item could be compared with that of another item.

After experimenting with several possible methods of obtaining an index number, the arithmetic mean was selected as best meeting the requirements. Recognition was given to the weaknesses of the arithmetic mean as a measure of central tendency but in this case it was felt that the use of the arithmetic mean could be defended. The number of cases was low, only twenty-two, and was constant. The highest possible score that any item could receive was 5 and the lowest was 1. The nature of the rating key and of the material being evaluated made it unlikely that any one item would receive individual ratings differing from one another in the extreme. Finally, the mean score would convey approximately the same meaning for all items, thus offering a fairly reliable method of comparing the group evaluation of one item with that of another.

Therefore, the arithmetic mean of the twenty-two separate evaluations for each item in the entire set of rating scales was calculated to two decimal places. The number obtained by this operation was assigned to the item as an index number. Throughout the remainder of this study the terms "index number" and "mean score of the item" will be used interchangeably.

Upon obtaining the mean score of the items it became immediately apparent that a direct comparison of individual means, each with all of the others, would be both impractical and meaningless. What was desired was a grouping of facts of similar index value. The need for such groupings will become apparent when it is recalled that the primary purpose of this study was to produce results useful to the Department of Biological Science. In an attempt to achieve the basic goal of presenting the results of the ratings in such a way as to facilitate reference to this work, a frequency distribution of items was prepared.

The intervals employed in the frequency distribution were arbitrarily selected in the interest of furthering the utilitarian nature of the results obtained by this investigation. An individual using the index numbers as a basis for determining the relative importance of factual items would find, in all probability, that as the index numbers approached unity the desire for finer judgments would arise. Not only does the nature of the key used in rating the items tend to make this true, but the ratings assigned by the jurors likewise contributed toward creating the need for finer intervals as smaller index values appear. The scoring key, it will be recalled, was set up so that "essential to understanding" was indicated by marking space one on the answer sheet. Subsequent spaces two, three and four were used to indicate decreasing contribution toward understanding. Space five, when assigned, indicated that the fact was considered by the juror as unrelated to the principle with which it appeared. The smallest mean score or index number which an item could have received was one, the largest five. Therefore,

according to the ratings, the closer the index value approached one, the more significant the item was in contributing toward an understanding of its related principle. If the frequency of index values had been made with intervals of one, the distribution would have had only four intervals. This would have resulted in an item with a mean score of 1.00 falling into the same interval with an item of mean score 1.99. This does not discriminate between index values to a sufficient degree for the ratings to be of practical value.

Determination of reliability. The reliability of the evaluative instrument used in this study was determined by the retake method. A unit of the rating scale involving two principles was redistributed approximately three months after the identical unit had been initially marked by the raters. The objective was to determine the correlation of the mean ratings which a given factual item received on the two administrations of the scale. The assumption was that a high correlation would indicate high reliability.

Area 7, Unit 2, Principles 1 and 2[7] were the sections of the scale selected for repetition. For principle 1, the scale contained 37 items and for principle 2, 188 items were listed. The two correlations were calculated separately using the product-moment method. The coefficient of correlation for principle 1 was .86. The coefficient of correlation for principle 2 was .75. Employing the t-test, both of these coefficients

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[7] See Appendix II.

proved to be significant at the 1 percent level of confidence. It is well to note that in terms of probability, the coefficient of correlation for principle 1 is likely to be spuriously high because of the fact that the number of cases is small, only 37 items.

CHAPTER IV

CHAPTER IV

RESULTS OF EVALUATIONS

Method of presenting results. The results obtained by calculating mean scores of individual items and then grouping items receiving mean scores falling within certain arbitrarily selected intervals are presented in Appendix I. This mode of presentation was adopted for the purpose of facilitating reference to this investigation.

In Appendix I results of the entire study appear, area by area, in exactly the same sequence as the corresponding material appears in the Study Guide for Biological Science. In compiling the results it was considered wise, for reference purposes, to preface each unit with the specific objectives and principles of the unit and to include the syllabus assignment from which the items were extracted. In short, the organizational pattern of the study guide was followed in presenting the results of this investigation, as well as in constructing the questionnaires. In both cases, it was felt that the personnel of the department, acting initially as jurors and subsequently as consumers of these results, would find a familiar pattern of organization less likely to distract from the fundamental purposes at hand.

The frequency of items with a mean score of 3.51 or higher was found to be very small. As indicated by the score, such items were not considered by the jury as particularly contributory to the principles with

which they appeared. For this reason, items with a mean score of 3.51 and higher are indicated in their respective intervals by number only. The number corresponds to the original number of the item in the questionnaire. Content of items indicated in this report by number only may be obtained by consulting the corresponding questionnaire in Appendix II.

All items with mean scores of 3.50 or less appear within the interval inclusive of the mean score of the item. Each item is preceded by the number assigned to it in the questionnaire, an arrangement which might prove useful should reason arise to locate a given item within the parent questionnaire.

The interval delimited by the values 2.51 to 3.50 was the recipient of items indicated by the jury to be of average importance in contributing toward understanding of related principles. All items falling into this interval are presented in Appendix I, since it was felt that in most practical applications of the results of this study it would be necessary to draw heavily upon the material of average importance.

No effort was made to arrange items within intervals in the order of their index values. If the results of this study are to have any practical value, significance must be attached to the fact that a given item fell within a certain interval with regard to its index value. No attempt should be made to evaluate relative standing within intervals. In other words, for the sake of practicality items within a given interval should be regarded as having the same value.

Interpretation of results. The primary undertaking in this study was to secure a collective, relative evaluation of the factual content of the lecture syllabus in terms of the principles presented in the study guide. The evaluation was to be collective in the sense that it was to be derived from the composite reaction of a "jury of experts" and relative in that it was to provide a basis for ranking the items of syllabus content in order of their respective contribution to understanding of related principles. The results of this effort are presented in Appendix I. The items of content from the syllabus have been displayed in terms of levels of contribution derived from categories of the rating key through combined use of index numbers and a frequency distribution. Since the details of this operation were given in Chapter III they need not be recounted here.

It now remains to generalize from these data concerning specific problem areas associated with Biological Science at Michigan State College and with other kinds of "principles" courses. To the extent that this can be accomplished the process of securing the evaluation of syllabus content will have been justified and the results of this study will assume a significance beyond that of mere tabulated data.

Characterization of the content of the intervals of the distribution. In the introductory section of this paper an attempt was made to show that facts are necessary for an understanding of principles. It was argued that since facts provide the raw materials from which understandings of principles are derived, they deserve as much care in selection as do the principles themselves. Even if this view is

granted, however, there still remains to be established a method whereby selection of factual content can be satisfactorily accomplished in terms of criteria derived from the principles presented in the course. The particular method by which it could be expected to select factual content most likely to contribute toward understanding of principles would obviously vary in accord with the specific situation. It should not be expected that exactly the same procedure of evaluating factual content could be employed in planning all types of courses nor that the same detailed approach could be used in selecting materials for a new course as in revising an existing one. Indeed, the basic problem may vary somewhat in character depending upon the task at hand. If the problem involves an established course, the investigation may logically be limited to an evaluation of existing course materials, for the purpose of bringing factual content into closer support of principles. On the other hand, if a new course is being organized it may be a matter of first concern to survey broad areas in search of factual support for proposed principles. In the first case the fundamental problem is embodied in the question, "What is the relative contribution of facts <u>already in the course</u> toward an understanding of the principles?" In a project of the latter type concerned with organizing a new course or radical revision of an old one, the problem of immediate significance is likely to be found within the meaning of such a question as, "Which of the available facts make the greatest contribution toward understanding of the principles?" The first type of problem requires an answer in terms of specific facts from sources limited by the scope of the

course. An attempt to solve the first type of problem must take the form of an effort to determine relative levels of contribution made by different facts toward an understanding of related principles. Progress toward solution of the second type of problem could best be served by a set of criteria describing the kinds of facts making various degrees of contribution toward understanding of a related principle. Such criteria could then be employed in the selection of desired facts relative to a given principle from broad areas containing many facts assortively related to the principle. The result should be an increase in the degree of relationship between fact and principle.

It is the contention here that the data obtained by this investigation are related to both types of problem situations outlined above. Since this study involved an established course, it was organized and conducted within the limits imposed by that fact. Therefore, the matter of chief concern was to obtain an evaluation of the content of the Biological Science Lecture Syllabus for the ultimate purpose of ranking the factual material into selected levels of contribution toward understanding of the principles of the course. In other words, the attempt was to answer the question, "What is the relative contribution of the facts already in the course toward an understanding of the principles?" The data in Appendix I constitute an answer to this question. Reference to these data will reveal the level of contribution of any fact in the lecture syllabus. The principle ways in which this information may be utilized as an aid to the solution of problems growing out of the teaching of the biological science course will be discussed later in this chapter.

Even though the data presented in this chapter were derived from the study of a specific course, it is possible to generalize from them toward the development of a set of criteria that might be employed in recognizing the approximate level of contribution toward understanding that could be expected from a fact, examined out of context. It may be assumed in the organization of a new course, or in the drastic revision of an old one involving the addition of new material, that it would be desirable to obtain the maximum contribution from factual content in the support of understandings. In most courses the scope is definitely limited in regard to the amount of factual material that can be, or should be, included. Therefore, the problem of selection of factual content cannot be avoided. Selection must be made; the dependability of the results depends on two factors: first, the choice of a basis for selection and, second, the consistency with which facts are selected which meet the criteria for inclusion. The point of view here is that degree of contribution toward understanding of principles affords the best basis for selection of factual content for the "principles" type of course. Assuming that this basis for selection has been adopted, it would be difficult to stay within the restrictions implied by its acceptance unless there were available criteria to aid in the task. It is in this capacity as a guide to the recognition of the desired facts that it is possible to visualize the usefulness of a description of the factual content of the respective intervals of the distribution appearing in Appendix I of this study. If the kinds of items making the greatest contribution toward understanding of principles

can be described in general terms, a means of recognizing such items in unstructured material will have been indicated and the relationship of these specific data to the problem of selection of factual content for a "principles" type of course in any area will have been partially defined.

The success of an effort to generalize upon these data in an attempt to formulate characteristics by means of which desired facts may be recognized awaits a positive answer to the following question: Is there a detectable difference in the content of the kinds of items falling into the various intervals of the distribution corresponding to the levels of contribution toward understanding? Study of the distribution makes it possible to characterize the content of the different intervals of the distribution if it is permissible to do so in terms of generalizations. To be of value in other areas such characterizations would have to be in the form of generalizations; therefore the attempt will be made to describe the content of the intervals in that manner.

Inspection of the first interval of the distribution, corresponding to the first level of contribution toward understanding of the related principle, reveals that the items tend toward the definition type of statement. For example, where the principle is "Diffusion is the basic mechanism of transport operating in the physical activities of organisms assisted by the movements of fluids" a characteristic statement in the first interval is "Diffusion is a process whereby one substance becomes spread throughout another substance. In many instances

the statements seem to involve restatements, in full or in part, of the principle to which they relate. In the case of the principle "Only green plants, those containing chlorophyll, can utilize solar energy for the manufacture of food" it is found that such statements as "Green plants have the ability to take the light energy of the sun and convert it into chemical energy" occupy the first interval of the distribution. In this instance the item is an obvious restatement of the principle. Items at this level of contribution are characterized by an almost complete absence of personal judgment. Items in this interval tend to be statements of facts that have been accepted for so long that their validity is seldom questioned. Perhaps a better way of phrasing it is that they are, for the most part, statements that have withstood repeated testing to the extent that their truth is highly probable. In short, the items receiving the highest ratings in terms of the criteria used are those tested facts from the accepted content of traditional biology from which the principles of the science have been synthesized. Those who may be disturbed by this finding because they feel that the use of definitions has little place in teaching for "understandings" should be reminded that the term "understandings" must be qualified. For "understandings of what" is it desired to teach? If the answer is "for understandings of principles", it is not surprising that basic definitions (the structural units of understanding) should be rated highly in contributing toward that end. Thus, these data indicate that knowledge of fundamental definitions related to the principle makes the greatest contribution toward understanding of the principle.

Characteristic items in the second interval of the distribution are much like those in the first interval except that they frequently contain suggestions of personal interpretation or other evidence of a lesser degree of unquestioned acceptance in the field of the biological sciences. In many cases, the items of the second interval are elaborations upon or express an implication of items appearing at the first level of contribution toward understanding. If many of the items from the second interval of the distribution were reworded or condensed so that their fundamental meaning were more clearly revealed it could be more readily seen why the jurors rated them highly in terms of contribution. For example, the statement "The major endocrine glands of man are the pancreas, thyroid, parathyroid, adrenal, pituitary, and gonads" appearing in the second interval means, in essence, that the raters thought that it was of this level of importance to an understanding of the principle of endocrine coordination and adjustment for the individual to be acquainted with the names of the endocrine glands. In this respect, of course, rewording of the items in the entire distribution would serve to clarify meanings for the unfamiliar reader. In order to make clear why this was not done, it must be repeated that it was considered preferable in view of possible practical applications of the results of this study to leave the results in the language of the syllabus because of its familiarity to those most likely to use these results.

The third category of the distribution includes items with mean scores ranging between 2.01 and 2.50. If the items in this interval can be characterized at all, it seems to be possible only in terms of items

in the first two intervals. Items making third order contribution, as evidenced by index numbers, are largely descriptive or they provide further subdivision of the parent fact appearing in the first or second interval. As an example, where the first interval item is "energy appears in several forms and can be changed from one form to another", the third category statement is "the energy of motion is called kinetic energy".

The items indicated by the evaluators to be of "average importance to understanding" occupy the interval delimited by the index values 2.51 - 3.50. This is the fourth category of the distribution. At this level of contribution, because of the heterogeneous nature of the items, it is not possible to characterize the content of the interval accurately enough for the information to serve as a guide to the selection of content in other areas.

What has been said of the fourth interval can also be said of the fifth interval. It is not practical to undertake a description of the content because it is too heterogeneous.

The implications of these data are for "what should be taught" and not for "how to teach"; that is, the inferences presented here are for the selection of factual content for a "principles" type of course in any area and do not concern the method of teaching. These implications may be summarized as follows: The first three categories of the distribution of these data indicate that the "jury of experts" believed that the factual content of a "principles" type of course should be built upon a foundation of definitions of related terms and upon the

tested facts from which the principles have been derived. There is further indication that the second and third order contributions to understanding of related principles are made by items which tend to be elaborations upon the definitions and tested facts of the first level. The evidence suggests the logical process of selection of factual content described in Chapter II. This process begins with the selection of course objectives on the basis of criteria provided by the objectives of general education and of the institution, followed by the selection of principles in terms of criteria derived from course objectives. The selection process should then continue through the selection of factual content in terms of principles, to the selection of first, second and third order facts, each in turn being selected on the basis of criteria provided by those selected in the preceding category. This relationship may be clarified if it is pointed out that facts making a second order contribution to understanding of principles should be so selected as to make that contribution through the medium of their contributory relationship to some first order content. The items in the fourth and fifth intervals, as mentioned previously, are too heterogeneous to characterize as units. This heterogeneity indicates that unless a conscious effort is made to maintain an orderly relationship in course structure as described above, almost anything can find its way into the peripheral areas of the course. This is the lesson to be learned from an examination of the content of the fourth and fifth intervals of the distribution of items. The material in these intervals serves as a reminder that the plan of content selection which is adopted must be

pursued consistently throughout the entire process of course organization or it may be belatedly discovered that the outer orbits of the course contain material that is unrelated in the sense that it makes no contribution to the central intent of the course.

Relationship of the evaluation of factual content of the lecture syllabus to the objectives of Biological Science. It was found by Burmester,[1] in 1948, that 76.9 percent of the staff of the Department of Biological Science felt that "To acquire knowledge of some of the basic laws (principles) of biology" was one of the "most important" objectives of the course. It was also found that the other 23.1 percent of the staff rated the same objective as "quite important" and that none of the staff rated it as any less important, although provision was made in the questionnaire for giving three lower ratings.

Assuming that the objective "to acquire knowledge of some of the basic laws (principles) of biology" is one of the truly important objectives in the mind of the staff, it might be expected that an examination of the data in Table II would reveal the extent to which the staff believes that the syllabus content contributes toward the attainment of that objective. However, further contemplation on this point leads to the realization that this expectation depends on certain other assumptions.

It must be remembered that the evaluations obtained in this study were ratings made in terms of specifically stated principles. Thus,

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[1]Mary Alice Burmester, "A Synthesis and Evaluation of Objectives for Biological Science in the Basic College of Michigan State College." Unpublished master's thesis, Michigan State College, 1948. P. 38.

there is the possibility that while the staff does feel that the acquisition of knowledge about basic biological principles is an important objective, it may not feel that the specific principles appearing in the study guide are the only principles contained in the course, or that the list includes all of the principles that should be in the course. It is also possible that some of the principles appearing in the study guide are principles which the staff feels should not be in the course because the syllabus does not offer an adequate treatment of them. Therefore, basic to the expectation that an analysis of Table II will reveal the extent of support accorded objectives by the syllabus, is the assumption that the principles in the study guide represent the complete embodiment of the objective, "to acquire knowledge of some of the basic laws (principles) of biology"; that is, that the stated principles in the study guide represent an adequate selection of principles within the meaning of the objective. When attention is called to the fact that the study guide was prepared after the determination of the objectives and after the publication of the syllabus, there is no more reason for assuming that the principles in the study guide represent the meaning and intent of the objective in question than there is for assuming that the content of the syllabus represents adequate support of the principles.

If the assumption is made that the principles in the study guide represent an adequate selection of principles within the meaning of the objective to which they relate, then it may certainly be inferred from the data in Table II that the content of the syllabus falls short, in

certain areas, of providing adequate clarification and support to the objective.

Pointing out that this indictment of the syllabus for failing to support the objectives depends on certain assumptions, does not provide a basis for dismissing the charge. The assumptions may be true. And even if the assumptions were false, it would not relieve the obvious inconsistencies involved in the situation. The fact that analysis of these data reveals the existence of this additional area of questionable relatedness among certain elements of course structure provides a basis for criticizing one of the basic assumptions of this study. This basic assumption is that the principles in the study guide represent the principles emphasized by the staff in teaching and testing and by the students in study.

In the preceding discussion, the objective selected for the purpose of illustration was the objective most closely related to this study. It would be possible to show the implications of the degree of relatedness between the syllabus content and other course objectives less closely allied to this study. The point has been made, however, and it is not the intent of this investigation to undertake a study of objectives.

The position assumed here is that consideration of the relationship of these data to course objectives provides the most convincing evidence of the need for thorough reorganization of the content of the lecture syllabus and study guide. It is not possible to make the unqualified statement that much of the syllabus content does not support the

objectives of the course. But, it can be said that if the principles of the study guide constitute the only avenue whereby the content of the syllabus can contribute to the objectives of the course, much of the syllabus content does not support the objectives. This is indicated by the data in Table II where it can be seen that, with respect to certain principles, much of the material in the syllabus was assigned to the fourth and fifth levels of relatedness. These are levels representing little contribution toward understanding of related principles.

Relationship of these data to the "minimum essentials" concept. In part as an outgrowth of the "passing grade concept," many individuals have expressed the idea that students should be required to demonstrate mastery of certain "minimum essentials" before being allowed to receive a "passing grade" in the course.[2] As propounded, this idea usually embodies behavioral aspects as well as knowledge of certain facts. It is for the latter case that these data have implications. The feeling has been that students should be required to demonstrate mastery of a minimum number of essential facts as a prerequisite to receiving a passing mark. Implicit in this view is the belief that agreement could be reached on the content of a list of "minimum essential facts". Granted that if a list of "essentials" could be prepared it might be incorporated into grading procedures in an acceptable and beneficial

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[2]Herbert E. Hawkes, E. F. Lindquist, and C. R. Mann, The Construction and Use of Achievement Examinations, New York: Houghton Mifflin Company, 1936. p. 36.

manner, many difficulties still stand in the way of the preparation of such a list. The best insurance of success in preparing a list of "minimum essentials" is full acquaintance with the problems involved. Usually problems must be defined before they can be solved. Study of these data enables identification of some of the problems connected with the determination of "minimum essential facts" for Biological Science. To a limited extent, certain implications for the solution of these problems are also revealed. It should be clearly understood that this study does not represent a perverted attempt to identify "minimum essentials" for the biological science course although an effort was made in planning the investigation to design it in such a way that some clarification of the problem would ensue. It is now in order to examine the data for the purpose of discovering if this purpose has been realized.

One of the difficulties involved in identifying "minimum essentials" was revealed when it was discovered that none of the items falling into the first interval of the distribution actually received a mean score as small as 1.00. In other words, no single item in any of the units of the questionnaire was marked as "essential to understanding of related principle" by all of the raters composing the jury. This is not startlingly different from what should have been expected. It is almost certain that the jurors, as a group, would agree with the statement in Chapter I that more than one set of factual material is capable of contributing toward an adequate understanding of a given principle. Because the syllabus contains many facts, one might expect that units of the rating scale pertaining to various principles would contain an excess

of factual material ranging from unrelated through practically all levels of relatedness. No doubt, in some cases it would be possible to extract from the content of a single unit of the questionnaire two or more complete sets of factual materials, each set equally capable of contributing toward the understanding of the principle to which it relates. To the extent that this is true, a given rater, thinking within the context provided by one chain of factual support for a principle, might rate an item as "essential to understanding" while another rater, thinking within a different context, might rate the same item as something less than essential. Before an item could fall into the interval .5 - 1.50 at all it must have been assigned to the "essential" category by at least one-half of the twenty-two jurors and designated as "quite important to understanding" by the other one-half. This amounts to an extremely high standard of agreement required for an item to fall into the "essential to understanding" group. Therefore, the surprising element in this situation is that as many items as did, fell into the first interval of the distribution.

It may be concluded that the dearth of material in the first interval is due partly to the small size of the interval and partly to the high level of agreement necessary before an item would come to occupy this interval. It has also been pointed out that more than one adequate set of items was probably present in each unit of the questionnaire, a fact which would operate to lower the agreement among the jurors. A third reason for the paucity of items in the first interval may have been a reluctance on the part of the jurors to indicate any <u>one</u> item

as "essential". Some evidence of this attitude was subjectively detected during the course of the investigation. Such a predisposition might have been partly due to the difficulty of judging the importance of an item out of context.

At the beginning of this study it was thought that items falling into the first interval of the distribution, and thereby corresponding to the first orbit of material about the core of principles would, in effect, constitute a list of "minimum essentials" for the course. It is now apparent that, while the items falling into the first interval only would constitute the beginning of a list, they would not constitute an adequate list of such "essentials" except by the most limiting criteria. Because of the high degree of agreement necessary for an item to fall into the "essential" category employed in this study, there is considerable justification for lumping the materials of the first and second intervals into one group as far as the construction of a practical list of "minimum essentials" is concerned. Thus, it may be said that in the first two intervals combined, where the actual index values ranged from slightly more than 1.00 to 2.00, may be discovered the items that the staff feels are most important to an understanding of the principles presented in the course. As the foregoing statement implies, this does not mean that all of the essential items are within the first two intervals combined nor does it mean that all items in the combined intervals are essential. It does seem reasonable to believe, however, that there is a greater probability that any item within the combined intervals will approach more closely the status of

"essential", when subjected to other criteria, than any given item outside the combined intervals. This statement immediately raises the question as to whether the meaning of the term "essential" permits a relative interpretation. It may be argued that something is either "essential" or it is not. It is possible to concede on the point of definition with the reservation that it be remembered that one set of factual material may be just as adequately employed in teaching for understanding of a principle as another and that a given fact may be "essential" in terms of one set of facts and "not essential" in terms of a different set of facts.

Nothing definite can be concluded with regard to identification of "minimum essentials" on the basis of the results presented here. Rather, this study is more in the nature of a preliminary investigation of this particular issue. The ground has been prepared for further investigation if such is desired. In the meantime the relative evaluations obtained in this study offer an alternative that may be employed in almost any way that a list of "minimum essentials" could be used. Perhaps the relative evaluations presented here are to be preferred to a list of "minimum essential" facts because of the overtones of rigidity inherent in the "minimum essentials" concept.

Relationship of the evaluation of factual content of the lecture syllabus to course revision in Biological Science. Basic to the decision to undertake this investigation was the belief that an evaluation of the factual content of the lecture syllabus could play a fundamental role in the solution of several kinds of problems associated with

the course in biological science. The evaluation presented here should not be considered as an end in itself but as an operation prerequisite to the more detailed study of specific problems dealing with limited phases of course organization and structure. In substance, the evaluations provide a definition, by the staff, of the internal relationships of the factual elements of the course, as they now exist, exclusive of the laboratory program. Careful examination of these data should enable the identification of areas where the degree of mutual relationship between the factual content of the syllabus and the principles presented in the study guide could be improved. Not only do these data constitute a means of identifying the areas of weakness in this respect, but they could serve as the common basis for carrying out a revision of both the syllabus and study guide for the purpose of improving the relationship between the two. While it is not within the province of this investigation to provide a revision of the lecture syllabus and study guide, it is an obligation to attempt to show how these data could be useful in such a project.

Perhaps the most meaningful way in which discussion of the relevance of these data for course revision can be initiated is by reference to the analogy on course structure mentioned in the introductory portion of this work. It will be recalled that according to the terms of the analogy, factual content was visualized as occupying a series of concentric circles around the central core of principles forming the nucleus of course organization. The concentric circles were interpreted as levels of contribution toward understanding of the centrally located

principles. The factual content of the innermost circle was interpreted as making the greatest contribution and the content of each succeeding circle was interpreted as making a degree of contribution indicated by its distance from the center. Thus, in terms of this analogy, it is possible to establish categories of facts in terms of the levels of contribution which they are believed to make toward understanding of related principles. That is essentially what was accomplished by means of the ratings obtained in this study. This analogy provides a scheme into which the factual components of a course may be fitted with the results that existing lines of relationship are brought more sharply into focus. In the process of examining even one aspect of course structure, such as factual content, the complexity encountered when interrelationships are considered justifies the use of such a scheme if it promises to clarify the situation.

The concept of course organization embodied in the analogy outlined above has influenced the development of this study since its inception; therefore, the implications of these data for course revision will be discussed within the frame of reference which it provides. For purposes of orientation within the framework of the analogy, the principles of the course may be interpreted as occupying the nucleus of course structure. The evaluative instrument provided the means of establishing orbits or levels of factual content about the core of principles. The rating key enabled the jurors to assign items to any one of five categories. The first four were categories of relatedness ranging from "essential to an understanding of related principle" to "relatively unimportant to an

understanding of the principle". The fifth category, "unrelated to an understanding of the principle", in reality served two purposes. The dual function of the unrelated category arose from the fact that in the construction of the rating instrument it was necessary for the investigator to assign items of factual content to specific principles. It is probable that some errors in judgment were made, even though in cases of doubt items were assigned to more than one principle. It was assumed that the raters would assign such improperly related items to category five, thus affording a check on one phase of the construction of the rating instrument. The second function of the "unrelated" category was to receive items which the individual raters, themselves, believed should be placed in this category. It cannot be determined which of these functions was being fulfilled by the "unrelated" category as a given item was assigned to it by a rater, nor does it seem to be nec the first four categories that the fifth provided a measure of automatic

the first four categories that the fifth provided a measure of automatic

evaluation of the associations between fact and principle that were made during the process of building the rating instrument.

If the analogous concept of course structure described above is to prove fruitful, it must be shown how specific data from this study can be related to the problem of course revision within the terms of the analogy. In order to move toward this goal, selected material from the distribution appearing in the first part of this chapter has been displayed in Table II. Because of the manner of organization of the data in Table II, new relationships become visible. The significance of this study for the problems of course revision lies within these relationships.

Perhaps the most apparent evidence to be derived from a study of Table II is that there are many empty orbits about certain principles. This is unmistakable evidence that the syllabus does not give equitable treatment to all of the principles. For some of the principles there is no support at all beyond the first level of contribution. In the case of two of the principles there is no related material in the syllabus at any level of contribution. In terms of course revision this situation seems to call for remedial action. If the poorly supported principles are to be retained in the course, additional supporting material should be added to the syllabus. If it is assumed that the desire is for closer harmony between the two volumes, the alternative would be to delete the poorly supported principles from the course.

At the opposite extreme from the principles with many empty orbits, it can be observed that several of the principles have apparently been accorded a disproportionately large number of facts, particularly in the fourth interval of the distribution. Notable in this category is Principle 1 of Area IX. Area VIII, Unit 1, Principle 4 might also be included in this group, as could several others. The questions of significance here might be whether these principles are really overloaded with supporting facts and whether some of the factual material, therefore, should be deleted from the course. The overloading of the fourth orbit of a particular principle relative to the other levels of the same principle probably arose from the fact that <u>all</u> material in each syllabus assignment was assigned to one or another of the principles from the corresponding area of the study guide when the rating scales were

TABLE II

FREQUENCY OF ITEMS IN RESPECTIVE INTERVALS OF THE INDEX VALUE DISTRIBUTION FOR EACH AREA UNIT, EACH PRINCIPAL AND THE COMBINED TOTALS

	Frequency of Items in Each Interval of Distribution					Total Items
	1	2	3	4	5	
Area I	22	33	5	-	-	60
Area III						
Principle 1	1	3				4
Principle 2	2	3	1	2		8
Principle 3	3	5	1			9
Principle 4	5	6	8	45	6	70
Principle 5	No Syllabus Assignment					
Area IV						
Principle 1	5	6	3		1	15
Principle 2	4	0	1	1		6
Principle 3	5	1				6
Principle 4	1	5	3	1		10
Principle 5	2	2	4			8
Principle 6	6	1	3	12	20	42
Principle 7	8	19	9			36
Principle 8	3	2	1			6
Area V, Unit 1						
Principle 1	9	18	26	19		72
Principle 2	6	1				7
Principle 3	4					4
Principle 4	5	8	6	4	1	24
Principle 5	4	1	2			7
Area V, Unit 2						
Principle 1	4	7	2			13
Principle 2	12	36	25	19	2	94
Principle 3	12	23	24	18		77
Principle 4	4	14	7			25
Area V, Unit 3						
Principle 1	15	23	33	72	2	145

[illegible]	43	23	33	12	2	145
Principle 2	7					7
Principle 3	5	2				7
Area VI, Unit 1						
Principle 1	1	1				2
Principle 2	1	4				5
Principle 3	5	39	54	28	2	128
Principle 4	2	10	10	2		24
Area VI, Unit 2						
Principle 1	12	30	39	11		92
Principle 2	1	4				5
Area VII, Unit 1						
Principle 1	1	5	3			9
Principle 2		11	29	157	11	208
Principle 3	No Syllabus Assignment					
Area VII, Unit 2						
Principle 1	8	14	8	7		37
Principle 2	2	13	154	14	5	188
Area VIII, Unit 1						
Principle 1	5	9	9	2		25
Principle 2	2	12	4	3		21
Principle 3	5	4	12	3		24
Principle 4	14	23	39	88	25	189
Principle 5	1	18	56	42		117
Area VIII, Unit 2						
Principle 1	6	15	22	10		53
Principle 2	6	13	4			23
Area IX						
Principle 1	9	46	96	199	8	358
Principle 2		10	2	1		13
Principle 3	15	7	11	4		37
Principle 4	13	4	2			19
Totals Each Interval	263	511	718	764	83	2339

constructed. In some cases many of the facts were obviously poorly related to the principle with which they appeared in the rating instrument and probably should have been assigned to the "unrelated" category by the jurors. Reluctance on the part of the jurors to evaluate anything as "unrelated" undoubtedly resulted in the retention of much material that should have been eliminated. It should be noted that the reference to the reluctance of the jurors to evaluate anything as "unrelated" is only one possible interpretation. Another interpretation is that many of the facts in the syllabus, although they may be related to course objectives, are not provided with related principles by the study guide. This observation indicates the need for mutual revision of both syllabus and study guide.

It is also apparent from Table II, that the supporting facts in some instances are limited to the first and second orbits about the related principle. As a directive for revision, this can be interpreted as indicating a need for further scrutiny of this area in the syllabus, even though some of the fundamental facts are given. Elaboration of these areas of the syllabus for the purpose of including more and broader factual coverage is indicated. Examination of these areas in the syllabus might also serve to illustrate the nature of a "minimum essential" treatment of a principle for those who are interested in that problem.

The facts seem to be desirably distributed with regard to some of the principles, for example; Area IV, Principle 4; Area VI, Unit 1, Principle 3; and Area VI, Unit 2, Principle 1. There are no readily available criteria which can be applied for determining what constitutes

desirable distribution but these are examples of what might be considered acceptable distributions of content. Examination of these areas in the syllabus during the work of revision should help to develop ideas that would be helpful in achieving improved distribution in problem areas.

Table II also shows that, in general, there are few "unrelated" items as indicated by index values. This means that there were few areas where the facts did not fit the principles at some level of relatedness. In this connection it should be recalled that some of the principles were apparently overloaded with facts at the fourth level of relatedness. If this were due to a reluctance on the part of the raters to assign material to the "unrelated" category, there probably is more "unrelated" material in the syllabus than the results of the evaluations indicate.

The last line of Table II contains the distribution of total items. This distribution might appear to be satisfactory on a course-wide basis; however, it must be remembered that it conceals inequalities of the distribution of items related to individual principles. The total distribution cannot be interpreted as either desirable or undesirable because there is no point of reference upon which to base the judgment. Nevertheless, the large number of items placed in categories four and five indicates the need for a careful weighing of these items before they are included in a revision of the present syllabus.

Table II presents convincing evidence that revision of course material would be desirable if the objective is to bring about a closer

relationship between study guide and syllabus, but it does not indicate which volume should be revised. It is the view here that the discrepancies revealed by this study must be regarded as arising from both the syllabus and the study guide. This position is assumed notwithstanding the fact that the syllabus appeared in practically its present form several years before the preparation of the study guide.

Because the syllabus was published first, there might be a tendency to shift the burden of responsibility for the lack of relationship from the syllabus to the study guide. The question might well be asked why certain principles were included in the study guide when little or no material related to the principle was to be found within the syllabus. Even though the difference in dates of publication may shift some of the responsibility for the lack of mutual relationship in the direction of the study guide, it by no means places all of the responsibility there. The study guide includes assignments from other sources as well as from the syllabus and these assignments could justify the inclusion of some of the principles. To the extent that this is true, it could be offered as an explanation of why certain principles appearing in the study guide are poorly related to syllabus content.

Both the syllabus and study guide have been revised since the publication of the study guide but the revisions did not include any remedial work aimed at increasing the relatedness of the two. There were undoubtedly several reasons for not doing so but chief among them was the fact that no study of the relationship between the two had been made prior to the time of revision. Because the areas of poor relatedness

had not been defined, any improvement in that respect would have been accidental.

A careful revision of both the syllabus and study guide, each in terms of the other, offers the greatest opportunity for improvement of both the course and the books. There is some basis for the opinion that a revision directed toward the final incorporation of syllabus and study guide into one volume offers significant advantages. Not the least among the advantages to be gained through combining the volumes would be the proximity of the stated principles and the supporting materials.

The following points may be offered in summary of the implications of these data for course revision and of the recommendations concerning such action.

1. The analogy employed in this study provides a medium through which interrelationships involving facts and principles may be visualized. The postulated categories of contribution derived from the analogy are a means of examining content material in respective areas without losing sight of over-all course organization.

2. As evidenced by the empty orbits of the distribution, the syllabus does not afford equal factual support for all of the principles in the study guide.

3. In terms of increasing relationship between the two volumes there are certain alternative courses of action that may be taken where principles from the study guide are not adequately supported by the syllabus content. These alternatives are to add material to the syllabus,

to delete principles from the study guide or to do both.

4. The fourth interval, corresponding to a key rating of "average importance," seems to be overloaded in many cases. This may be due to a shifting effect associated with calculation of index values, a reluctance on the part of jurors to assign low ratings, to the fact that a principle was omitted from the study guide or to a combination of all three of these factors.

5. The condition referred to in Item 4 above might be relieved by adding the appropriate principle to the study guide in the areas where the fourth orbit of relatedness seems to be overloaded. The syllabus content would then have principles to support in those areas where there is abundant factual material which is now poorly related to the principles stated in the study guide.

6. Additional factual materials should be added to the syllabus in order to better support certain stated principles because these certain principles have all of their supporting facts at the first and second level of contribution. This constitutes what might be called "minimum essential" support.

7. Some principles are acceptably supported because the distribution of facts in the various orbits appears to be above minimal acceptability.

8. The total distribution of syllabus content can be employed as evidence pertaining to course revision in a limited way. Although it may be misleading because it does not take into consideration the much more important internal distribution of facts relative to individual

principles, certain steps for course revision are suggested. Items which fell into categories four and five in the distribution should be carefully evaluated before they are included in a revision of the present syllabus.

9. The syllabus provides inadequate support for certain of the principles in the study guide.

10. Because the syllabus is an avenue by which the most students may be reached, it should contain a basic development of all of the stated principles of the course.

11. A single volume prepared from essential content of the syllabus and the study guide would be advantageous.

Relationship of the evaluation of the factual content of the lecture syllabus to examining in Biological Science. Referring to the data presented in Table II, it can be seen that the syllabus contains large amounts of material pertaining to certain principles and little or nothing pertaining to others. This situation clearly indicates the need for mutual revisions of the syllabus and study guide for the purpose of rectifying the lack of relationship between the two. Until the time that such a revision becomes a reality, the examination program must be based on the textual material in the hands of the students. The question of significance is whether the results of this study offer a basis for improving examinations covering the present course material. The answer to this question is to be found in the validity of the evaluations obtained as a result of this study. Since these ratings are valid, the

categories of importance thus established provide a criterion against which factual items proposed for inclusion in examinations should be checked.

The factual items included in examinations should be largely items which test for knowledge of those facts making the most significant contribution to understanding of principles, assuming that understanding of principles is one of the paramount objectives of the course. In the preparation of departmental examinations it is difficult for the examination committee to avoid the criticism that items testing for knowledge of unimportant details, or even for unrelated material, are included in the examination. The relative evaluations of factual content provided by this study should serve as a practical guide for the examination committee in avoiding errors in judgment which elicit criticism from the staff. The evaluations could also be used to justify the inclusion of items testing for particular facts when the opinions of one, or a few, of the staff differs from that of the jury regarding the importance of the facts in question.

Most important of all, the use of the evaluations presented here should aid in the preparation of examinations which would actually test for knowledge of the basic factual elements of the course as opposed to the type of examination in which the factual questions are drawn largely from the peripheral areas of the course.

The importance of the examination in conditioning the attitude of students toward the course can hardly be overemphasized. This is especially true in a course organized as is Biological Science, where

the students take three departmental examinations each year. Because the character of the examinations is important, the examination committee should continuously seek new means of improving them. In this capacity the results of this study can be useful. This study does not provide the answer to the problem of constructing better, more valid examinations but the results can contribute toward the achievement of that objective.

Relationship of the evaluation of factual content of the lecture syllabus to the preparation of laboratory studies in Biological Science. In the laboratory program in Biological Science the primary emphasis is on the methods aspect of science. There is also concern for teaching understandings of principles and typical laboratory studies actually deal with method through the medium of principles and related facts.

It has been pointed out that one plan employed in the construction of laboratory studies for the course has been to select a principle and then to enumerate as many of the underlying facts as are considered important to an understanding of that principle.

An attempt is then made to weave the facts together through the medium provided by the methods of science, thus building a context in which the principle is presented.

To the extent that it is the practice to identify important facts pertaining to selected principles in the process of constructing laboratory studies, these results could be useful. The evaluations presented in this study could serve as reference material for this

operation in that they constitute a list of facts evaluated in terms of contribution to related principles. It should prove valuable to the individuals engaged in writing laboratory studies to have such a list available for use, both as a means of checking selections of related facts and as a source of ideas for new fact-principle relationships.

CHAPTER V

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

1. The purpose of this study was to obtain an evaluation of the factual material in the Biological Science Lecture Syllabus relative to an understanding of principles presented in the Study Guide for Biological Science and to attempt to show the implications of such an evaluation for certain related problems.

2. The criterion upon which the evaluation was based was derived from the assumption that factual content of an assignment in the Lecture Syllabus for Biological Science should contribute toward understanding of major principles of corresponding areas as they are presented in the Study Guide for Biological Science.

3. A rating scale was constructed by means of which the factual material from the Biological Science Lecture Syllabus was evaluated in terms of relative contribution toward an understanding of related principles.

4. Rating instruments covering the entire factual content of the Lecture Syllabus for Biological Science were submitted to the twenty-two members of the staff of the Department of Biological Science who served as the jury of experts.

5. Based on the twenty-two separate evaluations which each item received, a mean rating or index value for each item was calculated to two decimal places.

6. A frequency distribution of index values was prepared employing intervals arbitrarily selected for the purpose of facilitating reference to the results of this study.

7. The reliability of the rating instrument was determined by the retake method. The two sections of the questionnaire comprising Area 7, Unit 2 were executed a second time by the jurors after a lapse of three months. Coefficients of correlation for the two respective sets of index values, calculated by the product-moment method, were .86 to .75 respectively. When subjected to the t-test, both coefficients proved significant at the 1 per cent level of confidence.

8. The entire factual content of the Lecture Syllabus for Biological Science was rearranged within the organizational framework provided to the Study Guide for Biological Science while taking into account the index values received by the factual items.

9. Table II was prepared showing the number of factual items assigned to respective levels of contribution toward understanding of each principle presented in the study guide.

10. From Table II were derived certain inferences and generalizations having implications for the problems of objectives, "minimum essentials", course revision, examining, and preparation of laboratory studies in Biological Science. An attempt was made to relate these data in a general way to the problems of selection of factual content common to "principles" type courses, regardless of area.

CONCLUSIONS

On the basis of this study it is possible to conclude that, in the opinion of the teaching staff, the Biological Science Lecture Syllabus contains facts which contribute in varying degree toward an understanding of principles presented in the course. Furthermore, the staff of the Department of Biological Science, acting collectively, was able to identify the factual elements of the course in the order of the importance of contribution toward an understanding of principles.

As determined by this study, the lecture syllabus does not treat adequately, by comparison, all of the principles presented in the study guide. It may, therefore, be concluded that if equitable treatment of principles is a desirable feature of the syllabus, the need for revision of both the syllabus and the study guide is indicated. It is also concluded that this study not only indicates areas where revision is particularly needed, but that it also provides information concerning the general nature of the changes.

The conclusion is also reached that the content of the lecture syllabus does not adequately contribute toward the attainment of the course objective "to acquire knowledge of some of the basic laws (principles) of biology's" if it is assumed that this contribution must take the form of an adequate contribution by the syllabus content toward an understanding of the principles presented in the study guide.

Until a revision of the course material is accomplished, the evaluation of syllabus content presented in Appendix I should be utilized

in the following ways:

1. As a basis for the investigation of the "minimum essentials" concept as it relates to Biological Science.
2. In the preparation of examinations in Biological Science.
3. In the preparation of laboratory studies for Biological Science.

Data presented in this study also support the contention that by means of a detailed analysis of a course of study it is possible to marshall the factual elements of course content into orderly support of the major concepts and principles upon which the course is predicated.

EDUCATION IMPLICATIONS

Educational implications for Biological Science. As a result of the reorganization of the Basic College at Michigan State College the Department of Biological Science was officially dissolved on June 30, 1952. Biological Science will not be taught in the Basic College after the summer term of 1953. Instead, a new course, Natural Science, will be required of all entering freshmen and those transfer students who cannot satisfy the basic requirement in the science area.

Although Biological Science will no longer be taught at Michigan State College, a number of institutions will continue to use materials prepared by the Department of Biological Science and published by the Michigan State College Press. Certain of the authors have expressed a desire to undertake continued revision and improvement of Biological Science materials now in print, a move which appears to be warranted in view of the fact that other institutions will continue to use the

volumes. If this project materializes, the results of this investigation should prove significant to its development.

The data presented in this study indicate that revision of both the Biological Science Lecture Syllabus and the Study Guide for Biological Science is in order. The results of this study provide a partial basis for the revision. Each volume should be re-examined in terms of the other; both should be revised in the light of the results presented in this study. As a consequence of a revision so predicated, the factual content of the lecture syllabus could be brought into closer support of the principles appearing in the study guide.

The evaluations obtained through this study should provide a significant contribution to the testing program in Biological Science. This report presents a consensus of the group responsible for initial preparation of the textual material upon which this study was based. Essentially, it is an expression of their judgment as to the relative importance of the factual content of course materials in terms of specific criteria. Therefore, those engaged in the preparation of examinations covering the material might wish to consult this work.

In regard to the establishment of fixed standards of achievement, if that is desired, the results of this study should prove especially useful. In this respect it should be noted that these results constitute evidence beyond individual opinion and might well serve as the starting point for investigations on the problem of fixed standards of achievement, should it be felt that such a problem exists.

These results might be utilized as an aid in the organization of a supplementary reading program for the course. Where certain principles from the study guide have been shown by this study to be poorly or inadequately explained by the syllabus additional readings might be suggested.

Educational implications for Natural Science at Michigan State College. Although this study grew out of a specific problem area encountered in the teaching of Biological Science, the results of this investigation should have considerable significance for the development of the new course, Natural Science. It is reasonable to assume that, sooner or later, essentially the same problems as those which prompted the present study will arise in Natural Science. For example, such problems as identification of material to be included on examinations, selection of materials to be emphasized in lecture, and attempts to establish standards of achievement are almost certain to appear. Therefore, the content of this study should provide some basis for meeting problems in Natural Science that are recognized as essentially the same as those previously encountered in Biological Science.

Educational implications for general education courses. In this study analysis was confined to the factual content of Biological Science as presented in the general education program at Michigan State College. Thus, the usefulness of these specific results is limited. However, any course designed for general education purposes might benefit from similar scrutiny.

A process of self-evaluation in which the whole staff participates can be, in itself, the basis for considerable course growth. This experience in self-evaluation can be one of critical examination of course components in relation to objectives, concepts and principles. Properly conducted, it can become an activity in which the elements of the course are evaluated in terms of their contribution to understanding and to the progress of students toward ultimate goals.

The final outcome of a study such as this, in any course, might be elimination of that which fails to meet the test of contribution, thereby clearing the way for emphasis on those things which do contribute toward desired outcomes.

In substance, periodic examination of course structure, by these and similar methods, might be instrumental in reversing what appears to be a trend toward trying to cover more and more in general education courses and might help to establish instead a policy of attempting to teach thoroughly and well, a limited amount of carefully selected, integrated material.

PROBLEMS SUGGESTED BY THE STUDY

Speculation on specific ways in which results of this study might be beneficially applied to Biological Science suggests the need for several additional studies.

The practice of basing grades on the distribution of examination scores has been questioned by those who believe that the practice should be eliminated. At least two different alternate plans have been proposed.

One view is that fixed standards of achievement should be utilized in determining grades. Another view is that the distribution of examination scores should be combined with a minimum standard of achievement for purposes of determining grades. In effect, this latter plan calls for continued use of the distribution of examination scores but places an arbitrary floor under the curve.

Any realistic effort to implement either of these plans should be inaugurated by studies of the problems involved. The first plan would involve a description of course content, carefully and painstakingly done in terms of exactly what knowledge students would be expected to demonstrate before receiving a particular letter grade. In the case of the second plan, a no less thorough study of course content would be necessary in order to determine minimum knowledge required before students would be allowed to "pass the course with a D." Before either plan could be placed in operation, even on a trial basis, examinations would have to be devised covering individual items of course content, mastery of which would have been deemed "essential" to certain levels of achievement. The work of preparing such examinations should be preceded by prior indentification of "minimum essentials" corresponding to desired levels of achievement. To arrive at identification of "minimum essentials," it would be necessary to evaluate, in terms of specific criteria, the entire content of the course.

This study has provided an evaluation of the items of factual content in the Biological Science Lecture Syllabus which could serve as the beginning point for the construction of progressive "minimum

essentials" examinations. The construction of such examinations, followed by an experimental testing program, might be instrumental in determining the feasibility of further pursuit of the problem of "minimum essentials" in relation to grading policy. A study of this type should be undertaken. It offers the possibility of producing tangible evidence bearing on a problem of the sort which is not likely to be solved by debate alone.

This study was limited to obtaining an evaluation of the factual content of the lecture syllabus in terms of contribution to understanding of principles presented in the course in Biological Science. The method employed was that of the "expert jury." There remains to be investigated how the opinion of the jury agrees with student performance. This information should be obtained. A study should be done in which students would be given examinations containing problem situations so designed that the correct solution would demonstrate knowledge of and ability to apply the principles presented in Biological Science. The examinations given the students should also contain factual items representive of the various levels of contribution established by the present investigation. Knowledge of and the ability to apply a particular principle is generally interpreted as indicating an understanding of the principle. Presumably, there should be a positive relationship between knowledge of factual material deemed contributory to understanding of a principle and the ability to apply the principle in a problem situation. It such a relationship could be demonstrated, it could be offered as further evidence corroborating the use of the "expert jury"

technique and would further substantiate the results of this investigation.

The limitations imposed upon this study were such that only factual material from the Biological Science Lecture Syllabus was evaluated. Factual content is only one facet of Biological Science. Investigations should be undertaken for the purpose of discovering the contribution of the other learning activities in the course toward attainment of objectives. Both informational and behavorial objectives should be included in a project of this type.

Finally, it is strongly recommended that a thorough investigation of the relationship between the factual aspects of the biological science course and the stated objectives be conducted. A study of this problem would, in reality, involve analysis of the triangular relationships existing among objectives, principles and factual content. It is suggested that a promising beginning for an investigation of these relationships would be an attempt to synthesize the results of Burmester's[1] study on objectives for Biological Science with the results of the present investigation.

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[1]Mary Alice Burmester. "A Synthesis and Evaluation of Objectives for Biological Science in the Basic College at Michigan State College." Unpublished master's thesis, Michigan State College, 1948.

LITERATURE CITED

BOOKS

American Council on Education, Executive Committee on the Cooperative Study in General Education. Cooperation in General Education. Washington: American Council on Education. 1947. 240 pp.

Cohen, Morris R., and Ernst Nagel. An Introduction to Logic and the Scientific Method. New York: Harcourt, Brace and Company. 1934. 460 pp.

Hawks, Herbert E., E. F. Lindquist and C. R. Mann. The Construction and Use of Achievement Examinations. New York: Houghton Mifflin Company. 1936. 488 pp.

Lawson, Chester A. Biological Science Lecture Syllabus with Readings. East Lansing, Michigan: Michigan State College Press. 1951. 293 pp.

McGrath, Earl J., editor. Science in General Education. Dubuque, Iowa: William C. Brown and Company. 1948. 224 pp.

Noll, Victor H. "The Teaching of Science in Elementary and Secondary Schools. New York: Longmans, Green and Company. 1938. 214 pp.

Russell, Charles. Teaching for Tomorrow. New York: Prentice-Hall Inc. 1937. 477 pp.

Staff of the Department of Biological Science. Guide for Laboratory Studies in Biological Science. East Lansing, Michigan: Michigan State College Press. 1951 259 pp.

Stroud, James B. Psychology in Education. New York: Longmans, Green and Company, Inc. 1940. 644 pp.

Study Guide Committee of the Department of Biological Science. Study Guide for Biological Science. East Lansing, Michigan: Michigan State College Press. 1951. 147 pp.

MONOGRAPHS AND COMMITTEE REPORTS

Beauchamp, Wilber L., Instruction in Science, U. S. Office of Education Bulletin, 1932, No. 17, Monograph No. 22, Washingtown: Government Printing Office. 1933. Pp. 83.

Education Committee, "Objectives for Biological Science," unpublished report. Department of Biological Science, Michigan State College, 1946.

"Report of Committee on Secondary School Science of the National Association for Research in Science Education," Science Education, 22:223-233, October, 1938.

"Report of Committee on Research in Junior College Science of the National Association for Research in Science Teaching," "Trends and Problems in General Education College Science Courses", Science Education, 33:172-173, April, 1949.

PERIODICAL LITERATURE

Baker, Woolford B., "Science Teaching and the World of Tomorrow," Science Education, 34:7-15, February, 1950.

Bergman, George J., "Determination of the Principles of Entomology of Significance for General Education. I," Science Education, 31: 23-32, February 1947.

Bergman, George J., "Determination of the Principles of Entomology of Significance for General Education. II," Science Education, 31:144-157, March, 1947.

Berner, L. M., and others, "Objectives of Science Teaching," School Science and Mathematics, 31:550-557, May, 1931.

Bullington, Robert Adrian, "Subject Matter Content of General Education Science Courses," Science Education, 36:285-292, December, 1952.

Geer, Willard, "Objectives Students Seek in Physics Survey Courses," Science Education, 33:152-155, March, 1949.

Hard, H. O., and F. C. Jean, "Natural Science Survey Courses in Colleges," Science Education, 22:294-299, November, 1938.

Heineman, Ailsie M., "A Study of General Science Textbooks," General Science Quarterly, 8:11-23, November, 1928.

Hunter, George W. and Leroy Spore, "The Objectives of Science in the Secondary Schools of the United States," School Science and Mathematics, 43:633-647, October, 1943.

Irish, E. Eugene, "A Determination of Materials Dealing with Soil Conservation and Suitable for Integration into Courses of High School Science for General Education," Science Education, 37:84-99, March, 1953.

Keeslar, Oreon, "Contributions of Instructional Films to the Teaching of High School Science," Unpublished doctoral dissertation, University of Michigan, 1945. Reported in Keeslar, Oreon, "Objectives of Instruction in Science," Science Education, 29:212; 216, October, 1945.

Martin, W. Edgar, "A Determination of the Principles of the Biological Sciences of Importance for General Education," Science Education, 29:100-105, March, 1945.

McFadden, M. G., "Proposed Integration of Biology Workbook and Study Materials with Specially Designed Reading Procedures for the Course," Science Education, 33:156-162, March, 1949.

Miles, Vaden W., "A Determination of Principles and Experiments for an Integrated Course of Physical Science for High School. I," Science Education, 33:147-152, March, 1949.

Smith, Herbert F. A., "A Determination of Principles Desirable for a Course of General Science at the Junior High School Level," Science Education, 35:274-284, December, 1951.

Washton, Nathan S., "A Syllabus in Biology for General Education. I," Science Education, 35:84-91, March, 1951.

Washton, Nathan S., "A Syllabus in Biology for General Education. II," Science Education, 36:227-237, October, 1952.

Winokur, Morris, "A Survey of Generalized Science Courses in Institutions of Higher Education," Science Education, 20:132-140, October, 1936.

Wise, Harold E., "The Major Principles of Physics, Chemistry and Geology of Importance for General Education," Science Education, 25:371-379, December, 1941.

UNPUBLISHED MATERIALS

"Annual Report of the Basic College, 1951-52." Unpublished report, Michigan State College, 1952.

Burmester, Mary Alice, "A Synthesis and Evaluation of Objectives for Biological Science in the Basic College of Michigan State College," Unpublished master's thesis, Michigan State College. 1948. 128 pp.

"Report of Committee appointed 'For Study and Recommendations' Concerning Basic Education at Michigan State College." Unpublished report, Michigan State College, 1944.

APPENDIX I

AREA I

The Scientific Approach to Problems

The Specific Objectives

1. To understand the objectives of general eduction.
2. To understand the place of biological science in a general education program.
3. To realize the significance of scientific methods in effective living.

The Assignment

Biological Science Lecture Syllabus, pp. 1-5.

MEAN SCORE .05 - 1.50

6. Success of the individual as a member of society depends upon other skills and other knowledge (than ability to handle a special task). He must know how to cooperate, how to compromise his own particular needs and desires with those of others for the common good. He must understand the workings of society and the function of each individual within it. For this understanding he must know the origin, growth and development of society. He must appreciate the value of different parts of society, and above all he must learn to think in terms of the part he can play in promoting the welfare of mankind.

13. Man can learn how his body functions and how his life is dependent on matter and energy derived from the earth, from the sun, and from other living organisms. He can learn the nature of the universal interrelationships and interdependencies of living things and so better control them for his benefit. He can learn the nature and habits of his competitors and he also must learn that to match successfully the strength of his competitors he must work with other members of his group.

15. Biological Science is designed to give the student an understanding of basic biological principles so that he may better understand his own nature and that of all living things.

16. With an understanding of his own nature and that of all living things the individual can live more effectively as an individual and as a member of a group.

17. A science is a body of knowledge that is obtained by means of the scientific method concerning any part of the universe.

18. In using the scientific method, one makes observations concerning natural phenomena.

19. The results of these observations concerning natural phenomena (data) are recorded, classified, and analyzed, and from this information relationships are determined.

29. Formulation of an hypothesis is a technique of the scientific method that aids in the search for relationships or generalizations.

32. The hypothesis must be tested.

33. The hypothesis is tested by the collection through observation of more data that relate to the hypothesis.

35. In experimentation the emphasis is on the relationship between cause and effect. Two similar events are observed, both of which are exactly alike except for one factor. If the observed results of the events differ, the difference must have been due to the variable factor.

37. If the hypothesis proves incorrect a revaluation of all the facts, including those brought out in the testing, is made and a new hypothesis is stated.

40. A principle is a relationship or generalization that is supported by such a wealth of data that its truth is very highly probable.

41. It must be emphasized that no scientific fact, hypothesis, theory, or principle is ever proved absolutely ture.

42. Scientific truth is a matter of probability.

48. The scientific method may also be used in everyday life.

52. The scientific method is useful in arriving at opinions that guide the course of action.

53. In terms of the scientific method the opinion is the hypothesis and a person trained in this method will be aware of the basis (facts) on which the opinion (hypothesis) has been made. His degree of confidence in the opinion will vary according to the adequacy of the facts used in its formulation.

54. An opinion based on many verified facts will be given more weight than one without much substantiation.

55. When an opinion has been accepted it will not be accepted unconditionally, but further information will be sought in order to revaluate it (the opinion).

58. A person who uses the scientific method open-mindedly has the ability to view his opinions in the light of facts and is willing to change his opinions in the light of new information. Such a person also reserves judgement if after considering the facts he realized that they are not sufficient for the formulation of an opinion.

61. The ability to recognize a competent authority and the willingness to be guided by his opinions are very important factors in living more scientifically.

MEAN SCORE 1.51 - 2.00

1. Man's behavior has been guided since the beginning of human life by two basic requirements, food and reproduction.

3. Out of primitive man's cooperation with other men grew a complex society which has evolved into our modern complex civilization.

5. Special education is necessary to prepare the individual to do the special tasks that enable him to satisfy his basic requirements with the result that there are schools of business, trade schools, schools of medicine, schools of agriculture and many others.

7. General education courses teach the skills and knowledge that are necessary for successful group living.

8. The welfare of the modern world depends in large measure on the success of the general education program in its efforts to teach people to live together.

9. Man is a biological organism.

10. Man's primary activities are biological because without food he could not live and without reproduction human life would cease to exist.

11. Man competes with other biological organisms for his food and frequently for his life. He struggles for his existence just as other organisms do.

12. Man has one advantage not enjoyed by his competitors (in the struggle for existence). This advantage is his ability to learn to a greater extent than any other organsim and to profit by that learning.

14. The battle against disease, insects, and erosion is no task for a single individual. Rather it is a task requiring the united effort of all the people.

20. The observations (of natural phenomena) to be useful must be made with great accuracy.

21. To increase the accuracy (of observations), various measuring devices are employed and the senses are extended by means of microscopes, telescopes, X-ray machines, and many other instruments.

22. Results of the observations (data) are classified in an orderly manner.

23. The order (in the process of classifying data) is developed in accordance with what man thinks is logical and meaningful.

24. In the classification of data facts that appear related are grouped together.

25. The classified data are thought over in the search for relationships.

26. It is in the search for relationships that the ability to think logically and brilliantly is of paramount importance.

31. An hypothesis is made on the basis of too few facts to be accepted as proved and is no more than a reasonable guess concerning a possible relationship that seems to exist.

34. The testing of the hypothesis may include experimentation, which is a controlled observation.

36. An hypothesis that has been tested may still stand as the best statement of the relationship available or it may be found to be totally incorrect, in which case it is discarded.

38. As a third alternative the original hypothesis may be partly correct and in need only of modification.

39. A theory is an hypothesis that has withstood repeated tests, but which has not been tested sufficiently to be accepted as true with a very high degree of probability.

43. The hypothesis, being based on a few facts only, has the least chance of being a true statement of relationships. Further observation may easily show that the hypothesis is untenable.

45. The principle (law or doctrine) has the greatest chance of surviving as a statement of relationships among natural phenomena because it is the result of the accumulation of years of repeated observations and tests by many scientists.

46. Because there are so many observations or facts that support the principle, the possibility that any facts will ever be discovered that disprove it is remote.

47. It should be remembered also that the relationships are man-made and are what seem to be logical explanations of the observed phenomena of nature.

49. Every individual holds certain things to be true or false, good or evil.

50. These are opinions (judgements of good, evil, true, false) and on the basis of them all people make decisions that govern the course of their action.

51. Every individual must make many decisions during the course of his life, and the welfare of the individual, his family, and society as a whole depends on how well these decisions are made.

56. In terms of the scientific method the hypothesis (opinion) will be tested. If this further information supports the original opinion, more confidence can be placed in it. However, if it disagrees with the opinion, all of the information must be re-examined in order to formulate a new one. A new hypothesis is made to fit all of the facts.

57. A person using the scientific method is open-minded.

59. Many people are faced with the necessity of making a decision without adequate information to do it sceintifically. They may lack both time and facilities for gathering the needed information; but the decision must be made nevertheless.

60. In cases where a decision must be made without adequate information the scientifically trained person seeks the advice of some one whose opinions are based on adequate information.

MEAN SCORE 2.01 - 2.50

2. Primitive man developed forms of cooperation with other men which resulted in the satisfaction of his basic requirements.

4. For an individual to succeed in obtaining his basic requirements he must have certain skills that enable him to do some special task.

27. The great scientist of the past were great because they could see relationships not apparent to most men.

28. Our modern "greats" (in science) qualify in the same manner (as the greats of the past).

30. The hypothesis is a statement of relationships that goes beyond known facts.

AREA III

Characteristics Common to All Living Things

The Specific Objectives

1. To learn the characteristics of living things.
2. To understand the fundamental organization of plants and animals.
3. To understand the basic significance of respiration to living things.

Principles

1. Protoplasm is a consequence of the organization of matter and energy.
2. The bodies of plants and animals are composed of cells and products of cells.
3. Life processes are the activities of protoplasm.
4. Living things have a common structural pattern.
5. Cellular respiration is a process of releasing energy from organic foods.

The Assignment

Biological Sceince Lecture Syllabus, pp. 5-14.

Principle I - Protoplasm is a consequence of the organization of matter and energy.

MEAN SCORE .5 - 1.50

2. Living things take into their bodies non-living materials that are synthesized chemically into living protoplasm or oxidized to release energy that is used in the living process.

MEAN SCORE 1.51 - 2.00

1. Living things assimilate and utilize materials and energy.

3. Life can be maintained only when a constant stream of materials and energy is passing through the living organism.

4. All of the substances in protoplasm are combined into a complex organization in which chemical and physical processes occur that result in life.

Principle II - The bodies of plants and animals are composed of cells or products of cells.

MEAN SCORE .5 - 1.50

2. Protoplasm usually takes the form of small blocks or spheres called cells.

3. In the smallest organisms the entire structure is composed of one cell, while in the larger more complex living things such as man the cells are multiplied millions of times to form the complete individual.

MEAN SCORE 1.51 - 2.00

1. Each individual organism is made of the same material, which is a complex kind of fluid substance known as protoplasm.

4. Complex organisms are made of many millions of cells which are differentiated into various kinds. In complex organisms the cells are grouped on the basis of structure and function into tissues and these are combined to form organs. The organs are united into systems.

5. Groups of cells of similar structure which perform specialized functions are called tissues.

MEAN SCORE 2.01 - 2.50

6. The bodies of man and other complex animals as well as the bodies of vascular plants are composed of several kinds of tissues.

MEAN SCORE 2.51 - 3.50

7. Organs in both plants and animals are composed of tissues that work together to perform a specific function in maintaining life.

8. Organs that work together to accomplish one of the primary functions of the individual compose the organ systems.

Principle III - Life processes are the activities of protoplasm.

MEAN SCORE .5 - 1.50

2. Every process or function of a living organism, such as digestion, movement, seeing or thinking is the result of the action of cells.

4. All of the substances in protoplasm are combined into a complex organization in which chemical and physical processes occur that result in life.

6. Living things grow.

MEAN SCORE 1.51 - 2.00

1. Each individual is made of protoplasm organized into cells.

5. Living things assimilate and utilize materials and energy.

7. Living things reproduce.

8. Living things are adapted to their environment.

9. Living things move.

MEAN SCORE 2.01 - 2.50

3. The protoplasm of which cells are made is from 60 to 90 per cent water. The rest is composed of proteins, carbohydrates, fats, minerals and enzymes in varying proportions.

Principle IV - Living things have a common structural pattern.

MEAN SCORE .5 - 1.50

2. Each individual is made of the same material, which is a complex kind of fluid substance known as protoplasm.

3. In living organisms protoplasm usually takes the form of small blocks or spheres called cells.

4. The cell is the unit of structure and function of all living things.

6. A cell is made of protoplasm and has two major parts, the nucleus and the cytoplasm.

12. A thin, tough protoplasmic membrane, the cell membrane, surrounds the entire cell.

MEAN SCORE 1.51 - 2.00

5. Every process or function of a living organism, such as digestion, movement, seeing or thinking is the result of the action of cells.

15. Groups of cells of similar structure which perform specialised function are called tissues.

16. The bodies of man and other complex animals as well as the bodies of vascular plants, are composed of several kinds of tissues.

42. Meristem tissue consists of small, thin-walled cells which have the ability to divide repeatedly.

66. Organs in both plants and animals are composed of tissues that work together to perform a specific function in maintaining life.

69. Each system is composed of organs that work together to accomplish one of the primary functions of the individual.

MEAN SCORE 2.01 - 2.50

1. Superficially no common pattern is apparent, but the common pattern is there.

11. The remainder of the cell surrounding the nucleus is the cytoplasm.

35. Nerve tissue is made up of nerve cells (neurons).

39. Blood is a fluid tissue and consists of a liquid plasma and floating cellular elements.

43. Meristem tissue is found at the tips of stems and roots and in vascular bundles where growth takes place.

44. The cells or meristem tissue differentiate or change into all of the other tissues of the plant body.

45. Epidermal tissue of plants is similar to epithelial tissue of animals in that it covers surfaces.

70. The systems of the higher animal include the digestive, respiratory, circulatory, excretory, skeletal, muscular, nervous, endocrine and the reproductive system.

MEAN SCORE 2.51 - 3.50

7. The nucleus is usually a sperical structure and located near the center of the cell and limited by a thin, protoplasmic membrane known as the nuclear membrane.

9. Nucleoplasm is a thin, watery liquid in which is immersed a loose irregular network of chromatin granules.

13. Between the cell membrane and the nuclear membrane is the watery cytoplasm which contains a variety of structures such as vacuoles, food granules, cell products and wastes.

14. Plant cells have a wall made of cellulose outside of the cell membrane.

17. Epithelial tissue is thin and sheet-like and serves to cover surfaces and to line cavities.

18. The outer layer of the skin which covers the body is an epithelium, as are the linings of the digestive tract, the abdominal cavity, and the chest cavity.

19. Every cavity, duct and vessel in the body is lined with epithelial tissue.

20. Connective and supporting tissue holds the parts of the body together and gives support.

21. Several types of tissue are considered as connective and supporting tissue. They are white fiberous tissue, elastic tissue, fatty or adipose tissue, cartilage and bone.

22. The connecting and supporting tissues are characterized by the presence of cells plus a non-cellular substance known as matrix that lies outside the cells.

23. Muscle tissue contracts and in so doing moves body parts.

24. There are three kinds of muscle: striated or skeletal muscle, smooth or visceral muscle, and heart or cardiac muscle.

25. Striated muscle makes up the mass of the body and moves the skeletal parts.

26. Striated muscle is composed of elongated cells with many nuclei and with alternating light and dark bands across the cells.

28. Smooth muscle is so called because it lacks the striations of skeletal muscle.

29. Smooth muscle cells are spindle-shaped and contain but one nucleus.

30. In smooth muscle the spindle-shaped cells lie parallel and form sheets of tissue that form the walls of various tubes and ducts of the body.

31. The intestine contains two layers of smooth muscle which contract and move the food along.

32. Cardiac muscle is found in the heart.

33. Cardiac muscle is made of branching, striated cells.

34. The cardiac muscle cells contract and relax rhythmically to produce the pumping action that is so essential to the function of the heart.

36. Neurons have a rounded or triangular cell body to which are attached fibers, the dendrites and axons.

37. The dendrites and axons interconnect parts of the body and conduct nerve impulses.

38. Bundles of nerve fibers make up the nerves.

40. The cells of blood include the red cells and the white cells.

41. Blood tissue transports materials throughout the body and aids in disease resistance.

46. Epidermal tissue cells are usually small and arranged in a single layer.

47. In leaf epidermis the outer cell walls are thick and covered with a waxy layer which reduces water evaporation, while in root epidermis they are thin-walled and permit the absorption of water.

48. Some epidermal cells of roots have slender projections that extend between the soil particles. These are the root hairs.

49. Parenchyma tissue is made of large, thin-walled, unspecialized cells.

50. Some parenchyma cells are colorless and used mainly for storage, while others, in leaves and near the surface of green stems, contain chloroplast and are used mainly for food manufacture.

51. Two kinds of supporting tissue in plants are fibers and wood.

52. Fibers are extremely thick walled, elongated cells with pointed ends. When mature they contain no protoplasm.

56. The bulk of plant stems is composed of wood tissue which contributes the major support to the stem.

57. The transport of materials from place to place in a plant is accomplished by the vascular tissue.

58. Vascular tissue consists of tubes located in the phloem and ducts in the xylem.

59. The phloem tubes are made of tubular cells that contain protoplasm and are stacked end on end, forming a column that extends from roots to leaves.

60. At the end of each of the cells of the phloem, the wall is perforated, permitting the protoplasm of one cell to come in direct contact with that of the cell next in line.

61. Food is transported through the tubes of the phloem.

62. Ducts are found in the xylem of roots, stems, and leaves.

63. The cells that form the ducts are tubular and placed end to end. As they mature, the end walls dissolve, the protoplasm disappears and the cell walls form a continuous, hollow pipe-line through the plant.

64. Water and inorganic salts are transported by the ducts.

65. The ducts also aid in supporting the plants.

67. Plants have fewer organs (than animals), the entire list being roots, stems, flowers, and fruit with seeds.

68. Organs are composed of many tissues, among which one is of primary importance while the rest are accessory but contribute to the function of the primary tissue.

MEAN SCORE 3.51 - 4.50

Items number 8, 10, 27, 53, 54, 55. Content may be obtained from Appendix II.

Principle V - Cellular respiration is a process of releasing energy from organic foods.

Syllabus assignment contained no material related to principle number five.

AREA IV

Transformation of Solar Energy: Photosynthesis

The Specific Objectives

1. To gain some understanding of the nature of matter and energy.
2. To study the energy relationships in living organisms.
3. To understand photosynthesis and to realise the significance of this process to all living things.
4. To study the physical bases for the movement of water and dissolved materials in plants.

Principles

1. Matter is the substance of the universe.
2. The ultimate source of energy available to living organisms within our planetary system is the radiation from the sun.
3. Life is a result of the organisation of matter and energy in a dynamic equilibrium that can be maintained only by the constant utilisation of matter and energy.
4. Energy and matter are neither created nor destroyed in life processes.
5. In photosynthesis radiant energy is transformed to chemical energy.
6. Only green plants, those containing chlorophyll, can utilise solar energy for the manufacture of foods.
7. Diffusion is the basic mechanism of transport operating in the physical activities of organisms assisted by the movement of fluids.
8. The synthesis of fats and proteins and carbohydrates other than glucose is a sequel to photosynthesis which makes matter and energy available to living things.

The Assignment

Biological Science Lecture Syllabus, pp. 15-17, pp. 21:31.

Principle I - Matter is the substance of the universe.

MEAN SCORE .5 - 1.50

1. Matter occupies space, has inertia, and attracts other matter with a force called gravity. It can be seen, felt, tasted and smelled.

2. Matter is composed of atoms.

4. There are thousands of different kinds of matter, but this does not mean that there are thousands of different kinds of atoms, for atoms can combine and form substances that have characteristics entirely different from those of the atoms composing them.

6. The combinations of these elements (atoms) produce all of the kinds of matter that make up the universe.

7. This matter (of the universe) is usually in the form of molecules, which is the name given to the particle formed by the union of two or more atoms.

MEAN SCORE 1.51 - 2.00

5. There are 92 kinds of atoms in nature and some unstable atoms produced in the laboratory, each of which is called a chemical element.

8. Examples of atoms or elements are carbon, hydrogen, oxygen and nitrogen.

9. Examples of molecules are water, carbon dioxide, sugar, lard and gelatin.

10. A molecule of water is formed when two atoms of hydrogen combine with one atom of oxygen. This reaction does not occur quite as simply as this, but for illustration can be written:

$$2H + O \longrightarrow H_2O$$

11. If one atom of carbon unites with two atoms of oxygen the result is a molecule of carbon dioxide. $C + O_2 \longrightarrow CO_2$

12. Molecules can also be combined to form larger molecules. For example, 6 molecules of carbon dioxide (CO_2) can be united with 6 molecules of water (H_2O) to form a molecule of glucose ($C_6H_{12}O_6$). In this reaction there are 6 more molecules of oxygen (O_2) than are required in the glucose molecule, so they are given off as molecular oxygen. The

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equation as written in chemical shorthand is:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

carbon dioxide water glucose oxygen

MEAN SCORE 2.01 - 2.50

13. Fat, another kind of food, is also formed by the combination of carbon, hydrogen and oxygen.

14. Protein, another food, is formed by the combination of carbon, hydrogen, oxygen, nitrogen, and frequently other elements such as sulfur, phosphorus and occasionally magnesium and iron.

15. Vitamins also contain carbon, hydrogen, and oxygen.

MEAN SCORE 3.51 - 4.50

Item number 3. Content may be obtained from Appendix II.

Principle II - The ultimate source of energy available to living organisms within our planetary system is the radiation from the sun.

MEAN SCORE .5 - 1.50

1. Stored chemical energy is the source of all energy used by living things.

2. Green plants have the ability to take the light energy of the sun and convert it into chemical energy.

3. The energy that is used by living things to carry on the process of life is chemical energy stored in molecules of carbohydrates, fats and proteins. The ultimate source of this stored energy is sunlight, which is changed from light energy to stored or potential chemical energy.

4. Only green plants can store energy (from the sun) in this fashion, so the source of all energy used by living things is the green plant.

MEAN SCORE 2.01 - 2.50

6. The light waves which produce the red, blue, and violet regions of the spectrum are absorbed by the chlorophyll in the palisade and spongy cells, and the energy is used in combination with water and carbon dioxide to produce glucose.

MEAN SCORE 2.51 - 3.50

5. Sunlight consists of light waves of different lengths which can be separated by passing through a prism to form a minature rainbow consisting of the following colors: red, orange, yellow, green, blue, indigo and violet.

Principle III - Life is a result of the organization of matter and energy in a dynamic equilibrium that can be maintained only by the constant utilization of matter and energy.

MEAN SCORE .5 - 1.50

1. Within the organism, matter and energy become a part of a complex, integrated mechanism that lives.

2. The organization of the matter and energy is stable so long as life continues, but it is a dynamic sort of organization in which both matter and energy are continually being utilized.

3. Life ceases if non-living materials and energy are not constantly being fed into the living protoplasm.

4. The stored chemical energy in organic foods is the source of all energy used by living things.

6. Oxygen is necessary for this process (of releasing energy from stored food) which explains why living organisms need a constant supply (of oxygen). The equation for this energy releasing reaction is:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow \text{Energy} + 6CO_2 + 6H_2O$$

MEAN SCORE 1.51 - 2.00

5. To use (this) stored energy, living things break the bonds that hold the atoms of the molecule together and the energy is released.

Principle IV - Energy and matter are neither created nor destroyed in life processes.

MEAN SCORE .5 - 1.50

5. Energy appears in several forms and can be changed from one form to another.

MEAN SCORE 1.51 - 2.00

1. In order to maintain life, non-living matter must be taken from the environment and built into the structure of the body.

2. Energy must also be taken from the environment and used to carry on the living functions.

3. Within the organism matter and energy become a part of a complex, integrated mechanism that lives.

6. In all (of these) forms of energy one type of motion replaces another.

8. Energy can be stored.

MEAN SCORE 2.01 - 2.50

4. The organization of the matter and energy is stable so long as life continues, but is a dynamic sort of organization in which both matter and energy are continually being utilized.

9. Stored energy is called potential energy.

10. Stored chemical energy is the source of all energy used by living things.

MEAN SCORE 2.51 - 3.50

7. The energy of motion is called kinetic energy.

Principle V - In photosynthesis radiant energy is transformed to chemical energy.

MEAN SCORE .5 - 1.50

1. Photosynthesis is the process whereby water, carbon dioxide, and light energy are combined through the aid of chlorophyll to produce carbohydrate food.

2. Chlorophyll in a living cell is essential in this reaction (photosynthesis) because it alone can make use of the radiant energy of the sun to separate certain of the carbon atoms from the oxygen in the carbon dioxide molecule; to separate certain of the hydrogen atoms from water molecule, and to recombine these atoms to form glucose, a simple sugar.

MEAN SCORE 1.51 - 2.00

3. The chlorophyll probably acts as a catalyst in this reaction (photosynthesis), but the details of the process are still obscure.

4. (In the photosynthesis reaction) six molecules of carbon dioxide combine with six molecules of water to produce one molecule of glucose. The equation written in chemical shorthand is:

$$6CO_2 + 6H_2O + (\text{energy}) \longrightarrow C_6H_{12}O_6 + 6O_2$$

MEAN SCORE 2.01 - 2.50

5. Six molecules of oxygen are not utilized in the process (of photosynthesis) and diffuse to the atmosphere. This is the primary source of oxygen for cellular respiration in animals and plants.

6. Photosynthesis serves not only as the source of energy-yielding food for all living things but also supplies the oxygen which is necessary to release the energy so that it can be used by living organisms.

7. The glucose formed within the plant cell (by photosynthesis) may be oxidized (combined with free oxygen), and the chemical energy which is released is used by the plant.

8. The energy used by plants cannot be taken directly from the sunlight but must be released by oxidation from a food molecule just as in animals.

Principle VI - Only green plants, those containing chlorophyll, can utilize solar energy for the manufacture of foods.

MEAN SCORE .5 - 1.50

1. Green plants have the ability to take the light energy of the sun and convert it into chemical energy.

2. They (green plants) use carbon dioxide and water and combine them into molecules of glucose.

3. Within the glucose molecule is the energy which has been converted from light energy into chemical energy. The equation for this process is: $6CO_2 + 6H_2O + \text{Energy} \longrightarrow C_6H_{12}O_6 + 6O_2$

4. The ultimate source of stored energy (in food) is sunlight which is changed from light energy to stored or potential chemical energy. Only green plants can store energy in this fashion, so the source of all energy used by living things is the green plant.

5. The green plant is the source of all energy-yielding foods and also of most of the foods that do not contain energy. Water and some minerals may be obtained from nonplant sources.

29. The leaves are the food-making organs of the plant.

MEAN SCORE 1.51 - 2.00

38. On both upper and lower surfaces of most leaves are tiny openings, the stomates.

MEAN SCORE 2.01 - 2.50

35. The cells of both layers (palisade and spongy layers) contain chloroplast.

39. These (the stomates) permit air from the atmosphere to enter the air spaces of the leaf.

42. Veins extending throughout the leaf, are extensions of the vascular bundles of the roots, stems, branches and leaf stems.

MEAN SCORE 2.51 - 3.50

6. The more common flowering plants are composed of roots, stems, leaves, flowers and fruits.

7. The roots extend into the ground where they serve to anchor the plant and to absorb and conduct water and inorganic minerals.

13. In the center of the root is the vascular tissue.

19. The stems also conduct water, minerals and other foods.

22. Inside of the cortex (of the stem) is the central cylinder of vascular tissue.

30. The leaf is usually of two parts, the leaf stem and the blade.

31. The leaf stem supports the blade and contains conducting tissue.

34. Inside the leaf are two cell layers, the palisade layer and the spongy layer.

36. The palisade layer is made of irregular and somewhat elongated cells that stand more or less close together.

37. The spongy cells are more or less irregular in shape and have air spaces between them which are interconnected throughout the leaf.

40. The stomates are usually more numerous on the under surface of the leaf than on the upper surface.

41. Each stomate is surrounded by guard cells which regulate the size of the opening.

MEAN SCORE 3.51 - 4.50

Items number 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 20, 21, 23, 24, 25, 26, 27, 28, 32, 33. Content may be obtained from Appendix II.

Principle VII - Diffusion is the basic mechanism of transport operating in the physical activities of organisms assisted by the movement of fluids.

MEAN SCORE .5 - 1.50

1. Plants absorb water from the soil by means of the root hairs.

3. The water enters the cells of the root by a form of diffusion known as osmosis.

4. Diffusion is a process whereby one substance becomes spread throughout another substance.

6. The force which causes the sugar to spread is a molecular force.

21. Osmosis plays an important part in the absorption and transport of water by a plant.

29. When transpiration occurs from the surface of the palisade and spongy cells, the water within these cells diffuses to the surface and replaces that lost by evaporation, with the result that the concentration of water within the cell is decreased below that in adjacent cells not exposed to the air. Osmosis results and the water moves from these adjacent cells into the cells lining the air spaces. This reduces the water content of these cells, which in turn causes water to move by osmosis from the cells next in line. This is repeated from cell to cell starting with the cells lining the air spaces and ending with the cells surrounding the xylem of the veins.

33. Minerals that are in solution in the soil water move by diffusion into the epidermal cells of the roots and then into the xylem.

36. Plants receive carbon dioxide from the air, which diffuses into the leaves through the stomates and then into the palisade and spongy cells.

MEAN SCORE 1.51 - 2.00

2. The roots and attached root hairs lie between soil particles which are immersed in water.

5. An example of diffusion is sugar and water. When sugar is added to water the sugar becomes dissolved and in so doing it gradually spreads throughout the water until it is equally distributed.

7. Molecules are subject to two opposing forces. Attraction tends to hold them together and their motion causes them to separate.

11. (When the molecules separate) such molecule moves in a straight line away from its neighboring molecules until it is stopped, by collision either with another sugar molecule, with the wall of the container, with the surface of the liquid, or with the water molecules.

13. Because the molecules move in a straight line until stopped and then immediately start off in another straight line, it is obvious that the molecules will tend to move away from the area of greater concentration to one of lesser concentration. Repeated collisions in congested areas prevent any great movement toward this area but in sparsely occupied areas progress is not impeded.

14. Finally the molecules fill all of the available space and become equally distributed among the water molecules.

15. Osmosis is diffusion of water through a membrane so constructed that it permits molecules of water to pass through but does not permit molecules of a dissolved substance to pass through. Such a membrane is differentially permeable.

16. If a vessel is so constructed that a differentially permeable membrane separates a solution of pure water and a solution of sugar and water, the water molecules can move both ways through the membrane but the sugar molecules cannot because the membrane permits the water molecules to move through but prevents the sugar molecules from doing the same.

17. The movement of the water molecules is entirely independent of the sugar molecules and they move in accordance with the laws of diffusion: that is, they move from an area of greater concentration of water to one of lesser concentration of water.

18. (In an osmotic system) the water molecules are more concentrated for any given space within the pure water side than they are on the sugar side of the membrane. This is due to the presence of sugar molecules which by occupying space among the water molecules cause them to be farther apart than they would be in a pure solution.

19. Hence, the water moves by diffusion from the pure water side to the sugar solution side of the membrane.

20. The sugar molecules would move by diffusion through the membrane to the pure water side likewise, but they are prevented from doing so by the membrane.

22. The roots (of plants) with their root hairs lie between particles of soil immersed in water.

23. The protoplasm within the epidermal cells, including the root hairs, contains more substances in solution, such as sugars and organic acids, than the water in the soil (in which the root hairs are immersed).

24. The cell membrane (of the root hair cells) acts as a differentially permeable membrane which permits the flow of water through it, but does not permit the dissolved substances of the cell to flow out. The result is that the water diffuses into the cell by osmosis through the cell membrane.

25. The water (that passes through the root hair cell membrane) moves first into the root hair cells and other epidermal cells that surround the root. This increases the water concentration of these

cells over that of the cells next to them inside of the root. Osmosis again occurs and water moves through the epidermal cells into these adjacent cells.

26. A repitition of this process of osmosis from cell to cell toward the center of the root brings the water eventually to the xylem cells of the vascular bundle in the center of the root.

30. The cells surrounding the xylem of the vein (of the leaf) receive water from the xylem.

35. In the leaves minerals in solution move from the veins into the palisade and spongy cells by diffusion.

MEAN SCORE 2.01 - 2.50

8. This separating force (acting on molecules) is heat energy.

9. When sugar (for example) is dry, the attractive or cohesive force of the molecules on each other is greater than the dispersing force and they cling together in crystals of sugar.

10. When the crystals (of sugar) are moistened with water, the bonds that hold the molecules together are loosened and they separate.

12. Whenever collision occurs the molecule moves in another direction, in a straight line again, until it bumps into something else.

27. The water is conducted upward by capillarity, root pressure, and other forces through the xylem of the root to the xylem of the stem, through the xylem of the stem, branches, and leaf stems until it eventually reaches the leaves.

28. The water evaporates from the surface of the spongy and palisade cells of the leaf. This evaporation is known as transpiration.

31. The xylem of the veins (of the leaf) is connected directly with that of the leaf-stem which is connected with the xylem of the stem. The stem xylem is connected with the root xylem.

32. Movement of the water upward through the xylem ducts is due in part to capillarity, root pressure, and other forces not fully understood.

34. Minerals are conducted upward into the leaves by the xylem of the roots, stems, leaf-stems, and veins.

Principle VIII - The synthesis of fats and proteins and carbohydrates other than glucose is a sequel to photosynthesis which makes matter and energy available to living things.

MEAN SCORE .5 - 1.50

3. The glucose may also be changed directly into double sugar or starch and stored in the leaves or it may be transported in the phloem to some other part of the plant and there stored as sugar or starch.

4. (The glucose) may also be changed into fat, which may be stored.

5. Finally other chemical elements may be added and the glucose changed into protein, which is used to build more protoplasm for the plant cells or stored.

MEAN SCORE 1.51 - 2.00

1. The glucose formed within the plant cell (by photosynthesis) may be oxidised (combined with free oxygen), and the chemical energy which is released is used by the plant.

2. The energy used by plants cannot be taken directly from the sunlight but must be released by oxidation from a food molecule just as in animals.

MEAN SCORE 2.01 - 2.50

6. In normal growth and development of plants food is stored in roots, stems, leaves and fruits.

AREA V

Utilization of Matter and Energy: Unit 1, Foods and Digestion

The Specific Objectives

1. To classify energy-containing foods as to their general characteristics and their specific actions.
2. To realize the significance of vitamins and the importance of water and mineral salts in the diet.
3. To understand the basic significance of the digestive processes.

Principles

1. Food is the only form in which matter can be utilized by living things.
2. The chemical energy of organic food is the only form in which energy is utilizable by the metabolic activities of organisms.
3. Solubility and diffusibility are prerequisites for the absorption of foods.
4. Digestion results in organic foods' being changed into their soluble and diffusible components.
5. Water is a basic medium for life processes.

The Assignment

Biological Science Lecture Syllabus, pp. 18-21, 31-33.

Principle I - Food is the only form in which matter can be utilized by living things.

MEAN SCORE .5 - 1.50

1. Food is any material that can be used by living things to maintain the normal state of protoplasm.

2. Some foods furnish energy and some foods provide building materials, while others aid in different ways in the metabolism of the body.

3. Foods include the organic foods- carbohydrates, fats, proteins and vitamins- and the inorganic foods- minerals, water, oxygen and carbon dioxide.

5. The carbohydrates supply living things with their main source of energy.

18. Fats are another good source of energy for living organisms.

25. Proteins are used as building materials for the protoplasm of the body but may also be used as a source of energy.

29. The molecules (of proteins) are formed by the union of simpler molecules called amino acids.

39. Vitamins are organic compounds required of living organisms in very minute amounts, but whose absence causes nutritive deficiency diseases.

69. Water and minerals are the essential inorganic minerals.

MEAN SCORE 1.51 - 2.00

4. Common foods such as meat, fruits and vegetables are mixtures of the basic food substances.

6. Carbohydrates include sugars, starches, glycogens and celluloses.

19. Fats are contained in quantities in such foods as vegetable oils, nuts, butter, cream, lard, bacon and other fatty meats.

20. The elements carbon, hydrogen and oxygen make up the fat molecule, but the hydrogen and oxygen are not in the ratio of H_2O as in carbohydrates.

22. Because fats are less oxidized than carbohydrates, they contain more energy per unit of weight.

24. Fats are formed by the union of fatty acids and glycerol, which are relatively simple molecules that have the building-block relationship to complex fat molecules that the simple sugar molecules, such as glucose or fructose have to the complex carbohydrates.

26. Foods high in protein content are lean meats, eggs, gelatin, cheese and nuts.

27. Proteins contain the chemical element nitrogen as well as carbon, hydrogen and oxygen.

30. The amino acids have the same relationship to protein molecules that the simple sugars have to complex carbohydrates and that fatty acids and glycerol have to fats.

31. Amino acids combine in infinite ways to form the large and complex protein molecules that make up the major proportion of living protoplasm.

35. The amino acids combine in different proportions to form many different kinds of proteins found in living things.

42. With the exception of vitamin D, the primary source of vitamins in nature is plants.

45. Vitamin A is essential for normal growth, for the maintenance of healthy epithelial tissues, and for the prevention of night blindness.

49. Vitamin B is necessary for normal metabolism, for the prevention of pellagra and to maintain healthy nerves.

66. Vitamin K is essential for the normal clotting of blood.

70. Life as we know it would be impossible without water.

71. The minerals necessary for organisms include calcium, magnesium, potassium, and sodium in combination with chloride, phosphate and carbonate.

72. Small amounts of iron, copper, cobalt, iodine, fluorine, manganese, and zinc are also necessary (in the diet).

MEAN SCORE 2.01 - 2.50

7. Chemically the carbohydrates are all fundamentally alike in that they are all composed of the three elements - carbon, hydrogen and oxygen.

8. There are usually six (or multiples of six) atoms of carbon in the carbohydrate molecule and the hydrogen and oxygen are usually present in the same proportion as in water, that is, 2 parts of hydrogen to 1 of oxygen (H_2O).

9. The formula for glucose ($C_6H_{12}O_6$), which is a simple sugar, illustrates this molecular relationship (in the carbohydrate molecule).

10. There are three classes of carbohydrates - simple sugars, double sugars, and complex carbohydrates.

16. By combining many simple sugar molecules in the same fashion complex molecules of starch, glycogen or cellulose can be formed.

21. In fats there is less oxygen in proportion to the hydrogen than in the case of carbohydrates.

28. Phosphorus and sulfur are often contained in the molecules (of protein).

32. Amino acids are recognized chemically by the grouping together of nitrogen and hydrogen as NH_2.

36. In man the proteins in the cells of different organs vary one from another.

43. Vitamin A is found in animal products such as egg yolk, butter, and cod-liver oil.

44. Certain pigmented plants such as carrots, squash, sweet potato and yellow corn contain a yellow pigment, carotene, which can be transformed by some animals into vitamin A.

46. Vitamin B is found in many plants, particularly in bran, wheat embryo and yeast.

48. Milk, oysters and lean pork are animal sources of vitamin B.

50. Vitamin B causes root growth in plants.

51. The effects of a deficiency of vitamin B on the nervous system vary from mold nervous disorders to the more severe symptoms found in beriberi.

53. Vitamin C is present in fresh fruits, particularly citrus fruits.

54. In the absence of vitamin C, scurvy develops.

55. Scurvy is a degenerative disease affecting many parts, including the teeth and bones.

57. Vitamin D is abundant in the liver oils of various fish, particularly cod and halibut.

58. Irradiation of milk, yeast and certain plant and animal fats will produce calciferol.

59. Human beings can synthesize vitamin D if the skin is exposed to direct sunlight.

60. Vitamin D is necessary for the absorption of calcium and phosphate from the intestine.

61. The absence of vitamin D results in a bone disease known as rickets.

65. The normal diet contains ample quantities of vitamin E.

67. Vitamin K is used to reduce bleeding in modern surgery.

68. Vitamin K is formed in the intestine by the action of bacteria on food residues and consequently is not needed as part of the diet.

MEAN SCORE 2.51 - 3.50

11. Glucose, fructose and galactose are simple sugars and have the formula $C_6H_{12}O_6$.

12. Maltose, lactose and sucrose or cane sugar are double sugars and have the formula $C_{12}H_{22}O_{11}$.

13. Starch, glycogen and cellulose are complex carbohydrates and have the formula $(C_6H_{10}O_5)$.

14. Two molecules of a simple sugar can combine to form one molecule of a double sugar. In this process one molecule of water is released.

15. When two molecules of a simple sugar combine to form one molecule of a double sugar the reaction can be written in chemical shorthand as follows: $C_6H_{12}O_6$ (simple sugar) + $C_6H_{12}O_6$ (simple sugar) $\rightarrow$ $C_{12}H_{22}O_{11}$ (double sugar) + H_2O (water)

17. The "n" in the formula for a complex carbohydrate $(C_6H_{10}O_5)n$ represents a high number (from 20 to 300) of simple sugar molecules that have combined to form the complex carbohydrate.

23. Fats are characterized also by being soluble in alcohol and ether and they feel greasy to the touch.

33. NH_2 is known as the amino group.

34. There are about twenty-three amino acids known.

37. There are also certain differences apparent in proteins of different individuals.

38. The proteins found in different species of animals and plants differ greatly.

40. The vitamins were first named alphabetically A, B, C, D, E and K, but these names are gradually being replaced by the chemical name of the substance as these become known.

41. Several of the vitamins have been synthesized in the laboratory and manufactured for commercial sale.

47. Vitamin B is a complex of several chemical substances.

52. Vitamin C is also known as ascorbic acid.

56. Vitamin D is known as calciferol.

62. Vitamin E is known chemically as tocopherol.

63. Vitamin E is probably essential for the maintenance of normal reproductive activites.

64. Vitamin E is found in wheat germ oil and in germ oil of other grains.

Principle II - The chemical energy of organic food is the only form in which energy is utilizable by the metabolic activities of organisms.

MEAN SCORE .5 - 1.50

1. Chemical energy can be stored in molecules.

2. Green plants have the ability to take the light energy of the sun and convert it into chemical energy.

4. Within the glucose molecule produced by the green plant is the energy which has been converted from light energy into chemical energy.

5. Fats and proteins also contain stored energy.

6. To use this stored energy (in organic foods) living things break the bonds that hold the atoms of the molecule together and the energy is released.

7. Thus the energy that is used by living things to carry on the process of life is the chemical energy stored in molecules of carbohydrates, fats and proteins.

MEAN SCORE 1.51 - 2.00

3. Green plants use carbon dioxide and water and combine them into molecules of glucose.

Principle III - Solubility and diffusibility are prerequisites for the absorption of foods.

MEAN SCORE .5 - 1.50

1. Food is stored in the form of large, complex, insoluble molecules in both plants and animals and cannot be used until the molecules are made simpler and soluble in water.

2. Neither plants nor animals can transport food material through the body except in a soluble form.

3. Food cannot be used for energy nor for building protoplasm unless it is in a simple molecular form.

4. Splitting complex molecules into simple ones, which makes them soluble in water, is called digestion.

Principle IV - Digestion results in organic foods being changed into their soluble and diffusible components.

MEAN SCORE .5 - 1.50

1. Splitting complex molecules into simple ones, which makes them soluble in water is called digestion.

3. The process of digestion is facilitated by the action of enzymes.

4. Enzymes are organic catalyst produced by living cells which speed up or slow down chemical reactions without themselves being used up.

5. In the process of digestion enzymes speed up the chemical reactions.

7. In digestion water is added chemically.

MEAN SCORE 1.51 - 2.00

2. Digestion is essentially the same in both plants and animals.

6. In the process of digestion enzymes enable the chemical reactions to take place at relatively low temperatures.

10. In plants digestion occurs through enzyme action wherever food is stored.

12. After digestion the food is soluble and can be transported, usually through the phloem, to the part of the plant that needs the energy or building material.

14. The process of digestion in animals is fundamentally the same in all forms.

22. The ameba protoplasm surrounding the food vacuole secretes digestive enzymes into the vacuole which digest the food and thus make it soluble.

23. In the ameba, digested food in the vacuole is then absorbed through the vascuolar membrane into the protoplasm, where it is utilized for energy production or to build more protoplasm.

24. The essential features of the processes associated with food getting in the ameba are (1) food intake (2) secretion of digestive enzymes by the protoplasm through the membrane surrounding the vacuole, (3) breakdown of complex food molecules by the enzymes into simpler soluble molecules, (4) absorption of the soluble molecules through the vacuolar membrane into the protoplasm of the cell.

MEAN SCORE 2.01 - 2.50

8. The chemical equation for the digestion of starch is:

$$\underset{\text{starch}}{(C_6H_{10}O_5)m} + \underset{\text{water}}{nH_2O} \longrightarrow \underset{\text{simple sugar}}{mC_6H_{12}O_6}$$

11. Digestion in plants may occur in the roots, stems, leaves or seeds.

13. The growing tips of roots or stems are the usual destination of such soluble energy-containing foods.

15. Before digestion can take place in an animal, it must eat either plant material or another animal that has already fed on plants.

16. The simplest illustration of the fundamentals of food intake and digestion is found in a single celled animal, the ameba.

21. The food vacuole of the ameba acts as a digestive structure.

MEAN SCORE 2.51 - 3.50

9. There is no digestive system in plants.

17. The ameba is microscopic in size, lives in water, is composed of one cell only, and moves by a flowing of the protoplasm.

19. When a food particle is met in the wanderings of the ameba, two or more protoplasmic processes move toward and around the food until it is completely surrounded. The processes also close over the top and bottom of the food until it is completely surrounded.

20. The surrounding of the food particle by the protoplasm of the ameba forms a space inside the cell which contains water and the food particle. This space is known as the food vacuole.

MEAN SCORE 3.51 - 4.50

Item number 18. Content may be obtained from Appendix II.

Principle V - Water is a basic medium for life processes.

MEAN SCORE .5 - 1.50

1. The protoplasm of which cells are made is from 60 to 90 per cent water.

2. Food is stored in the form of large, complex, insoluble molecules in both plants and animals, and cannot be used until the molecules are made simpler and soluble in water.

6. Water is part of the protoplasm and of all body fluids.

7. Life as we know it would be impossible without water.

MEAN SCORE 1.51 - 2.00

3. All forms (of life) require a certain amount of water, but some require less than others.

MEAN SCORE 2.01 - 2.50

4. Chemicals dissolved in water also have an effect on the kinds of organisms living in any area.

5. Water comprises over 60 per cent of the human body by weight.

AREA V

Utilization of Matter and Energy: Unit 2, Organ Systems

The Specific Objectives

1. To understand the structural characteristics of the digestive, respiratory and excretory systems which function directly in the intake-outgo activities of living things.
2. To understand the significance of these organ systems to the organism as a whole.

Principles

1. The exchange of matter between organisms and the environment is accomplished in the simpler organisms by the physical process of diffusion almost exclusively. In the complex multicellular animals, supplementary specializations of tissues and organs evolved to effect the intake-outgo activities.
2. The specializations in the digestive process which evolved to meet the organism's requirements are those involved in (1) the mechanical subdivision of foods (2) the increased secretion of digestive fluids (3) the stirring of the digestive tract contents (4) the absorption of the end products of digestion and (5) the reabsorption of water from the fecal wastes.
3. Respiratory organ systems evolved to effect adequate gaseous exchanges between the organism and the environment. All respiratory organs are characterized by having sufficiently large areas of thin, moist membranes richly supplied with blood vessels to meet the oxygen intake and carbon dioxide outgo demands of the organism. The air-breathing organisms possess a system of tubes which permit a more ready diffusion of gases to and from the respiratory surfaces.
4. Excretory organ systems evolved to maintain normality in the chemical composition of the fluids comprising the internal environment of the organism. In the multicellular animals this is accomplished by a system of tubes and channels of varying degrees of complexity which permit the outgo of metabolic wastes filtered from the blood or other body fluids to the external environment.

The Assignment

Biological Science Lecture Syllabus, pp. 33-42, 55-63.

Principle I - The exchange of matter between organisms and the environment is accomplished in the simpler organisms by the physical process of diffusion almost exclusively. In the complex multicellular animals, supplementary specializations of tissues and organs evolved to effect the intake-outgo activities.

MEAN SCORE .5 - 1.50

3. Associated with the digestive tube (in man) are several glands, which secrete enzymes and other essential materials necessary for digestion.

6. The fundamental method of obtaining oxygen and removing carbon dioxide is the same for both land and water animals, though the details of the mechanism may differ.

7. The fundamental method of obtaining oxygen and removing carbon dioxide in both land and aquatic animals is diffusion through a moist cell membrane.

8. The cell membrane must be moist or diffusion through it cannot occur.

MEAN SCORE 1.51 - 2.00

1. Man is a complex animal made of billions of cells, some of which are specialized and combined to form a digestive system.

2. The digestive system (in man) is a tube extending from mouth to anus through which the food must pass to be digested.

4. Practically all animals must take in free oxygen and must get rid of carbon dioxide.

5. The immediate source of oxygen and the place of disposal for carbon dioxide is air for land animals and water for aquatic animals.

9. The simplest example of the mechanism (of diffusion) is a single-celled organism, such as the ameba.

12. Cellular respiration in the ameba removes the free oxygen from the cell with the result that the concentration of oxygen within the cell is below that of oxygen in the water outside. Therefore, the oxygen diffuses from the water through the moist cell membrane into the protoplasm of the cell.

13. Cellular respiration in the ameba also produces carbon dioxide, which accumulates within the cell in quantities greater than those present in the water outside the cell membrane. Therefore, carbon dioxide diffuses out of the cell through the moist cell membrane into the surrounding water.

MEAN SCORE 2.01 - 2.50

10. The cell membrane of the ameba is covered with water in which the ameba normally lives, and this water contains oxygen dissolved in it.

11. Oxygen is also present within the cell, where it is used in cellular respiration.

Principle II - The specializations in the digestive process which evolved to meet the organism's requirements are those involved in (1) the mechanical subdivision of foods (2) the increased secretion of digestive fluids (3) the stirring of the digestive tract contents (4) the absorption of the end products of digestion and (5) the reabsorption of water from the fecal wastes.

MEAN SCORE .5 - 1.50

1. The (human) digestive system is a tube extending from mouth to anus through which the food must pass to be digested.

2. Associated with the tube are several glands, which secrete enzymes and other essential materials necessary for digestion.

8. Food in the mouth is partly digested by the action of an enzyme secreted by the salivary glands.

53. The folds and villi serve to increase the surface area of the (intestinal) epithelium, and thus to increase the digestive and absorptive capacity of the intestine.

62. Bile emulsifies the fats, breaking them up into small droplets.

63. The emulsification process increases the surface area of the fat globules and thus aids the fat digesting enzymes in their work.

66. The pancreas secretes three kinds of digestive enzymes into the small intestine. They are protein-digesting, fat-digesting, and carbohydrate-digesting enzymes.

67. Glands in the walls of the intestine also secrete protein and carbohydrate-digesting enzymes.

71. The amino acids and simple sugars are absorbed through the epithelium of the small intestine, into small blood vessels, the capillaries.

72. Glycerol and fatty acids go not into the capillaries, but into the branches of the lymphatic system located in the villi.

74. The amount of absorption possible (from the small intestine) is dependent on the surface area of the epithelium.

85. However, a more important function of the large intestine (than the absorption of digested food) is the absorption of water.

MEAN SCORE 1.51 - 2.00

3. The (digestive) tube is divided into the following parts: mouth, throat, esophagus, stomach, small intestine, large intestine, rectum and anus.

4. The major glands that secrete into the tube are salivary glands, gastric glands, liver, pancreas, and intestinal glands.

7. Food is taken into the mouth, where it is broken up by the chewing action of teeth, tongue and cheeks.

9. Chewing increases the area exposed to the action of enzymes and speeds up digestion.

10. The salivary glands also secrete mucin, which mixes with the food to make the particles stick together in small balls and to slide more easily down the throat.

23. The pharynx is a common passage way for food and air.

25. The esophagus is a tube that connects the pharynx with the stomach.

34. The stomach is an enlarged portion of the digestive tube.

35. The stomach acts in part as a sac or reservoir for the temporary storage of food.

36. The inside of the stomach is lined with an epithelium and thousands of glands.

37. The glands of the stomach are of two kinds, those that secrete digestive enzymes and those that secrete hydrochloric acid.

40. The squeezing action (of the stomach) churns the food and breaks it up even more than occurred in the mouth.

41. The squeezing action of the stomach also forces the food into the small intestine.

42. The enzymes secreted by the glands in the stomach wall act on proteins only.

43. The enzymes produced by the glands in the wall of the stomach act only in an acid medium, hence the necessity of hydrochloric acid in the stomach.

44. Practically no food is absorbed in the stomach.

45. After the food has remained in the stomach for three or four hours and has been churned and acted upon by ensymes it is forced into the small intestine by a peristaltic wave of the stomach wall.

46. The small intestine is a continuation of the digestive tube.

51. Digestive glands lie in the wall (of the small intestine) beneath the epithelium and secrete into the cavity of the tube.

52. The inside walls (of the small intestine) are folded and on these folds finger-like villi project into the intestinal cavity.

55. The intestinal walls contain many blood vessels and nerves.

57. The food and digestive juices are thoroughly mixed and churned in the small intestine by peristalsis and the pumping action of the villi.

58. After a period of churning (in the small intestine) the food is pushed along toward the large intestine.

59. The liver is a large gland that lies in the anterior portion of the abdominal cavity.

60. One of the liver's many functions is to secrete bile into the small intestine by way of the bile duct.

61. The bile mixes with the food as it enters the small intestine from the stomach.

68. Digestion of protein changes them to amino acids.

69. Digestion of carbohydrate produces glucose and other simple sugars.

70. Digestion of fats results in glycerol and fatty acids.

73. The lymphatic system is part of the circulatory system.

75. Because the amount of absorption from the small intestine is dependent on the surface area of the epithelium, the folded inner lining of the intestine and the finger-like villi are significant. They increase the surface area.

76. After digestion and absorption have taken place, the undigested residue plus some unabsorbed food and water pass into the large intestine.

82. No digestive ensymes are produced by the large intestine.

83. Some digestion and absorption occurs in the large intestine.

86. Absorption removes most of the water from the large intestine.

87. The food residues become fecal matter (feces).

MEAN SCORE 2.01 - 2.50

6. Posteriorly (to the rear) the mouth opens into the pharynx or throat.

12. The tongue aids in chewing by pushing the food between the teeth. The cheeks function in the same manner on the other side of the teeth.

13. The upper surface of the tongue is rough and contains numerous papillae, at the base of which are taste buds.

22. The pharynx lies just behind the mouth.

27. The esophagus contains two layers of muscle tissue in its walls.

28. Swallowing moves the food from the mouth into the esophagus and then into the stomach.

29. When swallowing occurs the food is moved to the back of the tongue. The throat muscles contract and push it into the esophagus, which in turn pushes it into the stomach.

30. The movement of the food through the esophagus is caused by the action of the muscle layers in the wall of the esophagus.

31. The action of the muscle layers of the wall of the esophagus is called peristalsis and is the same sort of action that occurs when one squeezes toothpaste out of a tube.

32. (During peristalsis) the muscles in front of the moving ball of food relax, while those behind it contract.

33. Both relaxation and contraction start at the upper end of the esophagus and continue toward the stomach. The food is pushed along by the squeezing action of the contracted wall of the esophagus.

47. The small intestine is smaller, though longer, than the stomach.

48. The pylorus, a ring-like band of muscle, separates the stomach and the small intestine.

49. The pylorus controls the passage of food from the stomach to the small intestine.

50. The small intestine is lined, like the stomach, with an epithelium.

64. The pancreas lies between the anterior portion of the small intestine and the stomach.

65. The pancreas is connected to the small intestine by a duct.

77. The structure of the large intestine is basically the same as the small intestine.

78. The large intestine has an epithelium lining the wall and two layers of smooth muscle tissue that make up the bulk of the wall of the tube.

79. There are no villi in the large intestine.

84. A certain amount of undigested food plus the enzymes pass into the large intestine. The enzymes continue to act and the digested foods are absorbed through its walls.

88. The large intestine contains a large number of bacteria that act upon and break down farther whatever is left over after digestion.

89. The residue (in the large intestine) varies with the diet but usually consists of cellulose from plant foods, tough connective tissue from meat, and some fats.

92. This (movement of feces into the rectum) exerts a pressure on the walls of the rectum which causes a peristaltic wave to pass over the entire large intestine to the anus.

94. (Peristalsis and straining provide the stimulus), the anal sphincter relaxes and the fecal matter then passes through the anus.

MEAN SCORE 2.51 - 3.50

5. The lips form the anterior (forward) boundry of the mouth. The palate forms the roof and the cheeks form the side walls. The floor is occupied by the tongue.

11. The tongue is a muscular organ that fills the floor of the mouth.

14. There are four tastes: sweet, sour, salt and bitter.

15. There are three pairs of salivary glands.

16. One pair (of salivary glands) lies below and in front of the ears.

17. A duct from each (of the salivary glands lying below and in front of the ears) opens into the mouth opposite the second upper molar tooth.

18. The second pair (of salivary glands) lies in the posterior part of the floor of the mouth.

21. The salivary glands beneath the tongue have a number of ducts that open along the side of the tongue.

24. The tonsils and adenoids are embedded in the walls of the pharynx.

26. The esophagus is lined with an epithelium.

38. The wall of the stomach contains three layers of smooth muscle tissue.

39. The muscle tissue in the wall of the stomach squeezes the stomach into a variety of shapes.

54. The intestinal walls contain two layers of smooth muscle.

56. Connective tissue binds the various structures of the small intestine together.

80. The junction of the small and large intestines is not a direct end to end union, for the small intestine connects with the large intestine a short way up from the anterior end of the large intestine.

81. The end of the large intestine that extends beyond the connection (with the small intestine) has a small finger-like appendage called the vermiform appendix.

90. The odor of feces is due to the products of bacterial action.

91. Peristalsis moves the fecal matter into the lower end of the intestine and into the rectum at the posterior end of the digestive tube.

93. Straining adds to the pressure on the feces by contraction of the diaphragm and the abdominal muscles.

MEAN SCORE 3.51 - 4.50

Item numbers 19 and 20. Content may be obtained from Appendix II.

Principle III - Respiratory organ systems evolved to effect adequate gaseous exchanges between the organism and the environment. All respiratory organs are characterized by having sufficiently large areas of thin, moist membranes richly supplied with blood vessels to meet the oxygen intake and carbon dioxide outgo demands of the organism. The air-breathing organisms possess a system of tubes which permit a more ready diffusion of gases to and from the respiratory surfaces.

MEAN SCORE .5 - 1.50

1. Practically all animals must take in free oxygen and must get rid of carbon dioxide.

2. The immediate source of oxygen and the place of disposal of carbon dioxide is air for land animals and water for aquatic animals.

3. The fundamental method of obtaining oxygen and removing carbon dioxide is the same for both types (land and aquatic animals) though the details of the mechanism may differ.

4. The fundamental method of obtaining oxygen and removing carbon dioxide is diffusion through a moist cell membrane.

5. The cell membrane must be moist or diffusion through it cannot occur.

18. Tissue fluids surrounds both capillaries and cells, so the oxygen diffuses through this tissue fluid to the cell.

20. The blood is returned (from all parts of the body) to the gills, where carbon dioxide diffuses out into the surrounding water.

21. Lungs are sacs contained within the thorax and their inner walls are lined with a thin, moist, cellular membrane.

22. Just beneath the moist cellular lining (of the lungs) are millions of blood capillaries.

49. The exchange of oxygen and carbon dioxide in the lungs takes place in the lining of the air sacs.

64. The inhaled air eventually reaches the air sacs, whose walls are thin and moist and contain capillaries. The air contains a greater concentration of oxygen than does the blood flowing through the capillaries, so the oxygen diffuses into the blood.

65. The concentration of carbon dioxide in the air sacs of the lungs is less than that in the blood, so it (the carbon dioxide) diffuses in the opposite direction, that is, from the blood of the capillaries to the air spaces in the air sacs.

MEAN SCORE 1.51 - 2.00

7. The cell membrane of ameba is covered with the water in which the ameba normally lives, and this water contains oxygen dissolved in it.

8. Oxygen is also present in the cell (body of the ameba) where it is used in cellular respiration. Cellular respiration removes the free oxygen from the cell with the result that the concentration of oxygen within the cell is below that of the oxygen in the water outside. Therefore, the oxygen diffuses from the water through the moist cell membrane into the protoplasm of the cell.

9. Cellular respiration (also) produces carbon dioxide, which accumulates within the cell in quantities greater than those present in the water outside the cell membrane. Therefore, carbon dioxide diffuses out of the cell through the moist cell membrane into the surrounding water.

10. Some aquatic animals such as fish and lobsters have special structures called gills for obtaining oxygen from the water and for releasing carbon dioxide.

11. Gills are composed of many finger-like filaments through which blood flows in capillaries.

12. The outer layer of a (gill) filament is composed of a thin, cellular membrane that lies over and is adjacent to the cellular wall of the capillary.

13. The aquatic animal lives in water which contains dissolved oxygen. This water flows over the surface of the filaments. The concentration of oxygen in the water is greater than in the blood flowing through the capillaries, so diffusion of oxygen takes place from the water through the moist cellular surface of the filament and through the equally moist cellular wall of the capillary into the blood.

14. Carbon dioxide is more concentrated in the capillary blood (of the gill filaments) than in the surrounding water and therefore diffuses out (into the surrounding water).

15. Several moist cell membranes are involved in this mechanism (of gaseous exchange in a gill bearing animal), but the underlying principle is the same as in the single-celled organism.

16. When blood leaves the gills by way of the vessels it carries oxygen to the tissues of the body.

17. The cells of these (body) tissues use oxygen in cellular respiration and thereby keep the concentration of oxygen in the cells reduced below that of the blood flowing through the adjacent capillaries. Diffusion again occurs and oxygen moves from the blood through the capillary wall, then through the cell membrane to the protoplasm of the cell.

19. Carbon dioxide is produced by cellular respiration (in aquatic gill bearing animals) just as in the case of the ameba, with the result that the concentration in the cell is higher than in the blood flowing through the capillaries. Diffusion takes place from the cell to the capillary blood.

23. The lining of the lungs is kept moist by the tissue fluid which always surrounds cells within the body.

24. The lungs of land animals differ in complexity but all are basically alike.

25. The human respiratory system is a type of complex respiratory mechanism.

26. The human respiratory system is composed of two major parts, the first is a series of tubular structures that serve to transport air into and out of the lungs. The second is a paired organ for absorption of oxygen and elimination of carbon dioxide. The two parts of this paired organ comprise the lungs.

46. The walls of the air sacs (of the lungs) are thin and contain millions of blood capillaries.

54. Breathing consist of inhaling and exhaling, or the movement of air into and out of the lungs.

55. Inhalation results when the air pressure within the lungs falls below atmospheric pressure, with the consequence that atmospheric pressure pushes air into the lungs.

66. Oxygen is transported by the hemoglobin contained in the red blood corpuscles.

72. Carbon dioxide is transported in the blood by both red corpuscles and plasma.

73. Carbon dioxide is produced in the cells of the body, where it is picked up by the blood; then it is carried to the lung capillaries. From the lung capillaries it diffuses into the air spaces of the air sacs and is breathed out.

76. In plants, the transport of oxygen to respiring cells and the transport of carbon dioxide away from them is by diffusion.

MEAN SCORE 2.01 - 2.50

6. The simplest example of the mechanism (of gaseous exchange) is a single-celled organism such as the ameba.

27. Inside of the nose and extending back into the head is the paired nasal cavity.

28. The paired nasal cavity is lined with a moist epithelium.

29. The nasal cavity opens into the pharynx.

30. The pharynx (throat) is a common passageway for air and food.

31. The larynx opens into the pharynx just in front of the esophagus.

38. The trachea is a cylindrical tube that extends from the larynx into the chest cavity.

40. The trachea is lined with a moist, ciliated epithelium.

42. The trachea branches within the chest cavity into right and left primary bronchi, which are smaller, but otherwise similar to the trachea.

43. The primary bronchi branch into secondary bronchi, which branch and rebranch, eventually forming microscopic tubules.

44. The microscopic air tubules end in small air sacs.

50. The thoracic cavity contains the lungs.

56. The pressure within the lungs is lowered by enlarging the thoracic cavity.

57. Enlarging the thoracic cavity is accomplished by moving the walls of the thoracic cavity out and by lowering the floor.

60. Exhalation is accomplished by the collapse of the lungs.

61. The lungs contain elastic tissue which stretches when they expand during inhalation. When the chest muscles and the diaphragm relax, both the walls and the floor of the chest cavity return to their original position. This releases the stretching pressure on the lungs and they collapse much like a leaky balloon.

63. The lungs are not to be thought of as empty sacs similar to one rubber balloon, but rather to millions of tiny balloons held together in a compact mass. Each of the tiny balloons has an air tube connecting it to the main passageway.

67. Hemoglobin is a red pigment that unites easily with oxygen, forming the compound oxyhemoglobin.

68. The oxygen also becomes separated from the hemoglobin easily under certain conditions.

69. In the lung capillaries the oxygen combines with hemoglobin, forming oxyhemoglobin and as such travels back to the heart to be distributed throughout the body.

70. Finally it (the oxyhemoglobin) reaches the tissues of the body where there is little or no oxygen. The oxygen then separates from the hemoglobin and diffuses into the cells.

71. (After the oxygen separates from the hemoglobin) the hemoglobin in the red cells continues on into the veins through the heart and back to the lungs; where it picks up another load of oxygen and carries it to the tissues again.

75. There are no special structures to transport gases in plants though there are openings such as the stomates in leaves and lenticels in bark which permit the air to enter and leave.

77. The carbon dioxide that the plant cells use in photosynthesis also is transported by diffusion.

MEAN SCORE 2.51 - 3.50

32. The larynx is a cylindrical structure with cartilage in its walls.

33. In the male some of these cartilages (in the larynx) protrude, forming the adam's apple.

34. Within the larynx are the vocal cords, which are connective tissue bands which stretch across the cavity of the larynx.

35. The glottis is the opening of the larynx into the pharynx.

36. The epiglottis is a flap of cartilage that extends upward for a short distance into the pharynx.

37. During swallowing the epiglottis forms a cover for the glottis and prevents food or water from entering the larynx.

39. The walls of the trachea contain C-shaped cartilagenous rings that keep the trachea permanently open.

41. The microscopic cilia on the pithelium beat toward the pharynx and remove inhaled foreign particles.

45. The air sacs attached to the microscopic tubules superficially resemble a bunch of grapes.

47. The capillaries in the walls of the air spaces of the lungs are supported by connective tissue, some of which is elastic.

48. Whether the air sacs (of the lungs) are lined with an epithelium is an open question.

51. The thoracic cavity is divided into right and left pleural cavities by a thick median partition.

52. Each pleural cavity contains a lung.

53. The muscular diaphragm forms the floor of the thoracic cavity and separates it from the abdominal cavity.

58. The ribs lie within the walls of the thoracic cavity. Contraction of certain chest muscles which are attached to the ribs causes the ribs to swing out and produce a lateral enlargement of the cavity.

59. The floor of the thoracic cavity is made up of the muscular diaphragm. It is dome shaped, with the dome extending upward into the cavity. Contraction of the diaphragm flattens the dome and enlarges the space within the cavity.

62. The analogy with the balloon is not quite exact because each air sac increases and decreases in size during breathing. The entire lung increases and decreases in size accordingly.

74. The xylem and phloem which make up the vascular bundles are the main conducting tissues in plants.

Principle IV - Excretory organ systems evolved to maintain normality in the chemical composition of fluids comprising the internal environment of the organism. In the multicellular animals this is accomplished by a system of tubes and channels of varying degrees of complexity which permit the outgo of metabolic wastes filtered from the blood or other body fluids to the external environment.

MEAN SCORE .5 - 1.50

1. Metabolic processes in the body result in the production of useless or harmful materials that must be eliminated.

4. The nitrogen-containing wastes are excreted by the kidneys and leave the body as urine.

5. The kidneys also regulate the composition of the blood, particularly with respect to water and glucose.

14. The blood carries waste materials from the body cells to the kidneys.

MEAN SCORE 1.51 - 2.00

2. Carbon dioxide produced in the cells is eliminated by the lungs.

3. Food residue is elininated as feces from the digestive tract.

6. The (human) urinary system consist of two kidneys, two ducts known as ureters, which drain urine from the kidneys, the bladder, which is a reservoir for urine, and a single duct, the urethra, which carries urine from the bladder to the outside of the body.

8. Each kidney is composed of many small renal units which collectively secrete the urine.

9. Each renal unit consists of a small ball of capillaries, the glomerulus, through which blood containing nitrogenous waste flows.

12. Each renal tubule connects with other renal tubules which come from other capsules to form a larger duct that empties into a chamber in the central part of the kidney.

13. The ureter is attached to the central chamber of the kidney.

15. Within the kidneys the blood (containing nitrogenous wastes) flows through the glomeruli within the many glomerular capsules.

16. The pressure of the blood causes the fluid of the blood plus the wastes and other substances in solution (mainly glucose) to filter through the capillary walls into the cavity of the capsule.

17. This liquid (glomerular filterate), which is really blood minus the cells and the larger plasma proteins, passes into the tubule that drains the capsule.

18. As the liquid (glomerular filterate) passes through the tubule the cells lining its walls extract most of the water and dissolved substances, leaving the wastes and some water. This is urine.

19. It (urine) leaves the kidneys by way of the ureter which carries it to the bladder.

20. The urethra carries it (urine) from the bladder to the outside (of the body).

23. Carbon dioxide produced by cellular respiration may be eliminated also by diffusion if it is not used in photosynthesis.

MEAN SCORE 2.01 - 2.50

7. The kidneys are bean-shaped structures about four and one-half inches in length that lie along the dorsal wall of the abdominal cavity.

10. The glomerulus is surrounded by a microscopic cup-shaped structure, the glomerular capsule.

11. A small tube, the renal tube is attached to the glomerular capsule.

21. Plants have no special system to carry on the function of excretion.

22. The excess oxygen produced during photosynthesis diffuses out through the stomates of the leaves.

24. Other wastes are stored in various parts of the plant.

25. These wastes (of the plant) include oils, gums, resins, organic acids, tannins, alkaloids, pigments and certain useless minerals.

AREA V

Utilization of Matter and Energy: Unit 3, Cells and the Internal Environment

The Specific Objectives

1. To gain an understanding of the structure and functions of blood.
2. To know the substances transported by blood and the functions of these substances.
3. To understand the relationship between the evolutionary development of organisms toward greater complexity and the development of transport systems.

Principles

1. Transport is a means of bringing food, gases, hormones and antibodies to place of utilization. It is also a means of removing wastes.
2. The fluids of the transport system constitute the immediate environment of living cells.
3. The evolutionary development of transport systems in organisms is correlated with an increase in organism size.

The Assignment

Biological Science Lecture Syllabus, pp. 42-55.

Principle I - Transport is a means of bringing food, gases, hormones and antibodies to place of utilization. It is also a means of removing wastes.

MEAN SCORE .5 - 1.50

1. The food that organisms use as a source of energy and for building body structures must be transported from the place of digestion and absorption to the various parts of the body where it is used.

2. The oxygen that is used to release the chemical energy contained in food must be transported from its place of entry to the many places of use.

3. Many other substances essential to normal functioning of the body must be carried from place to place.

4. Finally, the wastes products of living processes must be removed.

5. The chief method of transport used by all organisms, both plant and animal, is diffusion.

6. In some small organisms this (diffusion) alone is sufficient, but in larger forms diffusion is not fast enough and additional means of transport are necessary.

7. These (additional means of transport) include the blood and blood vessels of animals, the air tubes of land animals, and the conducting tissues of plants.

8. Blood is made of a liquid portion, the plasma, and a cellular part, the corpuscles.

86. The heart pumps the blood through the blood vessels to all parts of the body and back again.

92. The heart is constructed of four chambers called the right and left aurioles and right and left ventricles. A muscular wall separates the right and left sides of the heart.

127. The blood that picks up food from the digestive tract flows to the liver.

129. This (the fact that the blood from the digestive tract flows through capillaries in the liver) enables the liver to remove the excess glucose and amino acids before the blood goes to other parts of the body.

130. The capillaries are thin walled vessels that form an extensive network throughout all body tissues.

135. It is because of the large number of capillaries that oxygen and food can be quickly and efficiently transported to cells and wastes products can be carried away.

145. The lymph capillaries also carry fat from the small intestine.

MEAN SCORE 1.51 - 2.00

9. The plasma is mainly water containing several substances dissolved in it, among them blood proteins, mineral salts, food, wastes products, hormones, antibodies, and gases such as carbon dioxide and oxygen.

13. Lymph is a part of the blood that has left the vessels and filtered out into the tissues.

18. A red pigment known as hemoglobin, is contained within the corpuscles and is the means of transporting oxygen.

19. When free oxygen is abundant it readily forms with hemoglobin a loose chemical union which is as readily broken when the corpuscles enter areas in the body where there is a scarcity of oxygen.

85. The (human) circulatory system consist of heart, blood, blood vessels, and lymph vessels.

87. There are two circuits (to the circulatory system), the pulmonary and the systemic.

88. The pulmonary circuit carries the blood to the lungs and back to the heart.

89. The systemic circuit carries the blood to all other parts of the body including the head, visceral organs, arms, legs and body muscles. The blood following this circuit also returns to the heart.

90. The heart is a muscular pumping organ.

104. The contraction (of cardiac muscle) sends the blood into the vessels and relaxation permits the heart to fill with blood again.

105. The arteries carry blood away from the heart.

110. The smallest (arteries) connect directly to the capillaries in the tissues of the body.

117. The pulmonary artery carries blood from the right ventricle to the lungs, where the artery breaks up into minute capillaries.

118. The veins carry blood back to the heart.

122. Blood flowing through capillaries in the tissues is collected by the smallest veins. These connect to larger veins which in turn connect to still larger ones. The largest veins flow into the auricles of the heart.

128. In the liver the blood from the digestive tract passes through a network of capillaries before it returns to the heart.

131. The capillary walls are a single cell in thickness.

132. The capillary tubes are so small that red corpuscles must pass through them in single file.

133. The number of capillaries in any given area of tissue is very large.

136. Scattered through the tissues along with the blood capillaries are the lymph capillaries.

137. The lymph capillaries are constructed in the same way as blood capillaries, but they differ in that they are closed at one end.

138. At their open ends the lymph capillaries interconnect like the twigs of a tree, forming a branch which forms larger lymph vessels which in turn unite to form large lymph ducts.

139. The lymph ducts empty into certain large veins near the heart.

MEAN SCORE 2.01 - 2.50

10. The blood proteins are a part of the blood and are not to be considered as food being transported.

15. The blood corpuscles include the red corpuscles, the white corpuscles, and the platelets.

44. Stopping the flow of blood in one of the blood vessels of the heart prevents oxygen and food from getting to the heart muscle tissue.

50. The differences in human blood cause blood to be categorized into groups. These are known as the O group, the A group, the B group and the AB group.

58. Both antigens and antibodies are present in normal blood, having been produced during embryonic development.

93. The right auricle receives blood from the systemic circuit and sends it into the right ventricle.

94. From the right ventricle the blood is pumped to the lungs.

95. The left auricle receives the blood returning from the lungs and sends it into the left ventricle, which pumps it into the systemic circuit.

96. Valves guard the openings between the auricles and ventricles.

97. These valves (between auricles and ventricles) consists of flaps of tissue that act like an ordinary door; that is, they open in one direction only.

98. When the blood flows from the auricles to the ventricles, the valves are pushed open by the flow of blood, but when the ventricles contract, the blood cannot flow into the auricles because the valves are forced shut.

99. The arteries that carry blood away from the ventricles also contain valves.

100. The pulmonary valve is in the pulmonary artery and the aortic valve in the aorta.

101. These valves (in the arteries) open when blood flows out of the ventricles, but close when the blood attempts to flow back into the heart.

102. The walls of the heart are composed of a type of muscle tissue called cardiac muscle.

103. The outstanding feature of this (cardiac) muscle is that it contracts and relaxes alternately and thythmically.

106. The arteries are thick-walled blood vessels composed of three layers. The innermost layer is a thin, cellular layer called the endothelium. The middle layer is thicker and is composed of smooth muscle. The outside layer is composed of connective tissue.

108. The largest arteries are those leading from the ventricles.

109. The larger arteries branch and rebranch, gradually getting smaller and smaller until they are quite minute in the tissues.

111. The major systemic artery is the aorta that carries blood from the left ventricle.

113. Branches from the aorta at the bend carry blood into the head. One branch goes up the right side of the neck and another up the left side.

115. Several arteries leave the aorta along the back and carry blood to the stomach, intestine, and other organs in the abdominal cavity.

116. In the pelvic region the aorta branches into two arteries which extend into the legs.

119. Veins have the same three layers that are present in arteries, but they (veins) are much thinner walled.

121. Valves that prevent the blood from flowing in a direction away from the heart are found at intervals along the veins.

123. Blood returns to the heart from the head by way of the jugular veins.

124. Blood returning to the heart from the head and arms is carried by veins that meet in the thorax to form the anterior vena cava which opens into the right auricle.

125. The blood from the legs and back muscles and abdominal organs returns to the heart by way of veins that join to form the posterior vena cava, which lies along the mid-line of the back parallel to the aorta.

126. The posterior vena cava empties into the right auricle.

134. There are 2,000 capillaries in each square millimeter of muscle.

140. At intervals along the lymph vessels are lymph nodes or glands.

143. Lymph glands also filter out and destroy bacteria contained in the lymph that flows through the vessels.

144. The lymph capillaries drain some of the tissue fluid from the spaces between the cells.

MEAN SCORE 2.51 - 3.50

11. One of the blood proteins is fribinogen, which is important in blood clotting.

12. Plasma with fibrinogen removed is called serum.

14. The volume of blood in an adult averages five or six quarts, depending on the size of the individual.

16. The red corpuscles are small circular discs shaped somewhat like a doughnut.

17. There is no nucleus in the red corpuscles of mammals.

20. The red corpuscles originate in the red bone marrow.

21. During development they (red corpuscles) possess a nucleus which is lost before the cells reach the circulating blood stream.

22. Red corpuscles are fairly constant in number.

23. In certain diseases the number (of red corpuscles) falls below normal. Such a condition is known as anemia.

24. The white corpuscles are larger than the red, have a nucleus and contain no hemoglobin, and some can move under their own power.

25. White corpuscles originate in red bone marrow and lymph nodes.

26. There are fewer white cells in the blood than red cells and they vary more in number.

27. The variability (of white cells) in number is linked up with their primary function, which is to aid the body in combating infection.

28. When bacteria enter the body, the white corpuscles cluster around and ingest them.

29. The white corpuscles move from place to place in the body within the blood stream, but also they can leave the blood vessels and move through the tissues.

30. White corpuscles move by means of pseudopodia or protoplasmic processes in the same manner as an ameba.

31. The white corpuscles also engulf and digest bacteria as an ameba does food.

32. When an infection is present (in the body) the number of white corpuscles increases.

33. The increase in white blood corpuscles is used by the physician to determine whether a suspected infection is present, such as in the diagnosis of appendicitis.

34. The platelets are small, colorless, round or spindle-shaped bodies about one third the size of red corpuscles.

35. The platelets have an important function in blood clotting.

36. A solid, crusty plug forms over a wound shortly after the blood leaves the vessels and flows over the skin. This plug stops the leakage of blood from the vessels and is known as a clot.

37. The chemical changes that result in the formation of the clot from the liquid blood start when the platelets disintegrate.

38. The platelets are very fragile and burst whenever they come in contact with a rough surface.

39. When the platelets disintegrate they release a substance which reacts with the blood plasma to produce thrombin, and enzyme-like substance, which in turn reacts with fibrinogen, a normal protein constituent of the blood. The fibrinogen is changed into insoluble fibrin. The red cells are caught in the meshwork to form a blood clot.

40. The steps in the clotting of blood are as follows:

Thrombin + Fibrinogen → Fibrin
Fibrin + Cells → Clot

41. A thrombus is a blood clot in a blood vessel.

42. An embolus is a thrombus that is moving freely in the blood stream.

43. Coronary thrombosis is the cause of many heart attacks, a thrombus or embolus plugging one of the blood vessels of the heart and stopping the flow of blood.

45. A stroke may be caused by an embolus, or a thrombus, becoming lodged in one of the blood vessels of the brain.

46. Hemophilia is a disease in which a person's blood does not clot quickly enough to prevent severe and sometimes fatal bleeding.

47. One tape of hemophilia is hereditary and is thought to be due to the lack of fragility of the platelets.

49. The blood of human beings differs, so it cannot be mixed indiscriminately in transfusion. If different types are mixed, the red corpuscles may clump or agglutinate and cause death. They may also disintegrate with equally fatal results.

51. Another type of blood group which is important in transfusion is known as the Rh. The Rh group is not related in action to the O, A, B and AB groups and must be considered separately.

52. Understanding of the importance of the blood groups in transfusion depends on an understanding of the antigen-antibody reaction.

53. This (antibody-antigen reaction) is based on the fact that when a foreign protein is injected into an animal, the injected animal's body reacts by manufacturing a chemical substance to counteract the effect of the injected protein. The substance injected is called an antigen and the substance produced because of the presence of the antigen is called an antibody.

54. The antibody-antigen reaction is the basis for immunization against such diseases as smallpox, diphtheria, whooping cough and typhoid fever.

55. To illustrate (the antibody-antigen reaction), diphtheria is caused by a germ that produces a poison known as toxin, if the toxin is injected into a human being or if it enters naturally because of an infection, it acts as an antigen and stimulates the body to produce an antibody known as antitoxin. The antitoxin neutralizes the toxin.

56. The fatalities that result from mixing different types of blood in transfusions are due to an antibody-antigen reaction.

57. The antigen-antibody process differs in the blood groups from the reaction described in the diphtheria example in that the antigens do not stimulate the production of the antibodies.

59. Certain hereditary determiners, the genes, cause development of both antigens and antibodies (concerned in ordinary blood groups).

60. The antigens are present in the red blood corpuscles.

61. There are two kinds of antigens, A and B.

62. A person may have A antigen only, or he may have the B antigen only, or he may have both A and B. It is also possible for a person to have no antigens in the red corpuscles.

63. If he has antigen A he belongs to blood group A. If he has antigen B, he belongs to blood group B. If he has neither A or B antigen, he belongs to group O.

64. The antibodies are of two kinds and are known as "a" and "b".

65. When red cells containing the A antigen are mixed with serum containing the "a" antibody the blood cells clump.

66. Likewise clumping occurs when B antigen is mixed with "b" antibody.

67. It is obvious (from this) that a normal person of blood group A having antigen A does not have antibody "a". If he did the red corpuscles would clump.

68. However, he (a person with blood of group A) does have antibody "b".

69. A B-group individual lacks "b" antibody but has antibody "a".

70. An AB individual has neither "a" nor "B" antibodies).

71. A person belonging to group O has both "A" and "B" antibodies.

72. It is impossible to mix any two kinds of blood without uniting either A with "a" or B with "b". Nevertheless, blood types are mixed in transfusion and one of them, known as the universal recipient type, is able to take any of the other types. Another type, the universal donor, can be used in transfusion to any of the others.

73. How is this (mixing of A with "a" or B with "b") possible? The answer is to be found in the difference in quantity of blood between the donor and recipient. The quantity of the donor's blood that is transfused is much less than that of a recipient and is quickly diluted by the recipient's blood in the blood vessels. The antibodies of the donor are thus diluted to such an extent that their effect is negligible.

74. The donor's red corpuscles, however, are very quickly acted upon by the antibodies of the recipient because of the relatively large quantity of the recipient's antibodies.

75. In a transfusion it is necessary to be sure that the donor's red corpuscles do not contain an antigen that will react with the recipient's antibodies.

76. The universal donor is group O because its red blood cells contain neither antigen (A nor B).

77. The universal recipient is group AB because its serum contains neither antibody ("a" nor "b").

78. The Rh blood group is caused by the presence of an antigen known as the Rh factor in the red corpuscles.

80. There is no normal antibody to the Rh antigen but it may cause antibody production if blood of an Rh positive person (having Rh antigen in red cells) is transfused into an Rh negative person.

81. If at some future time a second transfusion of Rh positive blood is made (into an Rh negative individual who has received a previous transfusion of Rh positive blood), the Rh antigen reacts with the antibodies and death may result.

82. Another serious consequence is caused when an Rh negative expectant mother carries an Rh positive child. A few of the red corpuscles containing the Rh antigen leave the blood stream of the unborn child, get into the mother's blood stream and stimulate the production of antibodies. The antibodies of the mother diffuse into the blood stream of the embryo and destroy the red corpuscles.

83. Rh antibodies usually do not affect the first child, but subsequent offspring may suffer.

84. Death of the embryo may result (from affects of Rh incompatibility) or, if death does not occur, development may be impaired and an anemic or feebleminded child may result.

91. It (the heart) is a little larger than the person's fist and lies in the thorax, the tip extending to the left of the mid-line.

107. In the larger arteries there is a large amount of elastic connective tissue.

112. The aorta extends forward from the heart and then bends backward to continue to the posterior part of the body along the mid-line of the back just under the vertebral column.

114. The arteries that go to the arms also leave the aorta in this region (of the backward bend of the aorta).

120. There is little muscle or elastic connective tissue in veins.

141. The lymph nodes are little masses of connective tissue filled with white blood cells.

142. The function of the lymph glands is to serve as a place for the production of white blood cells.

MEAN SCORE 3.51 - 4.50

Item numbers 48 and 79. Content may be obtained from Appendix II.

Principle II - The fluids of the transport system constitute the immediate environment of living cells.

MEAN SCORE .5 - 1.50

1. The capillaries lie immersed in tissue fluid that also surrounds every cell in the body.
2. Oxygen and food materials diffuse from the blood through the capillary walls into the tissue fluid.
3. From the tissue fluid it (oxygen and food materials) diffuse into the cells.
4. Carbon dioxide and other waste materials diffuse from the cells through tissue fluid into the blood of the capillaries.
5. Tissue fluid is a part of the blood that filters through capillary walls.
6. It (tissue fluid) bathes the cells of the body and then passes into the lymph vessels or back into the capillaries.
7. The lymph capillaries drain some of the tissue fluid from the spaces between the cells.

Principle III - The evolutionary development of transport systems in organisms is correlated with an increase in organism size.

MEAN SCORE .5 - 1.50

1. The chief method of transport used by all organisms, both plant and animal, is diffusion.
2. In some small organisms this (diffusion) alone is sufficient, but in larger forms diffusion is not fast enough and additional means of transport are necessary.

3. These (additional means of transport) include the blood and blood vessels of animals, the air tubes of land animals, and the conducting tissues of plants.

4. Unicellular animals such as ameba live entirely surrounded by water that contains in solution the oxygen that the organism needs. This oxygen diffuses from the water into the protoplasm (of the ameba).

5. Since the ameba is small, the oxygen (that diffuses into the ameba's protoplasm) must travel only a short distance to reach all parts of the individual. For this short distance the rate of diffusion is adequate to keep the ameba continuously supplied with oxygen.

MEAN SCORE 1.51 - 2.00

6. Carbon dioxide, a waste product of metabolism, diffuses out of the cell (ameba) into the surrounding water.

7. Food diffuses in a similar manner. If the food is in solution outside the organism, it diffuses in. If it is not in solution, it is digested in a food vacuole within the cell and from this vacuole it diffuses to all parts of the cell.

AREA VI

Coordination and Adjustment: Unit 1, Nervous Coordination

The Specific Objectives

1. To understand that irritability is a fundamental characteristic of living matter.
2. To know that the structural and functional unit of the nervous system of most animals is the neuron.
3. To understand how nervous tissue functions to receive, conduct, and associate nerve impulses set up as responses to specific environmental stimuli.
4. To understand that animal behavior has its basis in the quality and degree of organization and association of nervous elements.
5. To realize that human intelligence is a consequence of the quality and degree of organization and association of nervous elements.

Principles

1. A characteristic property of protoplasm is its capacity to respond to stimuli of various kinds.

2. The ability of organisms to adjust to their surroundings is dependent upon the fundamental property of irritability in living things.
3. The nervous system is a mechanism which regulates and coordinates the activities of various parts of the animal body, making it possible for the animal to act as an integrated unit.
4. Nervous tissue has the capacity to "store up" the effects of previous reactions to stimuli. This capacity is basic to the establishment of instincts, habits and memory in animals.

The Assignment
Biological Science Lecture Syllabus, pp. 63-73.

Principle I - A characteristic property of protoplasm is its capacity to respond to stimuli of various kinds.

MEAN SCORE .5 - 1.50

2. Irritability is inherent in all living things.

MEAN SCORE 1.51 - 2.00

1. The ability to receive stimulation and respond to it is called irritability.

Principle II - The ability of organisms to adjust to their surroundings is dependent upon the fundamental property of irritability in living things.

MEAN SCORE .5 - 1.50

4. Irritability is inherent in all living things.

MEAN SCORE 1.51 - 2.00

1. Living things adjust to the environment.
2. Living things are sensitive to their surroundings and respond to them.

3. The ability to receive stimulation and respond to it is called irritability.

5. Unicellular animals and plants respond to environmental stimuli, though in general they have no structures specialized for this purpose.

Principle III - The nervous system is a mechanism which regulates and coordinates the activities of various parts of the animal body, making it possible for the animal to act as an integrated unit.

MEAN SCORE .5 - 1.50

4. All animals including man have specialized tissues that aid in adjusting the individual to the environment.

5. (These specialized) tissues which also coordinate the parts of the body are the nervous and endocrine tissues, which in higher animals are evolved into nervous and endocrine systems.

16. The specialized cells that make up the nervous tissue and the nervous system are the neurons.

75. The brain functions in controlling and coordinating the actions of the entire body.

81. In many organisms special organs have developed that function in receiving stimuli.

MEAN SCORE 1.51 - 2.00

1. Life is characterized by activity.

2. (The activity of life) may be the activity of growth, such as the growth of roots and stems or the growth of man from infancy to adult; or it may be the activity of parts of an organism; or it may be the activity of an animal moving from place to place.

3. All (life) activity (of organisms) must be controlled and coordinated.

6. The nervous system of man and other vertebrates has three major parts: (1) the central nervous system, (2) the peripheral nervous system, and (3) the autonomic nervous system.

7. These three systems are interconnected, extend to all parts of the body, and function something like a telephone system in a city.

8. Messages received at any point can be quickly relayed to any other part of the body.

9. (But) just as a telephone message must go through "central", so all nervous messages must go through the central nervous system before passing on to their intended destination.

10. The central nervous system is composed of the brain and spinal cord.

13. Nerves leave the brain and spinal cord and connect to muscles and glands in all parts of the body just as telephone wires extend from "central" to telephones in all parts of a city.

14. The peripheral nervous system comprises the nerves that extend from the brain and spinal cord to muscles and glands in the outlying parts of the body.

15. The autonomic nervous system consists of nerves that connect the brain and spinal cord to the internal organs of the body such as the heart, the stomach, and the intestines.

17. Each neuron has a cell body containing cytoplasm and a nucleus.

18. From this cell body two kinds of protoplasmic fibers extend. These are the dendrites and the axon.

19. The dendrites usually extend away from the cell body in one direction, while the single axon stretches off in the opposite direction.

20. The axon connects with the dendrites of another neuron whose axon, in turn, connects with the dendrites of another cell.

21. (In this manner) a chain of neurons is formed that may reach from the brain to the foot or to any other part of the body.

22. Along (such) chains of nerve cells the messages (nerve impulses) pass.

23. The connection between an axon and a dendrite is known as a synapse.

24. The simplest type of nervous interconnection within the body is the reflex arc.

25. (The reflex arc) illustrates the principle of nervous function.

26. The reflex arc is composed of two neurons, a sensory neuron and a motor neuron.

33. When an appropriate stimulus is applied to the end of the dendrite near the surface of the body, a nervous impulse travels along the dendrite from the point of stimulation to the cell body near the spinal cord.

35. At the synapse it (the impulse) passes to the dendrite of the motor neuron and passes along it, through the cell body, and then through the axon of the motor nerve.

36. At the end of the motor axon it (the impulse) stimulates the muscle to action. The muscle then contracts.

38. The nerves are groups of nerve-cell fibers which extend from the brain and spinal cord to all parts of the body.

57. (Thus) nerve impulses that enter the spinal cord by way of the sensory nerves may go to any motor neuron within the central nervous system.

59. Something controls the direction taken by any impulse, and this control makes possible integrated action within the organism.

61. The structure which determines the direction that the impulse takes is the synapse.

66. All of the neurons of the brain are interconnected and all are connected with the neurons of the spinal cord.

76. All voluntary action is initiated in the cerebrum.

77. One area (of the cerebrum) known as the motor area controls all muscular action.

78. Another area (of the cerebrum) is concerned with vision, another with smell, and another with taste.

82. Structures that function primarily to receive stimuli are called receptors.

83. External receptors which receive stimuli from the external environment include the eyes, the ears, the nose, the taste buds and the sensory areas of the skin.

84. Internal receptors receive stimuli from within the body and include those in the tendons of the muscles and the semicircular canals of the inner ear.

92. The taste buds are on the tongue and are responsive to chemical substances in solution.

98. The effectors are the organs of the body that respond with action whenever they are stimulated by nerve impulses.

99. There are two kinds of effectors - muscles and glands.

113. A muscle contracts normally only when a nerve impulse is discharged into it.

MEAN SCORE 2.01 - 2.50

11. The brain lies in the head, entirely surrounded by a bony covering, the cranium.

12. The spinal cord connects with the brain and extends down the middle of the back within the vertebral column.

27. The sensory neuron has a long dendrite, the end of which lies near the surface of the body.

28. It (the dendrite of the sensory neuron) extends from there (near the surface of the body) to near the spinal cord where it enters the cell body (of the sensory neuron).

29. The axon of the sensory neuron leaves the cell body and extends into the spinal cord.

30. Within the spinal cord it (the axon of the sensory neuron) connects with a dendrite of the motor neuron. This connection is the synapse.

31. The dendrite of the motor neuron is short and is almost immediately connected with its cell body, which also lies within the spinal cord.

32. The axon of the motor nerve passes out of the spinal cord to connect with a muscle within the body.

34. (The impulse) goes through the cell body to and through the axon.

37. This action (as described) is purely automatic like pushing a doorbell, which initiates the passage of an electric current through a wire. When the electric current reaches the doorbell, the bell rings.

39. The nerves enter and leave both sides of the central nervous system at intervals.

40. The twelve pairs of cranial nerves extend from the brain to various organs in the head region such as the eyes, ears, throat.

41. The spinal nerves extend from the spinal cord to other parts of the body.

43. Each (spinal) nerve is attached to the spinal cord by two roots.

44. The dorsal root (of the spinal nerves) contains sensory fibers that bring impulses into the cord and the ventral root contains motor fibers that carry impulses away from the cord.

45. The dorsal sensory root has a ganglion containing the cell bodies of the sensory neurons.

46. The spinal cord is composed of two parts, the inner gray matter and the outer white matter.

51. Both the cell bodies and the dendrites of these neurons (motor neurons) lie within the gray matter of the cord.

52. The axons of the dorsal sensory spinal nerves enter the cord from the spinal ganglion and may connect directly with the dendrites of the motor neuron.

53. Usually, however, there are one or more connective neurons between (the axons of the sensory neurons and the dendrites of the motor neurons.)

54. The connective neurons may extend from the sensory axon to the motor dendrite at the same level and on the same side of the spinal cord.

55. They (the connective neurons) also may extend across the cord to a motor neuron of the other side, or they may go up or down the cord and connect with a motor neuron at a different level.

56. Some (connective neurons) extend up into the brain.

58. (However) none of the impulses that enter the spinal cord goes to all of the motor neurons.

60. If nothing controlled the pathway taken by nerve impulses, the various parts of the body would react haphazardly with no relation to the action of other parts. Controlled, coordinated action would be impossible.

62. When an impulse reaches a synapse it is either reinforced or inhibited.

63. The brain is a large mass of nervous tissue at the anterior end of the spinal cord.

64. It (the brain) contains both gray and white matter.

65. The gray matter (of the brain) is composed of cell bodies and the white matter consist of axons and dendrites.

67. The brain has three major parts, the brain stem, the cerebellum and the cerebrum.

68. The brain stem is made up mostly of axons and dendrites that extend from the spinal cord to the cerebellum and cerebrum.

69. The medulla is the part of the brain stem that connects directly with the spinal cord.

70. The cerebellum is a mass of nervous tissue that lies at the back of the brain over the medulla and behind the cerebrum.

74. The cerebrum is divided into two halves, the right and left hemispheres.

79. Hearing also is dependent on the proper function of a certain area of the cerebrum.

80. The cerebellum functions in coordinating muscular action.

85. The eyes receive light stimuli, which activate nerve impulses in the optic nerve.

86. These nerve impulses (in the optic nerve) when carried to the cerebrum, result in the sensation of light.

87. The ears receive sound waves, which stimulate nerve impulses in the auditory nerve.

88. The auditory nerves carry the impulses to the brain, which interprets them as sound.

89. Cells lining the epithelium of the nose are sensitive to chemical substances that become dissolved in the nasal fluids.

90. When stimulated by chemical substances in solution in the nasal fluids nerve impulses go to the brain by way of the olfactory nerve and the brain interprets these impulses as smell.

91. Taste is closely linked to smell.

93. The skin contains receptors for touch, pain, pressure, and the sensations of cold and hot.

94. The skin receptors are localized in certain areas.

95. It is possible to find them (skin receptors) by touching the skin in different places with a fine pointed instrument.

111. Every muscle in the body contains one or more nerve ending.

112. The nerve endings (in muscle cells) are the ends of nerves that bring nerve impulses from the central nervous system.

116. Heart muscle contracts rhythmically.

117. Heart muscle can contract without nervous stimulation, though there are nerve endings in the heart.

118. The nerves that supply the heart function mainly in controlling the rate of heart beat.

119. One type of nerve carries impulses that stimulate the heart to beat faster, and another type carries impulses that stimulate it to beat more slowly.

123. Nerves also connect with smooth muscle (cells).

127. (Glands) may secrete their substances into a tube and then into some special organ or they may be without tubes or ducts and secrete directly into the blood stream.

MEAN SCORE 2.51 - 3.50

42. There are thirty-one pairs of spinal nerves in man.

47. The gray matter contains the cell bodies of the motor neurons.

48. The white matter is composed of cell fibers that extend up and down the cord.

49. The white color (of the white matter) is due to a fatty covering material, called myelin, which surrounds each cell fiber.

50. The axons of the motor neurons extend out of the cord within the ventral motor spinal nerves.

71. The cerebellum has an inner branching core of white matter and an outer cortex of gray matter.

72. The white matter (of the cerebellum) contains nerve fibers that connect to cell bodies in the gray matter.

73. The cerebrum also contains a core of white matter containing nerve fibers and a cortex of gray matter.

96. The sensation of cold will be perceived only if a cold needle touches a cold receptor. If it misses the cold receptor, no sensation results unless it is one of pressure or touch.

97. The same thing is true for any of the other skin senses (that is true for cold receptors).

100. There are three kinds of muscles: skeletal, heart and smooth.

101. The skeletal muscles are usually attached to the bones.

102. They (the skeletal muscles) work in pairs, one of the pair pulling a bone one way and the other pulling it in the opposite direction.

103. Skeletal muscle is made up of elongated cells with many nuclei scattered along the periphery of the cell.

104. A muscle cell is also called a muscle fiber.

106. Each muscle is made up of many (of these) cells, some lying side by side and some end to end.

107. The (muscle) cells are held together by connective tissue that continues beyond the muscle cells at each end to form a tendon.

108. The tendon is a tough cord of connective-tissue fibers and attaches the muscles to bone.

109. When a muscle contracts, the muscle cells shorten, and this shortens the entire muscle and pulls on the tendons attached to each end.

110. Usually one end (of the muscle) remains fixed while the other end moves.

114. The heart is composed of cardiac muscle.

115. The (muscle) cells (in the heart) are striated like skeletal muscle but they differ in that individual cells are branched and each cell has one nucleus.

120. The walls of the body tubes such as the digestive tract, blood vessels, and bladder are composed primarily of sheets of smooth muscle tissue.

121. These (smooth) muscle cells are not striated and each cell has but one nucleus.

124. Glands are composed of epithelial cells which produce particular substances that have a definite function in relation to maintaining life functions.

125. The digestive glands that secrete digestive enzymes are examples (of glands).

126. Glands may be one-celled or many celled.

128. The endocrine glands are without ducts and, hence, are frequently called ductless glands.

MEAN SCORE 3.51 - 4.50

Item numbers 105 and 122. Content may be obtained from Appendix II.

Principle IV - Nervous tissue has the capacity to "store up" the effects of previous reactions to stimuli. This capacity is basic to the establishment of instincts, habits and memory in animals.

MEAN SCORE .5 - 1.50

13. Learning consists of developing new modes of behavior which replace inherited behavior or are superimposed upon it.

14. Every organism starts life with an inherited behavior pattern. This pattern is changed by learning, either by the suppression of the inherited behavior or by the addition to it of new types of behavior.

MEAN SCORE 1.51 - 2.00

1. Coordinated actions constitute behavior.

2. The nervous system works as a unit and coordinates all of the actions of the body.

3. Much (of this) integration is automatic and is the result of inheritance, while some kinds of coordination are learned.

4. The inherited type of coordination is illustrated by the simple reflex such as the knee jerk.

8. Most of the lower animals depend entirely upon automatic reflexes to coordinate their responses to environmental stimuli.

15. The cerebrum is essential for this process (of learning).

16. How the cerebrum works in accomplishing learning, no one knows for sure, but it involves receiving impulses from the separate senses and coordinating these into a meaningful whole.

17. The conditioned reflex offers a clue to the mechanism of the learning process.

23. (This new association of stimulus and response) is a conditioned reflex and also a learned response.

24. It is believed that almost all learning is dependent on this basic mechanism.

MEAN SCORE 2.01 - 2.50

7. Other examples of automatic behavior are the visceral reflexes that control breathing, the action of digestive tract and the heart.

9. Bees build intricate honeycombs without learning.

10. Birds build nests exactly like their ancestors did, even though they have never seen them built before.

11. Human infants suckle at the breast without learning and they show a fear reaction if startled.

12. They (human infants) also cry without training.

18. The classical example of a conditioned reflex is that of salivation in the dog.

19. Normally a hungry dog will secrete a quantity of saliva when food is seen or smelled. This is a reflex which involves the reception of the stimulus through the eyes or nose, the conduction of that stimulus to the brain, and the transmission of the stimulus to the salivary glands. The glands are stimulated to secrete saliva, which flows into the mouth.

20. If a bell is rung at the same time that food is presented to the dog, he will associate the ringing of the bell with the presence of food.

21. After repeated trials, the ringing of the bell without the presence of the food will cause the dog to secrete saliva.

22. (Thus) a new association of stimulus and response has been formed.

MEAN SCORE 2.51 - 3.50

5. If one sits with the lower leg hanging freely, a sharp tap with a blunt instrument just below the knee will cause the leg to jerk forward.

6. The impulses stimulated by the blow travel up the leg along a sensory neuron to the spinal cord. Within the cord they cross a synapse to a motor neuron that carries the impulses to the leg muscles, which contract and cause the leg to move.

AREA VI

Coordination and Adjustment: Unit 2, Chemical Coordination

The Specific Objectives

1. To understand that special chemical compounds called hormones produced by certain tissues can modify the functional activities of other tissues in the animal and plant body.
2. To realise that hormones act as chemical coordinators and in conjunction with the nervous system of animals control and integrate the life processes of organisms.
3. To understand that hormones influence behavior in definite ways.

Principles

1. Hormones function in the coordination and integration of life processes, such as metabolism, growth and reproduction, which require prolonged stimulation rather than the rapid stimulation characteristic of nervous action.
2. The systems of chemical and nervous coordination are interdependent to a considerable degree.

The Assignment

Biological Science Lecture Syllabus, pp. 73-77.

Principle I - Hormones function in the coordination and integration of life processes, such as metabolism, growth and reproduction, which require prolonged stimulation rather than the rapid stimulation characteristic of nervous action.

MEAN SCORE .5 - 1.50

1. Adjustment of an organism to its environment involves not only the proper response to external stimuli, but also the coordination of activities within the body.

5. The endocrine system coordinates the chemical processes.

7. In general, endocrine responses are slow, cumulative ones which stretch over considerable periods of time in contrast to nervous responses which are almost instantaneous.

10. (The endocrine) glands secrete chemical substances directly into the blood that flows through the glands.

12. The hormones are carried by the blood to all parts of the body.

13. The hormones affect only certain organs of the body.

14. In these organs (affected by the hormones) they produce a specific type of reaction.

15. There are many different hormones, and each hormone usually produces one kind of reaction.

61. (The pituitary gland) is called the master gland because its hormones regulate and coordinate many of the other endocrine glands of the body.

70. The pituitary hormones regulate the performance of other endocrine glands, such as the thyroid, adrenal and sex gland.

82. Both the estrogenic hormone and progesterone play essential parts in the reproductive cycle.

83. Plants produce hormones that are essential for growth.

MEAN SCORE 1.51 - 2.00

3. The autonomic nervous system and the endocrine system coordinate internal activities.

6. Examples of these chemical activities (coordinated by the autonomic system) include the oxidation of carbohydrates for the release of energy, the maintenance of the proper amount of calcium in the blood and the stimulation and inhibition of the growth processes.

8. The endocrine system is made up of several glands.

9. (The endocrine) glands have no ducts.

11. The chemical substances secreted by endocrine glands are called hormones.

16. The action of the hormone secretin illustrates the way in which hormones coordinate chemical processes in the body.

19. If these two activities, the entrance of the food into the small intestine and the secretion of the digestive enzymes by the pancreas, occurred at different times, the food and the enzymes would not mix and digestion would not take place. A hormone, secretin, coordinates the two events so that they occur approximately at the same time.

22. The major endocrine glands of man are the pancreas, thyroid, parathyroid, adrenal, pituitary, and gonads.

26. A constant supply of islet hormone, insulin, is necessary for the proper oxidation of glucose in cellular respiration.

27. Insulin also plays an essential part in the storage of glucose in the liver.

29. The thyroid is a paired gland that lies near the trachea in the neck region.

30. (The thyroid) secretes the hormone thyroxin, which regulates the rate of metabolism of the body.

38. An overproduction of thyroxin increases the basal metabolic rate.

44. It (parathormone) regulates the calcium metabolism of the body.

45. Removal of the parathyroids causes the level of blood calcium to to down, which in turn causes the muscles to contract spasmodically.

52. During times of stress such as in fright or anger the medulla (of the adrenal gland) pours adrenalin into the blood.

53. This (adrenalin in the blood during times of stress) stimulates the heart to beat faster and causes the liver to release glucose. The intake of oxygen is increased also.

54. The net result (of the affect of adrenalin in the blood during stress is to increase carbohydrate metabolism and thus to increase the muscular efficiency of the body.

55. The autonomic nervous system is connected to the medulla and stimulates the production of adrenalin.

63. An excess of one of the hormones (from the pituitary) during early growth stages results in the production of giants.

68. A deficiency of the pituitary hormone during early growth stages results in the production of normally proportioned midgets.

71. They (pituitary hormones) control the secretion of milk by the mammary glands.

72. They (pituitary hormones) also regulate the metabolism of carbohydrates, fats and proteins.

74. Both (ovaries and testis) produce reproductive cells, but they also produce hormones.

75. The testes in the male contain two kinds of tissue. One kind is concerned with the production of sperms. The other kind produces the hormone testosterone.

77. The normal development of the secondary sex characteristics in the male is dependent upon the development of testosterone.

78. The secondary sex characters include all of those physical and mental traits that are associated with maleness, other than the gonads, which are primary sex characters.

79. The ovaries of the female produce an estrogenic hormone.

80. The ovaries of the female produce progesterone.

81. The estrogenic hormone is responsible for the development of female secondary sex characters.

MEAN SCORE 2.01 - 2.50

2. The sense organs and certain effectors and the central and peripheral nervous system take care of the adjustment of the whole organism with its external environment.

4. The autonomic nervous system is concerned primarily with the mechanical processes such as breathing, circulation, and peristalsis.

17. Secretin coordinates the action of parts of the digestive system.

18. The stomach mixes hydrochloric acid with food and digestive enzymes and eventually forces this mixture into the small intestine. The pancreas secretes digestive enzymes into the small intestine, where they digest the food.

20. The hydrochloric acid from the stomach stimulates the cells of the small intestine to produce secretin, which passes into the blood stream and is carried to the heart and then to all parts of the body including the pancreas.

21. Here (in the pancreas) the secretin stimulates the cells of the pancreas to secrete digestive enzymes that immediately pass into the intestine by way of the pancreatic duct.

23. The pancreas has two functions. One is to secrete digestive enzymes and the other is to secrete a hormone, insulin.

24. The endocrine part of the pancreas consists of small islands of cells scattered among the cells that secrete enzymes.

25. No ducts lead away from the islet cells, so the hormone is secreted into the blood capillaries that course through the pancreas.

28. The disease diabetes results if too little insulin is produced.

31. The lack of a sufficient quantity of thyroxin in an infant or child results in cretinism.

33. Thyroxin deficiency in an adult causes an individual to be overweight and to be mentally sluggish. The heart rate is slower than normal and the entire rate of metabolism of the individual is slower than normal.

34. One type of goiter is associated with thyroxin deficiency.

35. The production of thyroxin by the thyroid gland is dependent upon a sufficient supply of iodine.

36. When iodine is deficient in the diet, the thyroid gland produces less thyroxin than normal and also increases in bulk.

37. The goiter is the overgrown (thyroid) gland.

39. The individual (with an overactive thyroid) becomes irritable, nervous, and overactive. The eyes bulge and the heart beats irregularly.

42. (Each parathyroid gland) lies imbedded in or beside the thyroid gland.

43. The hormone produced by these (parathyroid) glands is called parathormone.

46. Death results (following removal of parathyroids) if calcium is not supplied.

47. The overproduction of parathormone causes calcium to be removed from bones and teeth.

48. The adrenal glands lie near the kidneys.

56. If the medulla is removed the autonomic nervous system takes over its function.

57. The adrenal cortex produces a hormone, cortin.

58. Cortin regulates the sodium and potassium level of the blood and tissues.

59. The removal of the cortex (of the adrenal gland) inevitably results in death.

60. The pituitary gland lies at the base of the brain.

62. It is believed at the present time that twenty or more hormones are produced by the pituitary gland.

66. If the excess of (pituitary growth) hormone production occurs after normal growth has ceased the individual develops the fatal disease acromegaly.

69. The intellectual development of such undersized people (pituitary midgets) is normal.

73. The gonads are the reproductive glands, ovaries and testis.

76. The cells of the testis that produce testosterone are called interstitial cells.

84. Plant hormones are known as auxins.

85. At the tips of stems, roots and buds and in young leaves cells divide repeatedly and produce some growth.

86. However, most growth (in plants) results from the elongation of cells behind the tip.

87. This elongation of cells (behind the tip) cannot occur unless auxin is present.

88. It (auxin) is produced in the dividing cells, at the tip of the stems and roots, and diffuses to the cells behind the tip.

89. (As a result of stimulation by auxin) these cells (behind the tip) elongate and growth results.

90. However, if the concentration of auxin is too great (in the region of elongation), growth is retarded.

MEAN SCORE 2.51 - 3.50

32. Cretins are stunted. They have short legs and in extreme cases they waddle when they walk. Their skin is leathery and their teeth are defective. They also are retarded mentally.

40. The parathyroids are usually four in number.

41. Each (parathyroid) gland is about the size of a pea.

49. (The adrenal glands) have two parts.

50. One part (of the adrenal gland) is a central core of cells called the medulla.

51. The other part (of the adrenal gland) is an outer layer of cells called the cortex.

64. (Some giants resulting from an excess of one of the pituitary hormones during early growth stages) attain a height of nine feet.

65. The growth of these (pituitary) giants is symmetrical.

67. In this disease (acromegaly) the bones of the hands, feet and face increase in thickness.

91. Stems can withstand a higher concentration (of auxin) than buds.

92. Roots can withstand the least concentration (of auxin).

Principle II - The systems of chemical and nervous coordination are interdependent to a considerable degree.

MEAN SCORE .5 - 1.50

1. The autonomic nervous system and the endocrine system coordinate internal activities.

MEAN SCORE 1.51 - 2.00

2. The autonomic system is concerned primarily with the mechanical processes such as breathing, circulation and peristalsis.

3. The endocrine system coordinates the chemical processes of the body.

4. The autonomic nervous system is connected to the (adrenal) medulla and stimulates the production of adrenalin.

5. If the adrenal medulla is removed the autonomic nervous system takes over its function.

AREA VII

Maintenance of the Species: Unit 1, Reproduction and Development

The Specific Objectives

1. To understand the processes of cell division and their biological significance.
2. To realize the significance of the fact that all life comes from pre-existing life under present environmental conditions.
3. To understand the essential difference between sexual and asexual reproduction.
4. To understand the essentials of the structure and functioning of the male and female reproductive systems.
5. To realize the importance of hormones in coordinating the process of reproduction in animals.
6. To understand the essentials of human development.
7. To understand the important features of reproduction and development in plants.

Principles

1. New living organisms arise as the product of living organisms of the same kind.
2. The basis for all reproduction is cell division.
3. There is an inverse relationship between the number of reproductive elements produced by an organism and the degree to which the offspring are protected and cared for.
4. The embryonic development of any organism is directed by the interaction between the kind of protoplasm of the organism and the intrinsic and extrinsic environmental factors.

The Assignment

Biological Science Lecture Syllabus, pp. 78-104.

Principle I - New living organisms arise as the product of living organisms of the same kind.

MEAN SCORE .5 - 1.50

3. Now it is believed that living things come only from other living things.

MEAN SCORE 1.51 - 2.00

4. The process of producing new individuals is called reproduction.

5. Some organisms reproduce sexually and others asexually.

6. Asexual reproduction consists of the production of two or more individuals by the division of one.

8. In other cases the offspring separates from the parent as a smaller-sized replica. This is budding.

9. There are some other forms of asexual reproduction (besides budding and fission), but all of them are modifications of the same fundamental mechanism, which is cell division (mitosis).

MEAN SCORE 2.01 - 2.50

1. Organisms age and die, and thus it is essential that new individuals be produced.

2. Years ago it was thought that life could arise spontaneously out of non-living matter, such as worms from putrefying flesh or frogs from mud.

7. In some cases (of asexual reproduction) the parent organism divides into two offspring of equal size. This is known as fission.

Principle II - The basis for all reproduction is cell division.

MEAN SCORE 1.51 - 2.00

3. Asexual reproduction consists of the production of two or more individuals by the division of one.

6. There are some other forms of asexual reproduction (besides budding and fission), but all of them are modifications of the same fundamental mechanism, which is cell division (mitosis).

7. Sexual reproduction is similar to asexual reproduction in that cells separate from the parent to develop into offspring, but it differs in two respects.

8. (First), the cells that separate from the parent (in sexual reproduction) are special cells that go through an intricate process of development before they are ready for reproduction.

9. (Second), the two kinds of cells (gametes) must unite in a process called fertilization before offspring can develop.

10. There are two kinds of reproductive cells. One is the sperm and the other is the egg.

25. In the process of fertilization the sperm penetrates the egg and the nuclear material of both unite.

166. Reproduction involving sex is found in almost all plants.

167. As in animals, sexual reproduction in plants involves the union of two gametes to produce a zygote which develops into a new individual.

195. One of the male gamete nuclei unites with the egg to form the zygote. This is fertilization.

197. The zygote develops into the embryo.

MEAN SCORE 2.01 - 2.50

1. The process of producing new individuals is called reproduction.

2. Some organisms reproduce sexually and others asexually.

4. In some cases (of asexual reproduction) the parent organism divides into two offspring of equal size. This is known as fission.

5. In other cases (of asexual reproduction) the offspring separates from the parent as a smaller-sized replica. This is budding.

12. Gametes are germ cells (eggs and sperms).

13. Gametes or germ cells are produced in special organs called gonads.

14. The sperms are produced in testes in the male.

15. The eggs or ova are produced in ovaries in the female.

24. The union of the sperm and egg is called fertilization.

26. The fertilized egg is called the zygote.

29. Generally only one sperm unites with one egg (in the process of fertilization).

37. (Thus), internal fertilization is fundamentally the same as external fertilization in that water is the medium in which the sperms and eggs unite.

50. Human reproduction is sexual. The male produces the sperms and the female produces the eggs or ova.

57. The undeveloped germ cells have the full complement of chromatin material.

58. When the reproductive cells are fully matured they have lost most of their cytoplasm and half, or approximately half of the chromatin.

59. The details of the chromatin loss (during maturation) are important to heredity.

63. In each testis the tubules containing the sperms converge toward one side into a network of small tubes.

159. Plants reproduce in the same manner as animals, that is, asexually and sexually.

160. Fission occurs in the unicellular algae and bacteria.

161. Budding occurs in yeast.

164. Practically all plants develop spores or small cells with a protective coat.

165. (The spores or small cells with a protective coat) separate from the parent plant and develop into a new individual when conditions favor growth.

183. The reproductive structure that develops in the ovule contains a number of cells, the most important of which are the endosperm cells and the egg cell.

184. The anther contains cells that develop into pollen grains.

190. Following pollination the tube cell of the pollen begins to grow downward into the stigma and through the style until it reaches the center of the ovule.

193. The nucleus of the generative cell divides, producing two nuclei which become the male gamete nuclei.

194. When the pollen tube reaches the ovule, the end of the tube ruptures and some of its contents enter the ovule.

196. The other male gamete nucleus unites with the endosperm nuclei.

203. Growth of the embryonic plant requires energy which is obtained from food stored in the embryonic leaves.

MEAN SCORE 2.51 - 3.50

11. There are a few exceptional cases where the eggs can develop without union, but this does not invalidate the general rule that in sexual reproduction the usual procedure is for sperms and eggs to unite before development of young can occur.

16. The sperms are usually small and motile.

17. The eggs are usually comparatively large and non-motile.

18. The sperms and eggs are produced in organs within the body cavity of the male or female and must be transported to the outside of the body.

19. This (transport of gametes to the outside of the body) is accomplished by ducts or tubes that extend from the body cavity to an opening at the surface of the body.

20. In the male the ducts that transport the sperms are connected directly to the testis.

21. In the female the ducts do not connect directly to the ovaries, but open within the body cavity.

22. In some forms (of female animal) the open end of the tube is some distance from the ovary so the egg drops from the ovary into the body cavity and must be transported within the cavity to the open end of the duct that carries it to the outside.

23. In other (forms of females), such as the human being, the open end of the duct is so close to the ovary that the egg normally drops right into the tube.

27. Fertilization is external (outside of the body) in aquatic animals such as fish and in amphibians (frogs and toads), which reproduce in the water.

28. In these forms (fish and amphibians) the males and females come together in the water during the mating period. While they are together the female extrudes her eggs into the water and the male releases his sperms. This results in a mixing of the sperms and eggs, during which time the sperms swim to the eggs and unite with them.

30. Many sperms may attempt to penetrate one egg, but after one has entered the egg a fertilization membrane raises from the surface of the egg and prevents other sperms from entering.

31. In internal fertilization the sperms and eggs unite within the body of the female.

32. This (internal fertilization) is usually accomplished by a mechanism which injects the sperms into the reproductive ducts of the female.

33. The male usually inserts the penis into the reproductive duct, which normally branches and leads to the ovaries.

34. The eggs are released from the ovaries and travel down the reproductive ducts to meet the sperms coming up.

35. Fertilization (internal) occurs within the ducts (of the female reproductive system).

36. Inasmuch as the linings of the reproductive ducts are moist and the sperms leave the male in a fluid known as semen, the sperms can move upward within the tube at least partly by swimming.

38. Only those animals in which there is internal fertilization, such as reptiles, birds and mammals have become permanent land dwellers.

39. The amphibians that live on land part of the time must return to ponds and streams to reproduce because fertilization is external and can be accomplished in water only.

40. Variations in the usual form of sexual reproduction include hermaphroditism and parthenogenesis.

43. (In hermaphroditism) usually two individuals are necessary for reproduction. An exchange of sperms occurs between the two individuals and the eggs of both individuals are fertilized.

45. In some animals the females produce eggs that do not require fertilization for development.

46. The development of eggs without fertilization is called parthenogenesis.

47. The queen honey bee, (for example), produces eggs that may or may not be fertilized.

51. The primary reproductive organs of the male are the two testes.

52. The testes lie within the scrotum suspended from the lower abdomen between the legs.

53. Each testis contains a number of coiled tubules in which the sperms are produced.

54. The walls of each tubule (in the testes) contain reproductive cells in various stages of development.

55. The (immature sperm) cells near the outer edge (of the tubules) are the least developed, those lying at the inner surface near the cavity of the tube are the most developed, and the cells in between are at various intermediate stages.

56. The undeveloped germ cells are more or less spherical and have the normal amount of cytoplasm.

60. The mature male reproductive cell is known as the sperm cell.

61. It (mature sperm) has a head containing the chromatin tightly packed inside, a middle piece containing a spiral filament, and a long tail composed of cytoplasm.

62. The head (of the mature sperm) is oval as seen from the top or bottom and flattened as seen from the side.

64. From this network (of small tubes) a number of small ducts lead out of the testis and join the sperm duct.

65. The sperm duct passes upward into the abdominal cavity.

66. Within the abdominal cavity it (sperm duct) curves forward to meet the sperm duct from the other testis.

67. Just before the union (of the sperm ducts) a duct from a seminal vesicle opens into each sperm duct.

68. The fluid secretions of the two seminal vesicles make up part of the semen.

69. The semen is a fluid in which ejaculated sperms are immersed.

70. The two sperm ducts open into the urethra.

71. The urethra passes through the penis and opens at the end.

72. The prostate and bulbo-urethral glands secrete fluids into the reproductive ducts.

73. The secretions of the prostate and bulbo-urethral glands added to those of the seminal vesicles make up the semen.

74. The prostate gland lies at the juncture of the sperm ducts and the urethra.

75. The bulbo-urethral glands lie along side of the urethra.

76. The sperms produced in the testes pass through the small tubules into the epididymis.

77. The sperms remain in the epididymis until ejaculated.

78. When this (ejaculation) occurs they pass through the sperm duct and then through the urethra to the outside.

79. (When ejaculation occurs) fluid from the seminal vesicles, prostate, and bulbo-urethral glands is added as the sperms pass these glands.

80. Each ejaculate is said to contain 200 to 300 million sperms.

81. The female reproductive system consists of ovaries and reproductive ducts.

82. The two ovaries of the female are flattened, oval bodies about an inch in length.

83. The ovaries lie attached to the side wall in the pelvic region of the abdominal cavity.

84. Each ovary is filled with connective tissue cells and eggs in various stages of development.

85. An epithelium of undeveloped reproductive cells covers the surface (of each ovary).

86. At intervals groups of the epithelial cells sink into the connective tissue of the ovary. One of them (epithelial cells) becomes the reproductive cell while the rest cluster about it and become follicle cells.

87. The reproductive cell increases in size while the follicle cells increase in number and form a large ball of cells, the follicle.

88. A fluid filled cavity appears within the follicle. The reproductive cell lies on one side of this cavity surrounded by a group of follicle cells.

89. Growth of the follicle continues while it moves into the ovary and then back toward the surface (of the ovary).

90. It (the follicle) eventually reaches the surface, from which it projects as a bulge. It is now a mature follicle and the reproductive cell is ready to be released.

91. In the female the reproductive ducts consist of a vagina, a uterus or womb and two oviducts.

92. The vagina is a tube about three inches long which opens at the surface of the body at one end and connects with the uterus at the other end.

93. The uterus is also about three inches in length. It is a pear-shaped organ with thick, muscular walls and a glandular lining.

94. The cervix is a projection of one end of the uterus into the vagina.

95. At the opposite end of the uterus from the cervix, two oviducts lead off to the ovaries.

96. The oviducts do not connect directly to the ovaries but lead into the body cavity adjacent to them.

97. Finger-like processes surround the open ends of the oviducts, some of which attach directly to the surface of the ovary.

98. The discharge of the female reproductive cell, the egg, from the ovary is known as ovulation.

99. (When ovulation occurs) the follicle ruptures and the egg is squeezed out.

100. (After ovulation) the egg is drawn into the open end of the oviduct almost immediately, apparently through the action of cilia or hair-like processes that line the walls of the oviducts and beat toward the uterus.

101. In the human female ovulation begins at puberty, about the fourteenth year, and ends at menopause, about the forty-seventh year.

102. Generally one egg is released each month between these years (of puberty and menopause).

103. The two ovaries alternate irregularly in producing mature eggs.

104. Sometimes two or more ova are expelled at one time and if fertilized produce fraternal twins or triplets.

105. After the egg leaves the follicle the cells that line the follicle increase in number and develop into a large, yellowish, glandular structure known as the corpus luteum.

106. If pregnancy occurs the corpus luteum persist until the latter part of the pregnant period.

107. If no pregnancy occurs the corpus luteum degenerates in about two weeks.

108. The egg moves down the oviduct toward the uterus.

109. If the egg is fertilized it begins development into an embryo and travels to the uterus, where it remains until development is complete.

110. If the egg is not fertilized it degenerates before reaching the uterus.

111. The human egg looses its ability to be fertilized within a relatively short time after ovulation.

112. The act of placing the penis of the male into the vagina of the female is coitus or copulation.

113. The purpose of copulation is to introduce semen into the vagina.

114. After the sperms are deposited in the vagina, they may be drawn into the uterus within a minute or two by the muscular action of the cervix.

115. The sperms move through the uterus into the oviducts.

116. If ovulation has occurred, a sperm meets and fertilizes the egg in the upper part of the oviduct.

117. Sperms retain their vitality within the oviducts usually for no longer than one or two days.

118. In the human female uterine bleeding known as menstruation occurs at intervals of four weeks.

120. Menstruation begins (in humans) between the twelfth and fourteenth years and continues until the menopause.

121. The duration of any one menstrual period varies from one to five days.

122. The average interval between periods is twenty-eight days.

123. There is no exact regularity in the interval between periods.

124. The onset of menstruation coincides with the beginning of ovulation at puberty.

125. The cessation of both menstruation and ovulation usually occurs simultaneously at the menopause.

127. The relation of oculation to menstruation is not mere coincidence.

128. Both ovulation and menstruation are intimately linked in a series of events related to the reproductive function of the female.

129. We may consider the menstrual cycle as beginning when the pituitary gland that lies at the base of the brain secretes a hormone that stimulates the development of a follicle within the ovary.

130. If the pituitary gland is removed the ovary ceases to produce reproductive cells.

131. As the follicle (in the ovary) develops it produces an estrogenic hormone.

132. The estrogenic hormone is carried by the blood stream to the uterus, where it acts upon the uterine lining.

133. The estrogenic hormone causes the lining of the uterus to grow and develop.

134. The growth and development of the uterine lining involves a thickening of the lining and an increase in the number, size, and secretory activity of the glands.

135. Under the stimulus of the estrogenic hormone the glands secrete a nutritive substance which fills and dilates them.

136. Blood vessels bring a copious supply of blood to the lining of the uterus during the period of the thickening of its walls.

137. The pituitary gland produces another important hormone, the luteinizing hormone.

138. The luteinizing hormone directly affects the development of corpus luteum tissue.

139. The corpus luteum tissue replaces the follicle after ovulation.

140. The occurrence of ovulation causes reduction of the supply of estrogenic hormone (which has been providing the stimulus for uterine development and thickening).

141. With the reduction in the supply of estrogenic hormone, another hormone, progestrone, carries on the work of stimulating the development of the uterine lining.

142. Progesterone is produced by the newly formed corpus luteum.

143. If the egg produced by the ovary is not fertilized the corpus luteum maintains its production of progesterone for about two weeks, after which it degenerates and ceases its endocrine function.

144. As a result of the absence of the corpus luteum hormone, the arteries that carry blood to the lining of the uterus constrict.

145. The constriction of the arteries to the uterus stops the flow of blood and cuts off the supply of food and oxygen to the tissues of the uterus.

146. As a consequence of the lack of food and oxygen, the cells of the uterine lining degenerate, they begin to slough off, blood vessels rupture, and the bleeding and destruction of the uterine lining begins.

147. The menstrual flow continues from one to five days, after which it ceases and the lining of the uterus is repaired to begin the cycle all over again.

148. The beginning of repair coincides with the development of a new follicle in the ovary and the renewed production of estrogenic hormone.

149. The estrogenic hormone stimulates the repair of the uterus.

150. During the growth of the ovarian follicle, the estrogenic hormone stimulates the development of the uterine lining, so that it becomes gorged with the nutritive secretion of the uterine gland.

151. When the egg is released from the ovary, the corpus luteum hormone takes over and keeps the lining of the uterus in condition while the egg travels down the oviduct.

152. If the egg is fertilized in the oviduct it begins to develop into an embryo that passes to the uterus and there becomes attached to the wall.

153. The embryo uses energy for growth and development and lacking an adequate supply of yolk, it must find its nourishment elsewhere. It finds it in the lining of the uterus.

154. The nutritive material secreted by the glands nourishes the embryo, which at first attaches to the uterine wall and later sinks into it.

155. The periodic growth and development of the uterine lining coincides with ovulation, with the result that the young embryo has a favorable environment in which to develop.

156. The timing of the development of the uterine lining so that it coincides with the release of the egg and the descent of the embryo is the function of the estrogenic hormone and progesterone.

157. If no pregnancy occurs, the uterus looses its developed lining and starts all over again to be ready for the next ovulation.

158. If pregnancy does occur, the corpus luteum continues to produce its hormone long enough to insure the establishment of the embryo within the uterus.

162. Some plants, such as the strawberry, send out long, leafless stems or runners, which develop roots and separate from the parent plant.

163. The potato is a tuber or underground stem that will produce a new plant when planted.

168. The flower is the reproductive organ of the flowering plant.

169. The flower is attached to the end of the stem.

170. The flower consists of sepals, petals, stamens, and the pistils.

171. The sepals are usually green, leaflike structures which enclose the base of the petals at their point of attachment to the stem.

175. The stamens form a circle within the petals and around the pistil.

176. The pistil occupies the center of the stem end.

177. The parts of the flower concerned directly with reproduction are the stamen and the pistil.

178. Each stamen has two parts: the anther and a long upright support, the filament, which holds the anther aloft.

179. The pistil is usually flaskshaped, having a bulbous base, the ovulary, from which the necklike style projects upward.

180. The tip of the style is called the stigma.

181. The ovulary contains one or more ovules.

182. In each ovule a reproductive structure develops.

185. Each pollen grain consists of a generative cell and a tube cell and is covered by a drought-resisting coat.

186. When the pollen grains are mature the anther breaks open and the pollen is freed.

187. The wind blows the pollen of some flowers to other flowers.

188. In other plants visiting insects become covered with the pollen and transport it to other flowers.

189. When the pollen reaches a flower, some of the grains land on the stigma of the pistil. This is known as pollination.

191. The tube nucleus moves along the pollen rube just behind the growing tip.

192. The generative cell follows the tube nucleus through the cytoplasm of the pollen tube.

198. The outer layer or layers of the ovule develop into the protective covering.

199. The embryo and the endosperm surrounded by the protective covering comprise the seed.

200. The embryo is composed of one or two large embryonic leaves (the cotyledons), one embryonic root and one embryonic stem.

201. When the seed is mature and environmental conditions are favorable it will germinate.

202. Germination involves growth and development of the embryonic root into the ground and growth and development of the embryonic stem into the air above the ground.

204. The cotyledons or embryonic leaves are thick with stored food which is digested by enzymes.

205. After digestion the food is transported to the growing root and stem, where it is used for energy and building of protoplasm.

206. Development of both roots and stems involves the differentiation of embryonic (meristem) tissues into the mature tissues found in adult roots and stems.

208. Leaves develop on the stem (of the plant).

MEAN SCORE 3.51 - 4.50

Items number 41, 42, 44, 48, 49, 119, 126, 172, 173, 174, and 207. Content may be obtained from Appendix II.

Principle III - There is an inverse relationship between the number of reproductive elements produced by an organism and the degree to which the offspring are protected and cared for.

Syllabus assignment contained no material related to Principle III.

Principle IV - The embryonic development of any organism is directed by the interaction between the kind of protoplasm of the organism and the intrinsic and extrinsic environmental factors.

MEAN SCORE .5 - 1.50

1. The fertilized egg or zygote develops by a process of cell division, growth and differentiation into a new individual.

2. Food is necessary to supply materials and energy for development (of the zygote).

3. During the early stages of development the embryo's energy requirements are met largely by means of yolk stored in the egg.

10. (In mammals) the problem of nourishing the developing zygote is solved by the retention of the embryo within the body of the mother and the development of a temporary organ, the placenta, that connects the embryo with the tissues of the mother. The embryo gets its nourishment directly from the mother.

14. Embryos obtain the energy they use for growth and development by oxidation of food in the same manner as adult organisms.

35. All animal embryos, from the simplest forms to the most complex, must develop in water to prevent dessication and to insure that pressures will be equal from all sides.

48. The first step in the development of a human embryo is fertilization.

MEAN SCORE 1.51 - 2.00

4. In all animals yolk is manufactured in the ovary and included within the egg prior to fertilization.

5. Some animals such as the fish and the frog have relatively little yolk, and this is used up during the early stages of development.

6. After the yolk is gone the young embryo must depend on its environment for food.

7. (In forms having very little yolk) a mouth and intestine develop very early, with the result that they begin to feed quite early in development on small particles of food in the water.

8. Other forms, (such as reptiles and birds) produce eggs that have sufficient yolk to last them throughout their period of development.

9. Some animals, including man and other mammals, produce very little yolk for nourishment of the embryo.

11. Both the mother's blood stream and that of the embryo flow into the placenta. The two blood streams do not unite, but flow side by side, and food originally eaten by the mother and carried in her blood stream diffuses into the blood of the embryo to be carried to its tissues.

15. Cellular respiration (in embryos) could not go on without a continuous supply of oxygen.

16. The carbon dioxide produced by embryos must be excreted.

17. In aquatic animals whose young develop in the water, the oxygen (required by the embryo) comes (directly) from the water and diffuses into the cells of the embryo.

18. Eventually gills develop in aquatic animals, but prior to their development the oxygen diffuses from the surrounding water directly into each individual cell.

19. Carbon dioxide diffuses out of the cells (of aquatic embryos) into the water.

23. In the earliest stages of development (of the land egg) the oxygen of the air diffuses directly into the cells and the carbon dioxide diffuses out, but eventually a respiratory organ develops that serves to receive oxygen for the embryo from the atmosphere and to remove the carbon dioxide.

24. This (respiratory) structure (in the land egg) consists of a sac-like membrane that grows out of the embryo and comes to lie just beneath the porous shell. Blood vessels of the embryo carry blood to and away from it. While the blood flows through the membrane, oxygen diffuses into it from the air and carbon dioxide diffuses out.

28. In mammals the placenta serves as the respiratory organ for the embryo.

29. In mammals, the mother's blood, which flows into the placenta, carries oxygen as well as food and this oxygen diffuses into the embryo's blood stream. Carbon dioxide diffuses into the placenta in the opposite direction.

30. All developing embryos produce waste materials other than carbon dioxide and these must be removed from the body.

33. In mammals the placenta serves to permit wastes in the embryo's blood stream to pass into the mother's blood stream.

34. The kidneys of the mother excrete (the metabolic wastes from the embryo's body).

36. Normal symmetrical development would be impossible unless the pressure of the environment were equally distributed over the surface of the embryo.

37. The buoyant action of water plus its fluidity makes it an ideal medium for maintaining equal pressures.

38. Land animals do not develop in ponds and streams, but they do develop surrounded by water.

51. After fertilization, the zygote continues to move down the oviduct to the uterus.

52. During its passage down the duct it (the zygote) goes through a process of cell division.

53. The first division of the zygote results in the formation of two cells of equal size. These divide in turn to produce four cells.

54. By the time the embryo has reached the uterus repeated cell divisions have resulted in the formation of a ball of cells, all approximately equal in size.

56. The blastula differentiates at this time into an inner cell mass and an outer layer of cells.

59. Soon after entering the uterus the embryo attaches itself to the wall of the uterus.

69. Upon entering the uterine wall (the embryo) begins to grow, obtaining its nourishment from the dissolved uterine lining.

71. Gastrulation involves the differentiation of the inner cell mass into endoderm and ectoderm.

85. The placenta functions as an organ of exchange between the mother's blood stream and that of the embryo.

86. Food and oxygen pass from the mother's blood into the blood of the embryo, while waste move in the opposite direction.

107. (Thus), all food, oxygen, and wastes that enter and leave the embryo do so through the umbilical cord.

MEAN SCORE 2.01 - 2.50

12. Mammals have special milk-secreting glands, the mammary glands, that function to nourish the young after birth.

20. In land animals such as birds and reptiles, the eggs are not immersed in water but are laid on land.

21. In land animals the air of the atmosphere is the source of oxygen and the place of disposal of carbon dioxide.

22. The eggs of birds and reptiles are surrounded by a procus shell that permits the air to enter and leave the egg.

25. The sac-like membrane (under the shell of the land egg) is also a receptacle for the disposition of other waste products.

31. In aquatic animals waste diffuses out of the embryo into the surrounding water.

32. In birds and reptiles the sac-like membrane (just beneath the shell) serves as a receptacle for such (metabolic) wastes.

39. Early in development in all land animals including reptiles, birds and mammals, a sac-like membrane grows out and surrounds the embryo. This sac is called the amnion.

40. The amnion fulls with water and immersed in this water is the embryo.

41. It is the "bag of waters" that burst prior to the birth of the human child.

47. Mammals do not have a protective cover immediately surrounding the zygote, but the embryo develops within the body of the mother, which serves ably as a protective cover.

49. The sperm unites with the egg in the upper third of the oviduct.

50. The fertilized egg is called the zygote.

55. A cavity appears in the cneter of the ball of cells, which is now called a blastula.

57. The outer layer of cells forms a hollow sphere within which the inner cell mass is suspended.

58. The inner cell mass eventually gives rise to the body of the human embryo and the outer cell layer develops into membranes surrounding the embryonic body.

61. This (attachment of the embryo) happens on the ninth or tenth day after fertilization.

62. It is suspected that the embryo secretes an enzyme that digest the uterine tissue, for the wall of the uterus disintegrates beneath the embryo.

63. The embryo promptly sinks into the depression so formed.

64. It takes about one day for the embryo to penetrate completely into the wall of the uterus.

65. A clot fills the depression above the embryo, which is now effectively sealed in.

66. Disintegration of the uterus continues (until) the embryo becomes surrounded with digested uterine tissue, which is absorbed and used to nourish the growing embryo.

67. Up until the time the embryo penetrates the uterine lining, it remains the same size as the original zygote.

68. This (failure of the embryo to increase in size) is due to the limited amount of food the original egg contained.

70. As it (the embryo) grows, it continues to destroy the tissue around it and expands into the space thus provided.

72. The endoderm is formed when the outer layer of cells separates from the rest of the inner cell mass.

73. The ectoderm differentiates at the same time (as the endoderm) and is made up of the cells remaining after the endoderm has split off.

74. The endoderm forms a hollow sphere that remains attached to the inner cell mass along the surface from which it separates.

79. The human embryo and eventually the human infant develops from the embryonic disc.

83. A third layer of cells, the mesoderm, develops within the embryonic disc between the ectoderm and the endoderm.

87. The placenta is composed of two parts, embryonic and maternal.

88. As the outer cell layer (of the placenta) enlarges, fingerlike projections, known as villi grow out from its outer surface into the uterine spaces formed by the disintegration of the tissue of the uterus.

89. Blood vessels that form in the embryo grow down into the villi. Through them the blood of the embryo flows into the villi and then back into the embryo.

90. The villi occupy spaces in the uterine wall into which the mother's blood vessels empty, and it is here that the exchange of food, oxygen and wastes occur. Other blood vessels drain the spaces. Thus, maternal blood is carried to the uterine spaces and away.

91. That part of the uterus that contains the blood spaces in which the villi lie is the maternal part of the placenta.

92. It will be remembered that early in development the blastula is a hollow sphere of cells. The inner cell mass is attached at one point andhangs into the cavity of the blastula.

106. The umbilical cord connects the developing embryo body to the villi, which develop into the placenta.

108. All of the tissues, organs and systems that develop in the embryo and make up the adult body come from the three embryonic layers, the ectoderm, endoderm, and mesoderm.

109. The ectoderm develops into the nervous system and the outer layer of skin.

110. From the endoderm is developed the lining of the digestive tract and its glands, the liver and the pancreas.

111. The lungs also develop from the endoderm as an outfolding from the gut.

112. The mesoderm develops into the muscles, bones, connective tissue, blood vessels, and other organs that make up the bulk of the body and lie between the outer layer of skin and the inner lining of the digestive tract.

MEAN SCORE 2.51 - 3.50

13. The mammary glands are located on the ventral surface of the body.

26. When the young bird or reptile hatches, the membrane (beneath the shell) is separated and discarded.

27. In mammals, among which the young develop within the body of the mother, the saclike membrane starts to develop, but it never becomes functional.

42. The outer covering of the zygotes varies in different animal forms.

43. Many fish have no covering of any sort over their fertilized eggs.

44. Frogs, toads and other amphibians secrete a jelly-like substance that swells in contact with water and serves as a protective layer for the early stages of development.

45. Reptile eggs are covered with a leathery shell.

46. Bird's eggs have ahard, brittle shell.

60. The point of attachment (of the embryo to the uterus) varies, but usually it occurs high on either the front or back wall.

75. This endodermal sphere is called the yolk sac.

76. The ectodermal cells of the inner cell mass hollow out so that two hollow balls of cells lie adjacent to each other.

77. The area where the ectoderm lies next to the endoderm is known as the embryonic disc.

78. The embryonic disc is a circular disc-shaped structure composed of the two layers, ectoderm and endoderm.

80. The ectoderm that extends outward and upward from the embryonic disc arches over it (embryonic disc) to form a dome-shaped roof.

81. The ectoderm forming the roof over the embryonic disc is the amnion.

82. The cavity within the amnion is the amniotic cavity.

84. The mesoderm spreads out, covering the ectoderm of the amnion and the endoderm of the yolk sac.

93. A layer of cells, the endoderm, separates from the free surface of the inner cell mass and forms a hollow sphere called the yolk sac.

94. The ectoderm, or remainder of the inner cell mass hollows out to become the amnion.

95. The point where the two spheres (yolk sac and amnion) come together is the embryonic disc.

96. (Thus), the embryonic disc is composed of two layers of cells, the ectoderm and endoderm.

97. (The embryo develops from the embryonic disc) and the remainder of the tissues, including the amnion, yolk sac, and outer cell layers, become the membranes that function in aiding development.

98. The membranes that function in aiding development are discarded at birth.

99. During early development the embryonic disc raises upward relative to the amnion so that a circular groove appears around its edge. Actually the groove is caused by the downward growth of the amnion along the edge where it attaches to the embryonic disc. It (the amnion) grows downward and folds under.

100. As it (the amnion) continues folding under, the peripheral groove deepens and cuts under the edge of the embryonic disc. This infolding constricts the endoderm into two parts.

101. The upper part contained within the ectoderm of the embryonic disc is the gut, the forerunner of the digestive tract.

102. The lower part (of the endoderm) remains the yolk sac.

103. An outfolding of endoderm occurs in the floor of the embryonic gut just behind its attachment to the yolk sac. This saclike outfolding grows into a mass of tissue, the body stalk, which actually becomes the umbilical cord.

104. The amnion enlarges as it grows. As the edges of the amnion fold under the embryonic disc, they form a tube that extends away from the lower surface of the embryonic disc. This tube is called the umbilical cord.

105. The umbilical cord contains the yolk sac and blood vessels.

113. After four weeks of development the embryo is only a little over one-eighth inch long.

114. After four weeks of development the embryo possesses some fish-like characteristics. It has gill slits and a tail.

115. The arms and legs begin to form as small buds on the sides.

116. At six weeks it (the embryo) is a half-inch in length, the arms and legs have grown and the head is quite large in relation to the rest of the body. The parts of the head are becoming differentiated. The gill slits and tail are still present.

117. By eight weeks the human form is attained though the length is only about one inch.

118. From this time (attainment of human form) on it (the embryo) is known as a fetus.

119. Further development (of the fetus) consists of growth and completion of the development of the parts already formed.

120. The heart starts beating at five or six weeks.

121. Birth occurs about nine months after conception.

122. During pregnancy the growth of the fetus is accomplished by an enlargement of the uterus.

123. (The uterus) becomes approximately fifty times larger (during pregnancy) than the original size.

124. By the ninth month the uterus extends to the lower end of the sternum.

125. The other organs within the abdominal cavity are compressed and displaced as a result of the growth of the uterus.

126. The fetus assumes a characteristic position within the amniotic cavity in which the elbows, knees and hips are flexed, the feet and arms are crossed, the back bent and the head rests on the chest and is turned to one side.

127. At birth the most common position is head downward, although the reverse position may be assumed with the buttocks near the vaginal opening.

128. The fetus also may lie crosswise.

129. When the fetus is crosswise or with the buttocks nearest the vaginal opening birth is more difficult.

130. Childbirth occurs approximately 280 days after the last menstrual period or at the time of the tenth missed menses.

131. Labor consists of a series of contractions of the involuntary muscles of the uterus.

132. The contractions of the involuntary muscles of the uterus cause the "pains" of child birth.

133. Contractions of the abdominal muscles assist in forcing the fetal membranes, containing the liquid and the child, against the dilating cervix.

134. The fetal membranes or "bag of waters" burst and the child is extruded.

135. Further uterine contractions after the birth of the child expel the placenta and fetal membranes.

136. (After birth) the umbilical cord is severed close to the child's abdomen.

137. Severing the umbilical cord separates the child from the placenta.

138. The stump of the cord becomes the naval.

AREA VII

Maintenance of the Species: Unit 2, Heredity

The Specific Objectives

1. To understand the mechanism of heredity.
2. To recognize the social and economic significance of the science of genetics.

Principles

1. Chromosome behavior and distribution during the maturation of the germ cells determines the number of different kinds of germ cells an organism can produce.
2. Genes determine the potentialities of organisms. The environment determines the extent to which these potentialities can be realized.

The Assignment

Biological Science Lecture Syllabus, pp. 104-138.

Principle I - Chrmosome behavior and distribution during the maturation of the germ cells determines the number of different kinds of germ cells an organism can produce.

MEAN SCORE .5 - 1.50

2. In both sexual and asexual reproduction cells separate from the parent or parents to develop into the next generation.

3. The cells that separate from the parents and develop into the next generation represent the only protoplasmic link between parents and offspring.

4. It follows that whatever passes from parents to offspring to cause the development of parental traits in the offspring must be contained in the germ cells.

6. Chromatin contains chemicals known as genes which govern the development of the individual.

21. Thus, in sexual reproduction, the offspring inherit some of their traits from the father and some from the mother.

25. The part of maturation that is particularly significant in heredity is reduction division.

32. Each of the new cells (resulting from reduction division) which contains one chromosome of each former pair, becomes a germ cell, either an egg or a sperm, depending on whether it is produced by the male or the female.

33. The primary result of the reduction division is to separate the paired chromsomes.

MEAN SCORE 1.51 - 2.00

1. Heredity is the transmission of traits from parent to offspring.

5. The controlling substance that passes from parents to offspring is the chromatin.

18. Both daughter cells have the same number and the same kind of chromosomes and the same kind of genes.

19. Since genes control the development of traits in offspring, it is apparent that in this kind of reproduction where the offspring get exactly the same kinds of genes as were present in the parents, the offspring become exactly like the parents.

20. In sexual reproduction genes from two parents are combined during fertilization to produce the new individual.

22. In order to understand how the offspring inherit some traits from the father and some from the mother one must follow the history of the genes during development of the germ cells within the parent.

23. The germ cells or gametes are produced in the testis of the male and in the ovaries of the female.

24. The development of these cells (gametes) is fundamentally the same in both sexes (male and female) so far as its effect on heredity is concerned.

26. The cells in the gonad (either ovary or testes) undergo a division during their development into mature germ cells that is similar to but not exactly like mitosis.

27. Thus (in reduction division) the chromatin granules form threads, which shorten and thicken into chromosomes as in mitosis, but in this case the threads do not duplicate.

28. (Instead of duplicating themselves as in mitosis) the threads (chromosomes) pair.

30. (In reduction division in humans) the twenty-four pairs of chromosomes line up on the equator of the spindle, the paired chromosomes separate, and each member of a pair goes to the opposite pole of the spindle.

34. The paired chromosomes are homologus or alike; that is, they have genes for the same traits.

35. If we use the letters A, B, C and D to designate chromosomes an animal having eight chromosomes in a germ cell before maturation will have two A's, two B's, and so forth because each (kind of) chromosome has another like it. During reduction division the chromosomes will pair as follows AA, BB, CC, DD. When cell division (reduction division) occurs, two cells will be formed, each of which will contain A, B, C, D. This represents the chromosome content of a germ cell. The same kind of reduction occurs in the production of gametes by the other sex, so its germ cells also contain A, B, C, D. When fertilization occurs, the chromosomes of the two kinds of germ cells are united and the zygote contains AA, BB, CC, DD. This is the same number as in each of the parents, but half came from one parent and half from the other.

MEAN SCORE 2.01 - 2.50

9. The particular number (of threads) that form is constant for any species of organism, but varies among different species.

10. Each thread duplicates itself to become a double strand of chromatin.

11. The genes are arranged in linear order on the chromatin thread, like beads on a string, therefore the duplication of the chromatin thread also duplicates the genes.

13. These short rods are called chromosomes.

16. The double chromosomes separate, one going to each pole of the spindle.

17. The cytoplasm constricts in the middle of the cell between the two groups of chromosomes, with the result that two cells are formed.

29. In a human cell prior to pairing there are forty-eight chromosomes, after pairing there are twenty-four pairs.

31. Following separation of the paired chromosomes the cytoplasm constricts as in mitosis and two cells are formed.

MEAN SCORE 2.51 - 3.50

7. In asexual reproduction, such as mitotic minary fission, the single cell divides into two daughter cells. Before division takes place the chromatin is scattered in a granular form throughout the nucleus.

8. When division (binary fission) begins the chromatin arranges itself so that a number of threads are formed within the nucleus.

12. The double threads then shorten and thicken until short, double rods are formed.

14. While the chromosomes are forming, the nuclear membrane disappears and a spindle forms in the cneter of the cell.

15. The double chromosomes line up with their long axes parallel to the equator of the spindle, so that one chromosome is on one side of the equator toward one pole and the other chromosome on the side of the equator toward the other pole.

36. The illustration of the inheritance of a single pair of characters (a monohybrid cross) as given in the syllabus, pages 106-107.

37. The illustration of the inheritance of two pairs of characters (a dihybrid cross) as given in the syllabus, pages 107-108.

Principle II - Genes determine the potentialities of organisms. The environment determines the extent to which these potentialities can be realized.

MEAN SCORE .5 - 1.50

33. (In other words) each gene may produce an enzyme or it may produce a substance which in turn produces an enzyme.

34. (These) enzymes regulate the thousands of chemical reactions which take place in an organism and it is conceivable that a change or cessation of one or more of these chemical reactions would result in variations of the appearance or behavior of an individual.

MEAN SCORE 1.51 - 2.00

7. There are two kinds of chromosomes in every cell of sexually reproducing organisms. They are the sex chromosomes called the X and Y chromosomes, and the autosomes.

17. Occasionally an individual will appear among offspring that differs from any that have been produced before.

18. Sometimes the appearance of an offspring that differs from any that have been produced before is the result of the recombination of recessive genes and sometimes it is due to environmental causes producing a change in the chromosomes or genes.

19. Chromosomal or gene changes that result in the appearance of a new trait are called mutations.

20. Gene mutations are those in which a single gene is involved.

21. Chromosome changes include large sections of chromosomes and involve many genes.

23. The principles of heredity apply to man as well as to other organisms.

27. Another method (of obtaining knowledge of human heredity) is through the use of statistical analysis.

30. (In previous discussions), it has been stated that the presence of certain genes is responsible for the development of certain traits in an individual.

32. It has recently been shown by various workers in genetics that it is possible for a single gene to control a single biochemical reaction and that this control is probably due to a control of the production of enzymes.

45. It should be appreciated that genes which determine the absence or presence of a certain characteristic are often influenced by genes which determine other characteristics.

122. For this reason (relationship between heredity and environment) it is almost impossible to attribute an individual's intelligence wholly to heredity or to environment; rather it is a product of both.

123. It is probable that heredity sets the limits of mental development, while environment acts within these limits.

MEAN SCORE 2.01 - 2.50

1. If a red snapdragon is crossed with a white snapdragon, the offspring are pink because neither gene of the pair determining color is cominant.

2. (In snapdragons individuals) heterozygous (for color) always show an intermediate condition between the parents when one apir of genes only is concerned.

3. (A type of inheritance similar to color in snapdragons) is illustrated in crosses between Negro and white races involving skin color.

4. There are genes for black skin and genes for white skin and none are dominant.

5. The F_1's of a black and white cross are all mulattoes of the same intermediate shade.

6. The F_2's of a black and white cross show a gradation of color from pure black to pure white.

8. The sex chromosomes control development of sex traits, while the autosomes control the development of other body (somatic) traits.

9. The X chromosomes contain most of the female determining genes.

10. The Y chromosomes contain few or no sex-determining genes.

11. The autosomes contain male-determining genes as well as the great majority of genes affecting somatic characters.

12. Females have two X chromosomes plus autosomes.

13. Males have one X and one Y chromosome plus autosomes.

14. During development the presence of two X chromosomes in the zygote results in the development of a female because the genes for the development of the female sex are present in greater strength than the genes for development of the male sex in the autosomes.

15. If a zygote contains XY chromosomes the male genes in the autosomes control development and a male results.

16. The Y chromosome has no effect; rather it is the development of the extra X that makes possible the development of the male sex.

22. An example of chromosome changes is deletion, where a piece of chromosome becomes lost.

24. The study of human heredity is particularly difficult for several reasons. First, there are usually only three or four generations of humans produced within the lifetime of one investigator. Second, the number of human offspring is very small compared with the number of offspring produced by plants and animals. Third, individual and social resistance act as barriers which limit experimentation with human mating.

26. Some of this information (about human heredity) has been obtained through the study of family histories, which are interpreted on the basis of the laws of heredity originally discovered in other organisms.

31. The actual relationship between a gene and the trait which it determines, however, has been a matter of conjecture.

35. Albinism is an example of a characteristic in man which is a result of the failure of a certain chemical reaction to take place.

36. One of the amino acids is oxidized to form a substance called dopa. In normal man and women dopa is converted to a pigment called melanin which colors the eyes, skin, and hair. This change from dopa to melanin is attributed to a dominant gene.

37. The recessive gene evidently is unable to complete this chemical reaction (dopa to melanin) and, consequently, an individual who has two of these recessive genes will be an albino.

38. This person (an albino) will have very light skin, white hair, and pink eyes, because of an almost total lack of pigment in these structures.

43. The exact mode of inheritance of eye color is not known, though it is thought that several genes are involved.

46. Here is a situation (above) where the genes for albinism inhibit the potential development of eye color despite the fact that genes for eye color are present.

48. It is because of the complex interrelationships among genes that many of the things we would like to know about human inheritance have not been found out.

60. Apparently one pair of genes can express itself differently depending on the sex. In males the gene is dominant, while in females it is recessive.

63. This abnormality (red-green color blindness) is inherited as a sex-linked recessive.

64. A sex-linked character is one in which the genes are on the X chromosomes.

65. The gene for color blindness is recessive to the normal gene; therefore two genes for color blindness - one on each X chromosome - must be present in the female to cause color blindness.

66. If only one gene is present (for color blindness) in the female, she is not color blind, but is a carrier, and can pass the gene on to one-half of her offspring.

67. The male, on the other hand, with one X and one Y chromosome, will be color blind if the defective gene is located on the X chromosome.

68. The Y chromosome (of the male) carries no genes for this trait (color blindness).

69. Since only one gene is necessary to cause color blindness in males, more males are colorblind than females.

81. According to this hypothesis (that handedness is due to a single pair of genes with lack of complete dominance) those individuals who are homozygous for right-handedness will be right handed, those homozygous for left-handedness will be left handed. Heterozygous individuals, however, may be ambidextrous, right or left handed, depending upon environmental influences, which of course, are toward right-handedness.

82. Handedness among homozygous individuals may occasionally be changed by environment, but such a change, according to some psychologist, may result in nervous disorders such as stuttering.

84. All three blood groups (ABO, MN and Rh) are inherited independently of each other.

85. One explanation of the inheritance of the A, B, O blood group is that three genes are involved.

86. Gene A causes the development of antigen A in the red blood corpuscle; gene B causes the antigen B to develop; gene O causes the development of no antigen.

87. These three genes (responsible for the ABO blood groups) are present in the population in general, but any one individual has at most only two of the three.

88. Neither gene A nor gene B is dominant to the other but both are dominant to gene O.

104. For the sake of simplicity, however, Rh positive is said to be inherited as a dominant trait and Rh negative as a recessive trait.

109. If the Rh+ blood cells of the child diffuse into the blood stream of the mother, they cause in the mother's blood the production of antibodies.

110. If these antibodies (from the Rh- mother's blood stream) diffuse back into the infant's blood stream and come in contact with the infant's Rh antigen, the red blood cells of the infant may be destroyed and the child either dies or has severe anemia and jaundice at birth.

119. One thing is obvious, even if we assume that mental ability is inherited: environment has a definite role to play.

120. A potential genius, if completely isolated from society, would not develop his mental capacity to the point where it would be recognized as such.

144. Phenylketonuria is an example of a single gene's being responsible for the production of an enzyme, the presence or absence of which determines normality or feeble-mindedness.

148. Studies of twins show that when one fraternal twin is feeble-minded, the other is feeble-minded in one-fourth of the cases; in identical twins, however, when one is feeble-minded, the other is feeble-minded in practically every case.

153. To the geneticist, the segregation of genes is the most reasonable explanation for the occasional appearance of dull children in bright families.

155. Another test (of the relationship of environment and heredity to intelligence) is the measurement and correlation of the intelligence of adopted children and their foster paretns and comparison of the results with those derived from studies of true parents and their children.

157. Studies of identical twins show that they are more alike in intelligence than fraternal twins even when reared in different environments.

181. Our knowledge of genetics has enabled us to improve the stocks of our domesticated animals and plants to a considerable extent.

183. Biologist have long advocated the adoption of measures aimed at controlling the spread of known hereditary defects throughout the population as part of an eugenics program.

186. Before any progress can be made toward the betterment of mankind through genetics, society must understand the facts placed at its disposal by scientist and must develop a willingness to use these facts for the good of society.

MEAN SCORE 2.51 - 3.50

25. Despite the difficulties, much progress has been made (in human heredity) and a long list of inherited traits is known.

28. This method (of statistical analysis in the study of human heredity) involves observations of the frequency with which a certain trait appears in a given population (the gene frequency).

29. Geneticist have established certain mathematical formulae by means of which these data (gene frequencies) can be interpreted to indicate the mode of inheritance for a particular trait. This hypothetical mode of inheritance is then further investigated by studies of the trait in closely related individuals.

39. The color of the eyes is due to granules of pigment deposited through the back part of the iris.

40. Blue color is due to granules which reflect blue light. Brown eye color is caused by the presence of brown pigment in front of the granules responsible for blue eye color.

41. Other eye colors (besides blue and brown), such as gray or green, are due to the varying amounts of brown pigment laid down on the granules reflecting the blue light.

42. In the case of individuals where no pigment is present, the eyes appear pink because of the reflection of the color of the blood in the blood vessels of the eye.

44. Brown is generally considered dominant over blue.

47. This example (of the inhibiting effect of albino genes) may give you an insight into the complexities of the interrelationships existing between the actions of the genes.

49. Skin color is determined by the pigment in the skin.

50. There is much pigment in the skin of Negroes and little in the skin of whites.

51. In the Negro white crosses the offspring are mulatto and intermediate in color.

52. When two mulattoes are crossed, the offspring are various degrees of pigmentation.

53. It is thought by some geneticist that many pairs of genes are responsible for the inheritance of skin color.

54. One explanation (for the inheritance of skin color) is that two pairs of genes are involved.

55. A black skin results from the genotype AABB and a white skin from the genotype aabb. A mulatto would have the genotype AaBb.

56. The skin of an individual having a genotype Aabb would be intermediate between mulatto and white and similarly a genotype or AABb would result in a skin color intermediate between mulatto and black.

57. If this hypothesis (for the inheritance of skin color) is accepted, it can also be inferred that the genes are passed from parent to offspring as they are in an ordinary dihybrid cross where there is a lack of dominance in both pairs of genes.

58. There are small color differences within the white race which may be caused by the influence of only a single pair of genes. The darker pigmentation apparently is dominant over the lighter.

59. Some baldness may result from disease, but much of it is a hereditary characteristic.

61. This type of inheritance (as in baldness) is known as sex-limited or sex-influenced inheritance and explains why more men than women are bald.

62. In red-green color blindness the person cannot distinguish between red and green colors.

70. If a colorblind man marries a normal woman, all his sons and daughters will be normal, but one-half of his daughters will be carriers.

71. These (carrier daughters) may pass the gene to one-half of their sons, who will be color blind.

72. A color blind man will transmit this trait (colorblindness) to some of his grandsons through his daughters.

73. Total color blindness is also hereditary, as is the inability to distinguish between various pastel shades of color.

74. The mode of inheritance of these types of color blindness (total and pastel) has not been definitely established.

75. Surveys show that approximately 7 per cent of the white population is left handed.

76. Studies of closely related individuals indicate that there is a correlation between the handedness of parents and their offspring.

77. When both parents are right-handed, about 6 per cent of the children are left-handed.

78. When one parent is right-handed and the other left-handed about 16 per cent of the children are left-handed.

79. When both parents are left-handed, about 50 per cent of the children are left-handed.

80. Since two right-handed parents may have left-handed children and two left-handed parents may have right-handed children, one hypothesis is that handedness is due to a single pair of genes with lack of dominance.

83. There are at least three blood groups in men the ABO group, the MN group and the Rh group.

89. It has been discovered that the A and B antigens are present not only in the red blood cells, but also in every cell of the body.

90. Experimental work in the field of plastic surgery indicates that better results are obtained in the grafting of tissues from one individual to another when these individuals are of the same ABO type. This may be due to the same principles involved in blood transfusions.

91. The A and B antigens are soluable in the body fluids.

92. The degree of solubility (of A and B antigens in the body fluids), however, varies with different individuals. In about 70 per cent of the population the presence of these antigens can be detected in the saliva.

93. (The individuals in which the antigens can be detected in the saliva) are known as secretors, the remainder non-secretors.

94. The condition whereby antigens may be detected in the saliva is inherited as a simple dominant trait.

95. Under certain circumstances criminal investigators are able to determine the ABO type of secretors by analysis of saliva on recently discarded cigarette stubs.

96. In the inheritance of the MN group one gene (M) causes the development of the M antigen while another gene (N) causes the production of the N antigen.

97. Neither of the genes (for M and N antigen) is dominant.

98. The MN antigens are not known to produce any harmful effects as a result of blood transfusions regardless of the MN type of the donor or recipient.

99. A knowledge of the mode of inheritance of the ABO and MN blood groups is applied quite often in cases of disputed paternity.

100. Another of the inherited blood groups is the Rh complex.

101. One explanation of the inheritance of the Rh factor is the presence of three pairs of genes on a single pair of chromosomes.

102. The six genes (involved in the inheritance of Rh) when combined in all possible arrangements produce eight different Rh blood types.

103. Although these eight (Rh) types are due to different genotypes, seven of them are collectively known as Rh+, the eighth type, as Rh-.

105. According to this simplified explanation, an Rh+ individual would have a genotype or RR or Rr and an Rh- individual would have a genotype of rr.

106. About 85 percent of the white population is Rh+ and 15 per cent is Rh-.

107. Knowledge of the inheritance of the Rh group is important because a mating between an Rh+ father and an Rh- mother will produce in at least one-half of the cases, offspring that are Rh+.

108. The presence of an Rh+ child within the body of an Rh- mother sometimes leads to tragic results.

111. The first child born of such parents (Rh+ father and Rh- mother) usually escapes harm, but by the time the second or third child is developing there may be sufficient antibodies in the mother's blood to cause the symptoms described above (erythroblastosis) to occur in the infant if it happens to be Rh+.

112. This disease (Rh disease) known as erythroblastosis foetalis, has long been recognized, but the cause was not known before the discovery of the Rh antigens.

113. (As previously mentioned), the first child born to parents of this Rh combination (Rh+ father and Rh- mother) usually escapes harm and occasionally the second and third child may be unaffected.

114. There have also been cases in which no children (of Rh+ fathers and Rh- mothers) showed symptoms, however, surveys indicate that about one out of twenty-eight babies born to such parents show symptoms of this disease (Rh disease).

115. Of those (babies) showing these symptoms (of Rh disease) some recover without medical attention, others, more severely affected, may recover with medical treatment, and a few are stillborn or live for only a short time.

116. With increasing knowledge of the factors involved, physicians are constantly developing better techniques for the treatment of this disease (erythroblastosis).

117. The question whether mental ability is inherited has frequently been asked.

118. It is well recognized that the human population varies in intelligence from the idiot, who never reaches a mental age high enough to care for himself, to the genius, who presents the world with great accomplishments in literature, music, and science.

121. (On the other hand), an individual who has a low mental capacity could never become a genius even if he were exposed to a society of the highest academic level.

124. Tests have been compiled by psychologists to measure intelligence.

125. These tests measure intelligence in terms of mental age.

128. The persons considered mentally deficient or feeble-minded are classified as idiots, imbeciles, or morons.

131. Idiots are absolutely helpless when it comes to feeding and caring for themselves.

132. One type (of idiot) is the microcephalic, or pinhead, in which the bones of the skull close very early in the life of the individual - earlier than in normally developing individuals.

134. Another type of idiot is the cretin.

135. Cretinism is the result of insufficient thyroid hormone during early development.

136. One hypothesis as to the cause of idiocy is purely environmental, attributing the idiocy to faulty prenatal environment or birth injuries.

137. Another hypothesis as to the cause of idiocy points to heredity and requires the presence or absence of certain genes which, when expressed, produce the condition.

138. The third, and probably the least dogmatic hypothesis as to the cause of idiocy, includes both environment and heredity as contributing interacting factors.

139. An example of a type of feeble-mindedness which definitely is hereditary is phenylketonuria.

140. In normal individuals, phenylpyrivic acid, which is one of the products of metabolism, is oxidized by an enzyme.

141. In phenylpyruvic idiots, the enzyme (responsible for the oxidation of phenylpyruvic acid) is not present and phenylpyruvic acid is not oxidized and is excreted in the urine.

142. The excess of phenylpyruvic acid in the body damages the nervous system, thus causing idiocy.

143. Phenylketonuria is due to a recessive gene which results in the absence of the enzyme necessary for oxidation of phenylpyruvic acid.

145. Some feeble-mindedness, higher than idiocy, is also thought to be due to heredity.

146. Family histories indicate that this type of mental deficiency (feeble-mindedness higher than idiocy) occurs much more frequently in some families than in others.

147. The study of twins supports the hypothesis that heredity is the cause of certain kinds of mental slowness.

149. It is known that superior intelligence runs in families.

150. It is claimed by some that superior intelligence is due to an environment which encourages the development.

151. If environment is the sole cause (of superior intelligence) one would expect that all children reared in favorable surroundings would develop into superior people. This, however, is not the case.

152. Dullards do appear in favorable environments, though not so frequently as in other families.

154. Studies made of children reared in orphanages where, presumably, the environment is fairly constant for all individuals, show that just as much variability exist among these orphans as in children raised in their own homes.

156. It has been found that there is a closer correlation between true parent and true child than between foster parent and foster child.

158. Insanity is a derangement of the normal mind.

159. A person of normal or superior intelligence may become insane.

160. There are some twenty types of insanity, several of which are considered hereditary.

161. Huntington's chorea is inherited as an autosomal dominant.

162. Because Huntington's chorea frequently appears late in adult life, its presence is frequently unsuspected until after the individual has married and reproduced.

163. Because Huntington's chorea does appear late in life after the normal reproductive period its control is difficult.

164. Huntington's chorea is a rare disease.

165. Hospital records show no more than 100 to 200 cases of Huntington's chorea per year in the United States.

166. The victims of Huntington's chorea exhibit irregular and spasmodic movements of the face and arms. Gradually other voluntary muscles are involved and the mental functions either slowly degenerate or the individual becomes violently insane.

167. There is no known cure for Huntington's chorea.

168. Schizophrenia (Dementia Praecox) is characterized by melancholia, emotionalism, and delusions of persecution.

169. Some geneticist claim that schizophrenia is hereditary and they use as a basis for their claim the fact that the frequency of the disease among relatives of affected persons is much greater than in the general population.

170. A study of twins shows that when one member of a pair of fraternal twins develops the disease, the other develops it in less than one-fourth of the cases (schizophrenia).

171. In identical twins when one member of a pair develops schizophrenia, both twins develop the disease in nearly every case.

172. The environmentalist say that there is greater frequency (of schizophrenia) among relatives of affected individuals because of common environment, common problems and common frustrations.

173. It seems reasonable to assume that mental defects are determined, in part, by heredity, since mental illnesses have their basis in the nervous system and the functioning of the endocrine glands.

174. Geneticist who have worked on the assumption that schizophrenia is inherited have postulated that it is transmitted as a recessive trait.

175. It is further postulated that individuals possessing genes for schizophrenia will not exhibit symptoms for it unless they are faced with certain types of problems and frustrations.

176. If individuals possessing the genes for schizophrenia should never be placed in an environment where certain types of problems and frustrations exist, it is believed they may not develop the disease.

177. Epileptics suffer convulsions with loss of consciousness.

178. Recent work indicates that epilepsy is due to a dominant gene with variable expressivity.

179. By means of the electroencephalograph (an instrument used to record the electrical pulsations of the brain) it has been found that all epileptics have an abnormal type of brain wave (cerebral dysrhythmia) and that at least one of the parents will also exhibit this type of brain wave even though he may not be subject to the seizures.

180. It is assumed that the abnormal brain wave is the consistently expressed inherited condition (due to the genes responsible for epilepsy), and for some reason, possibly environmental influences, people displaying this abnormality may or may not exhibit epileptic convulsions.

182. There is little doubt from the standpoint of the common good of society that measures should be taken to control the spread of known hereditary defects throughout the population.

184. Biologist have also pointed to the improvement of the human stock through selective breeding.

185. Whether the measures of negative or positive eugenics will be applied is dependent upon the attainment of a degree of social consciousness which, at present, seems Utopian.

187. Through a program of general education society can come to understand the facts placed at its disposal by science.

188. The development of a willingness on the part of society to use facts for its own good will have to wait upon an advance in our social evolution.

MEAN SCORE 3.51 - 4.50

Items number 126, 127, 129, 130 and 133. Content may be obtained from Appendix II.

AREA VIII

Interrelationships: Unit 1, The organism and Its Environment

The Specific Objectives

1. To understand the nature of the environment of living things.
2. To understand that adjustment of organisms to an ever changing environment is essential if the organism or species is to survive.
3. To recognize that a knowledge of ecological principles increases one's understanding of human societies.

Principles

1. The animals and plants living in the same habitat constitute a community of interrelated and interdependent members. The plant life of the community is the primary determinant of the character of the community which because of its characteristics may be considered a superorganism.
2. The feeding relationships between the organisms of the community constitute the center of activity within the community. Other basic pursuits by the organisms of the community are those involved in obtaining shelter and protection from the biotic and physical elements of the environment, mating, and caring for the young of the species.
3. The world of nature is in a state of continual change. Organisms comprising a given community are continually altering the soil and water conditions of the habitat so that those organisms originally inhabiting the area must adapt themselves to the changes, migrate, or perish. Thus one community paves the way along the environmental path for another community in a dynamic progression called ecological succession.

4. The carbon cycle and the more complicated nitrogen cycle exemplify the complexity of the interrelationships among living things and their physical environment. In each instance there is a cyclic chain of events from the inorganic to the organic and back to the inorganic elements of the environment.
5. Social groupings among individuals of the same species and associations between individuals of different species are adaptive responses which often increase the chances for survival of the organisms involved.

The Assignment
Biological Science Lecture Syllabus, pp. 139-175.

Principle I - The animals and plants living in the same habitat constitute a community of interrelated and interdependent members. The plant life of the community is the primary determinant of the character of the community which because of its characteristics may be considered a superorganism.

MEAN SCORE .5 - 1.50

1. No animal or plant lives a completely independent life.

2. All organisms are in constant interaction with their environment and continually respond to environmental factors in order to maintain themselves.

4. The basic relation between organism and environment is the same for both plants and animals.

5. The environment of a given organism includes the sum total of the conditions or factors to which it is exposed.

20. The animal life of the biome is dependent largely upon the plant life in the area.

MEAN SCORE 1.51 - 2.00

3. The responses of animals are often more immediate and noticeable than those of plants because of the higher degree of organization in animal forms.

10. Plants and animals are associated in natural units over the earth.

15. The biome is not a static unit, but extremely dynamic.

16. The growth and development of the biome includes all of the changes bare or denuded areas pass through in arriving at a condition of relative stability called the climax stage.

19. The vegetation present (in a biome type or natural unit) is dependent upon climatic and other factors of the environment.

21. Man, in turn, is dependent upon both plant and animal raw materials obtained from these natural life areas in order to live and build his industries and institutions.

23. The habitat factors of climate and soil are important determinants of the distribution of plant and animal life.

24. The interaction of living organisms within the biome constitutes the biotic environment of the individual organism or the population.

25. All of the organisms living within the unit (biome) are striving to keep alive and reproduce their kind, the competition for food, shelter, space and mates results in a web of life exceedingly complex in its nature.

MEAN SCORE 2.01 - 2.50

6. The place or niche that an organism occupies in nature is called its habitat.

7. The term (habitat), however, includes only the physical factors in the environment of organisms and not the organisms themselves.

8. (In other words) the habitat is the physical framework that supports in one way or another the living organisms in a given community.

11. These (natural) units are called communities or, more specifically, biomes, and each contains many kinds of habitats.

12. To the biologist the biome is more than the sum of its parts.

13. In a certain sense the biome may be regarded as a kind of super-organism.

14. The biome concept is an operational concept in that it has proved useful in furthering our understanding of the interrelationships among living things.

17. The earth can be divided into eight biome types. These are (1) tundra and ice, (2) coniferous forest, (3) temperate forest, (4) grassland, (5) desert, (6) tropical forest, (7) temperate rain forest, (8) the ocean.

18. Each of the major natural units (biome types) produces characteristic vegetation.

MEAN SCORE 2.51 - 3.50

9. (For example) the habitat of an oyster population includes such physical factors as the type of bottom, the chemical conditions of the sea water, the pressure, and light and temperature conditions prevailing in the area, but does not include the interactions between the oyster and its prey, parasites or predators.

22. The major vegetation areas on the earth's horizontal surface are also evident in the vertical plane, as on high mountains.

Principle II - The feeding relationships between the organisms of the community constitute the center of activity within the community. Other basic pursuits by the organisms of the community are those involved in obtaining shelter and protection from the biotic and physical elements of the environment, mating, and caring for the young of the species.

MEAN SCORE .5 - 1.50

1. One of the most important integrating factors in the biotic environment is the food chain.

2. The degree of interdependence of living organisms is evident in the food relationships of the community.

MEAN SCORE 1.51 - 2.00

3. In a typical fresh-water pond the microscopic green plants or algae reproduce and grow in countless numbers.

4. The algae (in a fresh water pond) transform radiant energy into chemical energy of food by their photosynthetic activity and consequently serve as the basic source of food for the community.

5. Protozoans, microscopic crustaceans, and small insects feed upon the algae (in a fresh water pond), and these animals, in turn, are fed on by such larger animals as aquatic insects and small fish.

6. Large fish feed upon smaller fish and large insects (in a pond) and finally reptiles, birds, and mammals utilize the fish as food.

7. In a food chain such as that in a fresh-water pond, millions of algae are required to support thousands of microscopic animals, called key industry forms, which feed upon them.

8. The thousands of animals, which have transformed plant protoplasm into animal protoplasm, sustain hundreds of fish, which in turn support the relatively few fish-eating vertebrates.

9. A food pyramid is established for every food chain.

10. The food pyramid serves to present the quantitative aspect of the food web in a community.

11. Food pyramids are the result of two tendencies: (1) that smaller animals have a higher capacity to reproduce themselves than do the higher animals, (2) that the smaller animals usually are the prey for the larger animals.

12. Included as factors in the formation of food pyramids are such (factors) as the size of the food, the amount of food, the availability of food, and the capacity an animal has to utilize the food.

18. Studies of fluctuations in animal populations, whether free living or parasitic, demonstrate that a change in one link of a given food chain will inevitably influence all the organisms involved in the chain.

21. What is true for the free-living forms is true for the parasites they harbor. Food chains and parasitic life cycles are closely intertwined.

MEAN SCORE 2.01 - 2.50

13. Organisms expend energy to obtain food and nourishment.

14. A very large animal occupying the apex of the (food) pyramid might be able to maintain itself on ameba protoplasm, but the amount of energy required to obtain sufficient numbers of ameba for this purpose would be altogether out of proportion to the energy yield of the food.

15. Because of the relationship between energy required to obtain food and the energy obtained from the food, animals usually feed upon the next size group in the food pyramid, thus obtaining the elements in the ameba protoplasm at third or fourth hand.

20. Any factor or set of factors which renders the environment unsuitable for the rodents will seriously influence the carnivores which prey upon them.

MEAN SCORE 2.51 - 3.50

16. There are notable exceptions to this rule (that animals usually feed on the next size group in the food pyramid) such as the Whalebone whales and the Mississippi River paddlefish, which, despite their size feed on microscopic animal and plant life.

17. Man is the only organism which can feed on any size food.

19. It is well known that in Canada the arctic fox fluctuates with the lemmings, the numbers of red foxes fluctuate with mice and rabbits, the fisher varies with mice, rabbits and fish, and the lynx populations are correlated with the numbers of rabbits.

Principle III - The world of nature is in a state of continual change. Organisms comprising a given community are continually altering the soil and water conditions of the habitat so that those organisms originally inhabiting the area must adapt themselves to the changes, migrate, or perish. Thus one community paves the way along the environmental path for another community in a synamic progression called ecological succession.

MEAN SCORE .5 - 1.50

1. The tendency to change is characteristic of life, whether at the cellular, individual organism, population or community level.

2. The changes which take place at the community level tend to put the plant life in better adjustment with the soil, water, light and biological conditions in the area.

3. Once the adjustment (between the plant life and other conditions in the area) is affected, a relatively stable condition known as the climax stage is reached.

5. The primary causes of ecological succession are (1) the reactions upon the habitat by the organisms living there, and (2) modifications of the habitat by such physical forces as silting, chemical changes in the soil caused by leaching of salts from the soil, drainage of swamps, fire, cultivation and many others.

6. (In all instances) the biological and physical forces at work cause a change in the plant life of the area, and changes in the plant life cause changes in the nature of the animal life. In this way the character of the community changes and one type of community paves the way along the environmental path for each succeeding community until the relatively stable climax community is reached.

MEAN SCORE 1.51 - 2.00

4. The series of changes leading to the climax stage is called ecological succession.

15. Ecological succession may also have its beginning in a lake, pond or stream instead of barren rock.

19. Succession also occurs within a community.

23. A knowledge of the natural trends in ecological succession is of importance to man in his efforts to conserve soil, improve grazing conditions for his cattle, increase the productivity of his forest lands, and conserve his wildlife.

MEAN SCORE 2.01 - 2.50

7. A typical example of the interaction (leading to the climax community) is the transition of a given area from barren rock to the climax vegetation of the area.

8. The first organisms to invade a barren rock substrate are terrestrial algae, bacteria, lichens and mosses.

9. Through the continued action of climatic forces together with the biological action of terrestrial algae, bacteria, lichens and mosses, soil is formed from barren rock substrate.

10. When soil is formed in an area the environment is prepared for an invasion by various herbs and weeds.

12. Eventually, when sufficiently deep soil has been formed, shrubs and trees may invade the area, leading to dominant forms of vegetation which make it difficult for new species to gain a foothold.

13. Frequently the climax type of vegetation for a given area is not reached because it is arrested at some stage in the succession by such human activities as repeated burning or the constant use of an area for grazing purposes.

14. Arrested development (toward the climax stage) is temporary, however, for once the human influence is withdrawn, the natural process of change continues toward the climax type of vegetation.

16. When ecological succession begins in a lake, pond or stream the invasion of shore plants and the gradual deposition of silt reduce the area of open water and eventually a bog or swamp results.

17. The drying up of a bog or swamp and subsequent changes in the soil conditions create an environment suitable for land plants.

18. Over a period of time (beginning with a lake, pond or stream) a climax community with its characteristic animal life will develop.

22. In the type of succession occurring within a culture of protozoa, the accumulation of metabolic wastes together with the exhaustion of food are important determining factors.

24. Human efforts to conserve the replaceable natural resources without consideration of the natural trends in ecological succession are doomed to failure.

MEAN SCORE 2.51 - 3.50

11. Herbs and weeds are characterized by possessing light seeds which can very easily be transported by the wind.

20. An example of succession within a community is the succession in a culture jar of protozoa.

21. In a new culture of protozoa the clear culture medium becomes cloudy because of the rapid accumulation of bacteria. Changing environmental conditions in the culture jar then permit the development of various types of protozoa, eventually leading to a culture of the bell-shaped, stalked protozoa called Vorticella.

Principle IV - The carbon cycle and the more complicated nitrogen cycle exemplify the complexity of the interrelationships among living things and their physical environment. In each instance there is a cyclic chain of events from the inorganic to the organic and back to the inorganic elements of the environment.

MEAN SCORE .5 - 1.50

3. Soil is essential to life because it is the source of the chemical elements and compounds necessary for the formation and maintenance of protoplasm.

32. Because amino acids cannot be synthesized without nitrogen and proteins cannot be made without amino acids, the life of all organisms is dependent on the nitrogen of the atmosphere.

33. Despite the abundance of nitrogen in the air, green plants which manufacture the amino acids cannot obtain the nitrogen directly from this overhead supply.

34. Green plants must get nitrogen from the nitrogen compounds in the soil in the form of soluble salts and ammonia.

36. The interchange of nitrogen between the atmosphere and the soil is cyclic in nature.

37. The cyclic interchange of nitrogen between the atmosphere and the soil is one of the most fundamental interrelationships between living matter and the inanimate environment.

41. Animals eat (the) plants or saprophytic plants attack them and digest the proteins to amino acids, which are then resynthesized into the proteins of the devouring organisms.

46. Basically there are four processes involved in the nitrogen cycle: (1) the process of decomposition involving the organisms of decay, (2) the process of nitrification in which ammonium compounds are changed into nitrite and nitrate compounds, (3) the process of denitrification in which certain kinds of bacteria operating under certain soil conditions change nitrogen compounds of the soil into free atmospheric nitrogen, and (4) the nitrogen-fixing process involving the nitrogen-fixing bacteria which either live in a symbiotic relationship with leguminous plants or are free-living and convert atmospheric nitrogen into the usable nitrate form.

47. The element carbon is also constantly being withdrawn from the environment to become a part of the organic makeup of living things.

48. The source of the carbon used by living things is the carbon dioxide of the atmosphere and water.

49. The atmospheric supply of carbon dioxide is replenished through the respiratory activities of animals and plants, especially bacteria; through the combustion of animal and plant residues such as wood,

coal, petroleum, gas and the dead remains of organisms; and through volcanic eruption which bring into the atmosphere carbon dioxide trapped in the earth's crust in the geologic past.

50. Carbon dioxide diffuses into green plants and is used in the manufacture of simple sugars.

51. The simple sugars (manufactured by the plant) may be oxidised immediately by the plant for energy, in which case the carbon dioxide is released again to the atmosphere, or used again in photosynthesis.

56. If the plant dies, bacteria and other organisms digest and decompose the plant compounds and eventually release the carbon as carbon dioxide.

MEAN SCORE 1.51 - 2.00

1. The physical environment of animals and plants consists of three media - soil, atmosphere and water.

26. The atmosphere is (one of) the basic media in which organisms live and from which they obtain their requirements.

28. The atmosphere consist mainly of nitrogen, oxygen and carbon dioxide.

30. The amino acids cannot be synthesized without nitrogen.

35. Nitrogen is constantly being lost from the soil to the atmosphere and is being constantly returned from the atmosphere to the soil.

38. Certain bacteria known as nitrogen-fixing bacteria can utilise atmospheric nitrogen to manufacture nitrates (NO_3).

39. Nitrogen-fixing bacteria may be living either in the nodules of the roots of leguminous plants, such as peas, clover, alfalfa and beans, or as free organisms in the soil.

40. The nitrates produced by nitrogen-fixing bacteria are used by plants in the synthesis of amino acids and plant proteins.

42. In animals some proteins are used to produce carbohydrates, with the result that nitrogen is released and excreted as urea.

43. Urea and eventually the dead animal body are decomposed by putrefactive bacteria which change the nitrogen compounds to ammonia (NH_3).

44. Ammonia is returned to the soil (through the action of putrefactive bacteria) and is acted upon by a group of bacteria which change ammonia into nitrites (NO_2).

45. A third group of bacteria, the nitrate bacteria, change the nitrites into nitrates (NO_3).

52. The simple sugars (manufactured by the plant) may become a part of complex carbohydrate molecules to be used as a part of the plant structure.

53. The simple sugars (manufactured by the plant) may be synthesized into proteins or fats.

54. If the carbon becomes a part of the plant as complex carbohydrate, protein or fat, it remains in the plant until it is digested and used by the plant or until the plant is eaten by an animal or dies.

55. If the plant is consumed by an animal, it is digested and the carbon may become a part of the animal body as animal carbohydrate, fat or protein or it may be used for energy and carbon dioxide may be given off as a by-product.

57. The carbon in animals is also released to the atmosphere as carbon dioxide when the animal dies and decomposes.

59. By one of the three processes, fermentation, putrefaction, or decay, the carbon becomes a part of the microorganisms before it is released to the atmosphere as carbon dioxide.

72. Oxygen, like nitrogen and carbon, is constantly being passed back and forth between organisms and the atmosphere.

73. Both plants and animals remove oxygen from the atmosphere and use it in respiration.

74. The green plants return oxygen to the atmosphere through the photosynthetic process.

102. Light is essential to the process of photosynthesis and consequently is basic to the food supply of all living things.

103. The photosynthetic process carried on by chlorophyll bearing plants transforms the radiant energy of the sun into chemical energy, thus bridging the energy gap between the physical and biological worlds.

MEAN SCORE 2.01 - 2.50

2. Operating within these media (soil, atmosphere, water) are the physical factors of light, heat, pressure, gravity and chemical concentrations.

4. Living matter contains a minimum of ten essential elements.

5. The essential elements (in protoplasm) are carbon, hydrogen, oxygen, phosphorus, potassium, iodine, nitrogen, sulfur, calcium, iron and magnesium.

8. Soil is a mixture of fragmented rocks and minerals, organic matter, water and air in varying proportions.

9. Soil develops under the influence of climate and living organisms.

11. The extent of weathering in any area depends upon the climate.

12. Dead organisms contribute the organic matter of their bodies when they decompose.

13. Living organisms also contribute organic matter (to the soil) in the form of waste products.

14. Some living organisms, such as earthworms which live in the soil, improve it by burrowing through it, feeding on it, and mixing the organic matter and minerals.

16. The production of good soil requires long periods of time. It is estimated that 300 to 1000 years are required to produce one inch of productive soil by natural processes.

17. Bedause it requires such long periods of time to produce soil the importance of soil conservation becomes obvious.

18. The chemical, physical, and biological factors operating within the soil exert their primary effects on the root systems of plants.

19. The texture of soil, its temperature, and its water, air and mineral content must be optimum if plants are to attain their maximum growth and vigor.

20. The oxygen content of air in the soil is especially significant because of its influence on the respiratory activity of plant roots.

23. The lack or insufficient abundance of any one of them (certain mineral substances) can limit the growth and development of the plant.

24. A biological principle based upon (one phase) of the relationship or organisms to environmental factors is called the "Law of the Minimum". It states that the factor present in minimum concentration in the environment of an organism may limit the growth and distribution of that organism.

27. The atmosphere is a gaseous envelop that surrounds the earth.

29. Nitrogen makes up 79 per cent of the atmosphere by volume and is an essential element in living organisms.

31. Proteins cannot be made without amino acids.

58. Decomposition of organic compounds by bacteria and other fungi is known as either fermentation, putrefaction or decay.

60. Fermentation is the breakdown of sugars by bacteria and yeast with the production of alcohols and acids.

61. The souring of milk is an example of fermentation. Milk contains sugars which are changed through bacterial action to lactic acid.

63. Certain of the products of fermentation are carbon dioxide and water.

64. Putrefaction refers to the decomposition of protein molecules by microorganisms.

65. Protein molecules (may be broken down by microorganisms) into simpler compounds to produce amino acids and finally carbon dioxide, ammonia, hydrogen sulfide, nitrates, and other simple compounds.

69. Decay is similar to putrefaction in that protein compounds are decomposed.

75. Though oxygen is almost universally available, it is much more abundant in the atmosphere than in water.

80. Whether in a pond or at altitude, low oxygen concentrations are frequently a limiting factor to the life activities of organisms.

91. As a basic environmental medium, water has many outstanding characteristics. It serves as a solvent, food, circulating medium, temperature regulator, and catalytic, hydrolytic, and ionizing agent.

92. Water is an essential constituent of protoplasm and constitutes between 40 and 90 per cent of its substance.

95. An organism's water requirements are often partially met by the organism's ability to extract a supply of water through the metabolism of organic foods.

96. In most instances (however) living things depend upon free water to supply their needs.

97. The activation of the elements borrowed from the earth's crust and atmosphere and organized into living things is affected by the energy from the sun.

98. Organisms derive their energy from their surroundings and also give it up to their surroundings.

99. The available radiant energy varies greatly on different parts of the earth and also exhibits annual and daily cyclic fluctuations.

139. Temperature affects the distribution of plants and animals on the earth.

159. (Gravity) influences the structural characteristics of organisms as well as their behavior and physiological adjustment to the environment.

171. Organisms must be able to adjust themselves to their chemical environment.

172. The chemical environment supplies the organism or tissue with essential chemical foods.

MEAN SCORE 2.51 - 3.50

7. Sodium and chlorine are essential to animal nutrition although not indispensable to plants.

10. The original rock of the earth is broken up in weathering by the action of the wind, rain, heat and freezing.

15. Tons of soil per acre are moved and enriched each year by earthworms.

21. Water-logged soil will eventually cause the death of plants because water fills the air spaces in the soil, thus depriving the plant of its oxygen supply.

22. Deficiencies in concentration of certain mineral salts in the soil reduce the vigor of plants.

25. An example of the "Law of the Minimum" is that there may be a superabundance of water and optimum conditions of light and dissolved mineral salts, but the photosynthetic activity of any given plant may fall below the energy requirements of the plant if the concentration of carbon dioxide is too low. Should this persist over a period of time the plant will die.

62. The sour taste of dill pickles is also the result of fermentation.

66. Some of the intermediate products of putrefaction have unpleasant odors.

67. The microorganisms that cause putrefaction are anaerobes.

68. Anerobes do not require free oxygen for respiration, but obtain their oxygen from the compounds they decompose.

70. Decay differs from putrefaction in that no unpleasant odors are produced.

71. The process of decay is carried on by aerobic microorganisms that must have free atmospheric oxygen for respiration.

76. Many fresh water lakes are deficient in oxygen at the lower levels during the summer months.

77. Pollution frequently causes a depletion of dissolved oxygen in lakes and streams.

78. Atmospheric oxygen decreases in concentration with increase in altitude.

79. Breathing air at high altitudes results in oxygen starvation or anoxia.

81. Water covers about 72 per cent of the earth's surface.

83. Water evaporates from oceans, lakes and streams, land surfaces and living things and is transferred as water vapor to all parts of the world.

84. The water vapor in the atmosphere ultimately precipitates as rain, fog, dew, snow, or hail and provides regions far removed from the oceans with water.

85. The cycle of water from earth's surface to atmosphere and back is called the hydrologic cycle.

86. The hydrologic cycle has undoubtedly continued with little change throughout the geologic past until the present time.

87. It is estimated that about 6,500 cubic miles of water run off the land anually by way of streams.

88. Anmually, the run off water carries with it some five trillion tons of dissolved and suspended matter, all derived from the soil and the earth's crust.

89. The increasing saltiness of the sea is an evidence of the effectiveness of the erosion process.

90. Man's present and future welfare demands an effective control of the destructive action of water.

93. Unless animals and plants can adapt themselves to the water conditions of their surroundings, they must either migrate to more congenial conditions or perish.

94. The water content of an organism frequently determines its ability to withstand unfavorable environmental conditions.

100. Solar radiation penetrates the earth's atmosphere quite readily, but water absorbs certain of the wave lengths.

101. These facts (concerning energy) are of significance with relation to the distribution and activities of animals and plants.

104. As an environmental factor, light must be considered in terms of its quality and intensity.

105. The quality of light refers to its wave length.

106. Color of light is a function of its wave length.

107. Light intensity refers to the quantitative aspects of light.

108. The environmental effects of light quality and light intensity are well exemplified by the requirements of the photosynthetic process.

109. Chlorophyll is most rapidly decomposed in the orange-red region of the visable spectrum.

110. It is also true that more light is absorbed by chlorophyll in the orange-red region of the visable spectrum than in any other.

111. The optimum quality of light for photosynthesis (consequently) is light of the orange-red color.

112. If the light intensity is too great, light of these wave lengths (orange-red) becomes a limiting factor in photosynthesis.

113. Plants need a definite number of energy units of light for their growth and maturation.

114. Generally, a plant functions more efficiently when the light is distributed over a longer period of time at a lower intensity than when the opposite conditions prevail.

115. Animals, almost without exception, can live independently of light.

116. Some animals such as the cave dwellers, deep-sea fishes, and intestinal parasites normally live in environments lacking light.

117. Light does influence the activities and behavior of the majority of animals.

119. The color changes in animals in response to the incident of light are responses of the pigment-containing cells in the animal's integument and are often adaptive in nature.

120. In some fishes, as in some birds and mammals, the sexual cycle appears to be determined largely by the intensity of light.

122. Earthworms generally move away from the source of light.

123. Moths and many other insects move toward a given light source.

124. Plant stems are definitely positive in their reaction to light.

125. Plant roots are negatively phototropic.

128. Animals and plants are extremely sensitive to sudden changes in temperature and are frequently killed at temperatures only a few degrees above those at which they are accustomed to live.

129. The death of organisms because of heat is best explained at present by the fact that the proteins of the living cells become coagulated in the same way that egg albumin coagulates when heated.

130. The water content of organisms seems to be an important factor (in resistance to heat), susceptibility to heat increases as water content increases.

131. Animals and plants also may be killed by cold.

132. Water content is an important factor (in resistance to cold) susceptibility to cold increases as water content increases.

134. The rate at which biological reactions occur depends very definitely upon the surrounding temperature.

135. According to a physical law, the velocity of chemical reactions increases two or three times with each rise of 10°C. in temperature. Metabolic processes conform to this law in a general way.

136. (A more exact generalization is that) metabolic reactions are controlled by the slowest reaction in a metabolic system and that these systems have critical temperatures.

137. Enzymes are active within a narrow temperature range.

138. Cold blooded animals do not have temperature-regulator mechanisms and consequently their metabolic processes are more subject to temperature fluctuations than those of warm blooded animals.

140. Temperature influences the mechanical and chemical changes which occur in soil and thus it influences the nature of the plant cover of the region.

141. The distribution of herbivorous animals is correlated with the distribution of plants and the distribution of carnivorous and omnivorous animals is associated with the distribution of their prey.

142. All living things are subject to mechanical pressure in the environment.

143. Aquatic forms must withstand the pressure of the water which lies above them.

144. Terrestrial forms are adapted to the atmospheric pressure.

146. On land, the atmospheric pressure decreases with an increase in altitude.

150. The oxygen pressure at altitude decreases proportionately to the decrease in total atmospheric pressure.

157. As in the case of other physical factors of the environment, living things in general are adapted to a relatively narrow range of pressures.

158. All living things respond to the force of gravity.

162. Another example of the influence of this factor is evident in the adaptations which occur in the skeleton of birds.

164. As far as terrestrial forms are concerned, the factor of gravity definitely limits the maximum size that an animal can attain.

165. The behavoral and physiological adjustments of organisms to the factor of gravity are quite evident in living things.

166. Acting in conjunction with plant hormones, the factor of gravity causes the roots of plants to grow downward and the stems of plants to grow upward.

173. The chemical environment produces conditions of osmotic pressure and acidity or alkalinity (hydrogen-ion concentration) which must be optimum if the living matter is to function normally or at all.

174. Red blood corpuscles of a frog, when placed in mammalian physiological salt solution, will loose water and shrink.

175. Plants, if over-fertilized, will die as a consequence of the failure of their roots to adjust to the increased salt concentration of the soil water adjacent to the plant.

176. The adaptations of organisms and tissues to chemicals can also be extremely specific.

178. Magnesium is absolutely indispensible to the formation of the chlorophyll molecule.

179. The degree of acidity or alkalinity of the chemical environment is of great importance.

180. Adjustment of the hydrogen-ion concentration beyond an optimum range is a common method of inhibiting bacterial growth.

181. In human reproduction the degree of acidity of the female reproductive tract is a common cause of sterility because the male reproductive elements are adapted to a relatively narrow range of hydrogenion concentration, and if the female tract is too acid the spermatozoa are killed.

182. When living tissues or organisms cannot adjust themselves to their chemical environment they die. This is the basis of chemotherapy in the field of medical science.

183. Antibiotic substances such as penicillin or streptomycin create an unfavorable chemical environment for certain types of bacteria and inhibit the growth of the bacteria thus enabling protective mechanisms of the body to exert their influence.

184. Metallic compounds such as mecuric chloride and iodine cause the death of the bacteria in a short time.

185. If the chemical concentrations are not too unfavorable, organisms can adapt themselves to changes in their chemical environment.

186. Plants of the desert or seashore adapt themselves to increasing concentrations of salts in their environment.

187. Bacteria can adapt themselves to sulfonamide concentrations to the extent that they become resistant to the chemical.

188. Human beings living at high altitudes, such as the plateaus of Tibet and Peru, are adapted to the low oxygen concentrations prevailing at those altitudes.

189. The adjustment of living things to their chemical environment illustrates strikingly that adaptability is a fundamental characteristic of living matter.

MEAN SCORE 3.51 - 4.50

Items number 6, 82, 118, 121, 126, 127, 133, 145, 147, 148, 149, 151, 152, 153, 154, 155, 156, 160, 161, 163, 167, 168, 169, 170, and 177. Content may be obtained from Appendix II.

Principle V - Social groupings among individuals of the same species and associations between individuals of different species are adaptive responses which often increase the chances of survival for the organisms involved.

MEAN SCORE .5 - 1.50

2. Associations of animals vary in their degree of organization.

MEAN SCORE 1.51 - 2.00

1. In general animals live together. Birds form flocks while fishes form schools. Mosquitoes swarm and wolves travel in packs and hunt the herds of deer. Bees, wasps and ants build their own homes, where each individual has a specific function to perform.

3. Some associations of animals are completely lacking in any degree of integration and, in fact, are associated only.

7. Associations or aggregations of animals are caused by forces or factors that are more social in nature.

8. Such aggregations as bird flocks, schools of fish, "dancing midges", and herds of deer are caused by reactions to each other.

10. One aspect of aggregations (with a social basis) may be sexual and result in the collecting together of two or more individuals during the breeding season.

12. In some (animal) forms the association is distinctly a social phenomenon carried to a high degree of specialization.

15. Human beings live together in an intricate and complex interdependence. The human from birth to death is a part of a group. His distinctly human characteristics are the result of group living, and the group goes on after the individual is dead.

16. Group or social living is a common biological phenomenon.

17. Group or social living varies from loose, temporary, and accidental associations to highly integrated and permanent interrelationships.

26. The social characteristics that groups have in common involve (1) the holding of territory, (2) domination-subordination, and (3) leadership-followship.

36. Social hierarchies develop in groups of animals based on the second characteristic of group living, dominance-subordination.

60. In a community relationships exist between species which result in (1) the toleration of one species by the other (2) the exploitation of one species by the other, and (3) the unconscious cooperation of two species which results in mutual benefit being derived from the association.

63. The exploitation of one species by another is called parasitism.

92. The host also is specific in its tolerance of parasites. It accepts some and rejects others.

95. Animals and plants that are parasitic have evolved from freeliving ancestors.

97. During the evolutionary adaptation from free-living to a parasitic mode of life, the parasite changes, and the degree of change usually is correlated with the length of time the organisms has been parasitic.

98. Parasites that have been parasitic for a short time, in general, show few changes and those that have been parasitic for a long time show great changes.

99. The changes that a parasite undergoes are usually in the direction of greater dependence upon the host.

MEAN SCORE 2.01 - 2.50

4. An example of accidental association is organisms cast into long drift lines along the sandy beaches of lakes. In such drift lines one can find many organisms including insects, small bivalves, aquatic snails, and even fish.

6. The collection of insects about a light on a summer evening is an example of animals reacting in the same way to the same kind of environmental stimulus.

9. Instead of responding to an impersonal external force (animals which associate because of reactions to each other) collect as a result of positive reaction to the presence of others like themselves.

11. Sex, however, is not the only factor (involved in aggregations of a social nature) because many animals collect together in nonbreeding seasons or continue their association long after reproduction is accomplished.

13. For example, (of an association which is distinctly a social phenomenon carried to a high degree of specialization) hives of bees with the reproductive queen, the males or drones and the sterile females or workers constitute a permanent association that is organized so that the group is an entity in itself. Certain individuals may die but the group persist.

14. Ants and termites also represent social organization in a complex form.

18. (Apparently), living together offers some advantages over the condition of living alone.

19. The advantages of cooperative group effort in human society are obvious.

20. Many examples are available demonstrating that the combined, cooperative action of many people can accomplish tasks that are impossible for a single individual.

21. The advantage gained by the less organized and unconscious associations (such as fish in a school or birds in a flock) is survival.

22. An example that illustrates the survival value of aggregations of animals is as follows: A large group of fish can tolerate an amount of poison in the water that would kill a very few. The reason is that each one of the group absorbs a small portion of the poison and reduces the total amount so that no one fish is seriously affected. If only a few fish were present, the amount absorbed by each one would be enough to kill it.

23. Another example of survival value of aggregations is the collection of certain birds in close groups during cold weather. Collectively they can withstand the low temperature, while individually they would perish.

24. Social groups have certain characteristics in common.

25. The characteristics which social groups have in common are social characteristics and are derived from the interaction between the members of the group.

27. The different types of interactions in the group may occur in fairly pure form, or they may grade into each other, even in schools of fish, to give complicated organizational pattern.

28. The concept of territory refers to an animal's recognition and proprietorship of a certain area. It includes homing or the defense of a certain area, or both.

29. Homing reactions occur when an animal returns to a specific area after it has left it.

31. The defense of a given area is characteristic of territoriality.

33. Organisms that show a reaction to territory react negatively to invaders of the same species. They prevent, by actual combat, or threat of combat, any individual of the same kind from entering the selected area.

37. An example of dominance-subordination is the peck order in chickens. A newly collected flock of chickens will, in a relatively short space of time, develop a social organization based on the domination of certain individuals over others. The social order is established and maintained by the giving and receiving of pecks, or by reactions to threats of pecking. From this the term peck order has come to refer to established social hierarchy in chickens.

41. W. C. Allee has summarized the qualities that make for high social status in groups of vertebrates as follows: (1) the stronger individual usually wins in apir contacts, (2) mature animals usually dominate those less mature, (3) larger animals usually have a higher social rank than their smaller associates, (4) the location of the first meeting is often important, since many animals fight best in or near their home territory, (5) an animal surrounded by members of its own group often wins over a stranger, (6) animals with young tend to fight more fiercely than at other times, (7) males usually dominate females, (8) the amount of male hormone present often determines the social dominance of either sex, (9) the female consort of a dominant male tends to be accorded his social status so long as she remains near him.

42. Hereditary differences are important in relation to domination-subordination.

46. Leadership, another characteristic arising out of group living, consists in giving guidance and directing others along a certain course or pattern of behavior.

47. A leader may be able to attract others to follow him, but sometimes force is necessary to control the followers or even to secure them.

48. The position of leadership is held by the animal that initiates, stabilises, or integrates behavior of the group.

54. Leadership may or may not be associated with social status.

59. In rhesus monkeys there is a complete linkage of dominance and leadership. The strongly dominant and aggressive individual is also the leader.

61. The term symbiosis is used by the biologist to include all types of (such) partnerships (which exist in a community).

62. The toleration of one species by another is called commensalism.

64. The unconscious cooperation between species is called mutualism.

67. The commensal relationship may be casual, (as in the case of the honey bee and the flowering plant) or it may be obligatory as in the case of the Yucca moth and the Yucca plant.

71. Mutualism is found between species of animals, species of plants or between animals and plants.

74. Other examples of mutually beneficial relationships are those existing between certain fungi and algae resulting in the composite plants called lichens; the relationship between the root-inhabiting nitrogen-fixing bacteria and leguminous plants; and the relationship between certain termites and their intestinal protozoa.

75. Termites cannot live without the presence of the protozoa (in their digestive tract) for the protozoa digest the wood (cellulose) eaten by the termites.

76. Parasites are organisms, either plant or animal, that live on or within another organism and at the expense of the other organism.

77. The benefits derived by the parasite may include food, shelter, dispersal, and a means of completing the life history.

78. The host is an organism that harbors a parasite.

79. If the parasite is in an immature stage of growth, the host is usually known as an intermediate host.

80. If the parasite is adult, the host that harbors it is known as the final host.

81. The habitat of the parasite is the host.

82. The habitat provided by the host is comparable to the water and land habitats of free-living forms, and parasites become adapted to it just as free-living organisms become adapted to their (habitats).

83. The parasitic habitat is essentially of two types. One is ecto-parasitic, in which the parasite lives on the outside of the host. The second is endoparasitic, in which the parasite lives within the host.

86. Most parasites can live only in a specific host or hosts.

87. Parasites become adjusted to a certain host environment and can tolerate no other. This condition is known as host specificity.

88. (Furthermore) parasites usually are restricted to living in or on only certain parts of the host. This is tissue specificity.

90. Other viruses, such as those that cause chickenpox and smallpox, attack the skin.

96. Parasitism probably began as a result of a chance encounter of two organisms in which one served as a vehicle for the transportation of the other. This relationship probably persisted for sometime, during which the future parasite came to depend upon the host for food and perhaps other necessities, and as the degree of dependence grew the degree of parasitism grew.

100. The variations in the parasites may be simplifications of structure or they may be complications.

104. (Thus) immature or larval parasites live in intermediate host, of which there may be one, two or three. The adult lives in the final host. To complete development of the parasite or to complete its life history, it must pass from host to host.

106. The total effect of parasitism on the host depends upon a number of factors, including the virulency of the parasite, the number of parasites, the resistance of the host, and whether the parasite-host association is temporary or permanent and of long duration or of recent origin.

107. Virulence is the capacity of a parasite to produce abnormal conditions in a host by reproducing rapidly and producing highly toxic substances.

109. Parasites that are highly virulent cause the severe diseases, while those of less virulence cause mild illnesses only.

113. Resistance of the host to a specific parasite is great in some cases and very little in others.

115. When the parasite host relationship is of long duration and the parasite and host have lived together for countless generations, a mutual tolerance sometimes develops.

116. Under conditions of mutual tolerance between parasite andhost, the host may not be injured sufficiently to cause death, but he (host) may suffer from a slight and continued impairment of health known as a chronic disease.

117. If the parasite-host relation is of recent origin in the evolutionary sense, severe reactions may occur. The host is unable to inhibit the action of the parasite sufficiently to protect itself from harm, and as a result severe disease and perhaps death of the host ensues.

MEAN SCORE 2.51 - 3.50

5. Associations of animals may be brought about because the animals all react the same way to the same kinds of environmental stimuli.

30. The (return) distance covered (in the homing reaction) may be only a few feet as in certain mollusks, or it may be hundreds of miles, as in homing pigeons and the golden plover.

32. Birds defend their selected territory against invaders, as do many fishes, lizards and mammals, including man.

34. An exception to this (defense of territory against entrance by organisms of the same kind) is made to a mate or mates.

35. Organisms (that show territoriality characteristics) react positively to the (selected) territory, seeking it and living in it.

38. When two chickens meet for the first time either there is a fight or one gives way without fighting. The successful bird in the initial encounter retains the right to peck the other bird at any subsequent encounter. This process continues throughout the flock, each chicken engaging in battle or threat of battle until all fall into a serial hierarchy with one having the right to peck all other chickens and not be pecked in return; with a second being pecked only by number one while it pecks all other hens in the flock; with a third submitting to numbers one and two but dominating all the remaining birds, and so on, down to the last bird in the flock which receives the pecks of all and gives none in return.

39. Other animals that show a domination-subordination type of social organization include fishes, lizards and mammals.

40. Certain human social organizations are suspiciously similar to peck order.

43. Inbred strains of mice tend to differ both in aggresiveness and in fighting ability.

44. Defeat which results in lowered social status is often accompanied by easily recognised changes in behavior.

45. A defeated fish may drop its challenging posture of tense body and erect fins; the fish seems to hang limply in the water; it backs away slowly and then turns and flees. Many animals, among them hens, mice and boys, not infrequently emit characteristic cries when beaten. The head furnishings of defeated hens sometimes blanch, while those of the victor remain flushed. Defeated mice rear up in characteristic postures. Other signs of low social rank include the avoidance of encounters with superiors; defeated hens move about quietly, often with head held low, or hide in out-of-the-way places or in protected niches.

49. Leadership may be held by either male or female, who may be young, mature or old.

50. Leadership may be held by one individual or a group of individuals.

51. The leader may lead in the physical sense of going before when the group changes its location or activity. However, this is not always true.

52. The animal moving in advance may not be the real originator of the movement.

53. In some flocks of birds the bird in advance in flight is simply following along in front of the flock. Any change in direction originates within the body of the flock.

55. In flocks of hens leadership often rest in the mid-social ranks rather than with the number-one hen in the peck order.

56. In ants individual-to-individual dominance is unknown, yet leadership exist.

57. Among groups of mammals the socially dominant animal is often the leader.

58. Among the red deer of Scotland the males exert dominance, but the real leadership is held by a female.

65. Among the most interesting of the commensal relationships are those involving species of insects and flowering plants.

66. The collection of nectar and pollen by honey bees to supply food for the bee colony is an example of a commensal relationship. In the pursuit of nectar and pollen the honey bees make possible cross-fertilization in the plants.

68. The only insect capable of pollinating the Yucca flower is the Yucca moth.

69. The female moth, after collecting pollen from several stamens, drills a hole through the ovary wall of the Yucca flower and lays her eggs among the ovules of the flower. Development of the ovules into seeds is insured by inserting the pollen grains into the canal of the pistil.

70. Only a few eggs are laid in any one flower thus insuring an adequate food supply for the larvae without endangering the propagation of the plant upon whose existence the survival of the Yucca moths depends.

72. A mutually beneficial relationship existing between an animal and a plant is seen in the relationship between the green alga Chlorella and the fresh-water coelenterate hydra.

73. The green alga lives within the body walls of the hydra and utilizes the carbon dioxide released by the animal to manufacture sugar by photosynthesis. The hydra, on the other hand, uses the oxygen liberated in photosynthesis in its own respiratory activity.

84. Examples of ectoparasitic organisms are lice, fleas, and ticks on man.

85. Examples of endoparasitic organisms are protozoan blood parasites that cause malaria, tapeworms that live in the intestine, and bacteria that live in the respiratory tract.

89. Tissue specificity is exemplified by the viruses which cause rabies and poliomyelitis and affect the nervous system only.

91. The parasite is not the only part of the host-parasite relationship that shows specificity.

93. A host that tolerates the presence of a parasite is said to be susceptible.

94. A host that does not tolerate a parasite is said to be immune.

101. Complex life histories have developed in many parasitic species.

102. Complex life histories in parasites is associated with differences between young and adults.

103. When the offspring are like the parents, as in the case of bacteria, both can live in the same environment and the complex life histories do not develop. However, when the offspring have one form and the adults have another, they need different environments in which to live and develop.

105. The human pork tapeworm is an example of a parasite having a relatively simple life history. The adult tapeworm lives and reproduces within the human intestine, the fertilized eggs pass out of the intestine with the human excreta. Most of them die, but some are eaten by pigs. Within the pigs they undergo certain growth changes and migrate until they invade the pig's muscles. If man eats the pig's muscle tissue in the form of insufficiently cooked pork, the young tapeworm gains entrance into the human digestive tract, where it develops into an adult.

108. Parasites differ in their virulence.

110. The number of parasites that invade a host has a decided effect on the severity of the host's reaction.

111. A few parasites can usually be tolerated by the host, but if the numbers increase the host's resistance is usually overcome and the damage may be great.

112. The resistance of the host to the specific parasite determines whether the parasite will become established.

114. Temporary associations of parasite and host, such as mosquito and man, seldom do much damage, while more or less permanent associations such as tuberculosis-causing bacteria, hookworms and tapeworms can cause great damage.

AREA VIII

Interrelationships: Unit 2, Populations and Conservation

Specific Objectives

1. To understand the relationship between a species' capacity to reproduce its kind and the factors of the environment which resist increase in population size.
2. To recognize the fact that human populations are subject to the same biological forces as are the populations of other organisms.

3. To understand the significance of the conservation of natural resources to human welfare.

Principles

1. The population size of a species is a result of the interaction between the theoretical capacity of that species to reproduce its kind (its biotic potential) and the environmental resistance confronting the organisms comprising the species.
2. The conservation of natural resources is a logical consequence of man's understanding of the interrelationships among living things and between the living and non-living parts of the environment.

The Assignment

Biological Science Lecture Syllabus, pp. 176-216.

Principle I - The population size of a species is a result of the interaction between the theoretical capacity of that species to reproduce its kind (its biotic potential) and the environmental resistance confronting the organisms comprising the species.

MEAN SCORE .5 - 1.50

1. The physical and biological factors in the environment can be thought of as constituting a resistance to the increase in numbers of living things.

2. Unless the individual living organism is adopted or can consciously adjust itself to unfavorable environmental conditions, it cannot survive.

3. This principle (that unless the individual living organism is adapted or can consciously adjust itself to unfavorable environmental conditions, it cannot survive) applies with equal effectiveness to populations of individuals.

4. Since all living things possess a tremendous capacity to reproduce their kind, the size of animal or plant populations fluctuates with the degree of environmental resistance exerted.

5. This basic concept of interrelationships in the natural world can be expressed very simply by the equation:

$$\text{Population} = \frac{\text{Reproductive Capacity}}{\text{Environmental Resistance}}$$

23. In his efforts to understand the population aspects of group biology, the biologist is concerned basically with three factors. These factors are (1) the birth rate, (2) the death rate, and (3) the dispersion within the population.

MEAN SCORE 1.51 - 2.00

9. Biologist hypothesize that the failure or success of the human race will depend upon the wisdom man shows in controlling his reproduction quantitatively and qualitatively.

10. In this respect (ability to apply control measures to his reproduction both qualitatively and quantitatively) man differs from other living things, for he (man) can apply creative intelligence to a problem which other living things must leave to the action of non-conscious natural forces.

11. A population can be compared to a living organism in several respects.

12. Like an organism, a population has a life history, it grows in a typical fashion, undergoes changes that may lead to a division of labor among its members, ages and dies.

13. Like an organism it is an integrated unit. It meets the forces of the environment as a whole rather than as a loose assemblage of parts.

16. The basic similarity (between organisms and populations) is especially evident when a population growth curve is compared to the growth curve of an individual.

17. Under ideal environmental conditions the growth of a population follows the same pattern of development as does the growth of an individual.

18. Growth is slow at first, gradually increasing in rate until a maximum is reached. Almost imperceptibly this rapid rate of growth begins to slow down and after a time the rate decreases more and more rapidly until at a later date there is no appreciable increase in the size of the population.

19. When the growth of a population is plotted with either weight or numbers against time, a typical S curve is secured like that for the growth of an individual.

20. A population is defined as a group of living individuals set in a frame that is limited and defined in respect to time and space.

24. The birth rate, or population-increase factor, takes into consideration the theoretical reproductive capacity and the realized reproductive performance of a species.

42. One of the most significant elements in the biological environment of living things is population density.

45. Increased crowding of organisms in a population reduces the growth rate and can even bring about a decline in the population.

46. If there is competition for food the fecundity of the females in the population decreases with an increase in population.

50. A growing and vigorous population contains a great preponderance of young organisms.

MEAN SCORE 2.01 - 2.50

8. We need not, however, limit our example to bacteria. It has been estimated for humans that if one husband and wife had six children and each pair of children had six children, the entire world could be populated in nineteen generations. The fourth generation would produce 162 individuals while the nineteenth would consist of 2,324,522,934 individuals.

14. (A population) has an heredity.

15. The structure and composition (of a population) change with increasing age even though at any one time it seems very stable.

21. If more than one species is included in the group, the group is spoken of as being a mixed population.

22. Animal and plant communities are usually mixed populations.

26. (For example), a population might have a theoretical reproductive capacity of 20,000 offspring per year but a realized reproductive performance of only 3,000 individuals for the same period of time.

27. Statistics on human populations show that the range of reproductive performance extends between an average maximum of approximately 50 birth per 1,000 population per year to an average minimum of approximately 15 birth per 1,000 annually.

29. Studies also reveal that in humans the rate and success of reproductive performance in a population are determined by the age of the reproducing members.

31. The death rate, or population-decrease factor, interest the biologist from the standpoint of why organisms die and why they die at a certain age.

32. It is a population principle that different phases of the life history of a population have different and characteristic death rates.

33. If the cause of death (of a population) can be ascribed to the environment, it follows that a more complete knowledge of the environment can lead to reductions in the death rate, if this is desirable.

36. Although the human population may be declining in certain areas on earth, in general the human population is increasing in size at a relatively rapid rate.

40. The dispersion factor is concerned with the emigrations and immigrations which occur within a population.

41. If either (emigration or immigration) is excessive a condition of depopulation or overpopulation can take place within an area.

43. (Population density) is defined as the number of organisms per unit space they occupy.

44. (Population density) has been shown to affect the growth form of a population.

47. When the total environment is unsaturated, increased emigration caused by crowding leads to survival in the population because the organisms moving out find environmental niches still unexplored.

48. When the total population is static, however, emigrations from one place to another lead to death.

49. (Finally), the age composition of a population reveals the "youngness" or "oldness" of the population in terms of its life history.

51. A stationary population has an intermediate number of young as compared to old individuals.

52. A declining population is characterized by a preponderance of old organisms.

53. The social, economic, and political implications of these facts for human populations are manifold.

MEAN SCORE 2.51 - 3.50

6. The idea of an organism's theoretical capacity to reproduce can be gained from the following example. It has been estimated that a single bacterium 1/20,000 of an inch long and 1/30,000 of an inch thick, if allowed to reproduce to the limit of its capacity without the restraining influence of its environment, could, in one day's time, fill a pipe one inch in diameter reaching from New York to San Francisco.

7. Within twenty-four hours this reproductive spree (of a single bacterium) would result in four sextillion bacteria.

25. The distinction between them (theoretical reproductive capacity and the realized reproductive performance) is clear.

28. Countries populated by members of the caucasoid race tend to have a lower birth rate than countries populated by non-caucasoids.

30. (For example), mothers 19 years of age and under are the most fertile and fertility decreases with increasing age.

34. There is a tendency for the industrialized caucasoid countries of the world to have lower death rates, just as they have lower birth rates.

35. (Conversely), a country with a high death rate also has a high birth rate.

37. Some biologist point out that the human race is actually enjoying a "breeding storm" notwithstanding wars, famines and disease.

38. In 1630 approximately 400,000,000 inhabited the earth. By 1830 this number had doubled. By 1900 the number had increased to 1,600,000,000 and the total at present is over 2,000,000,000 with an annual increase of 20,000,000 or roughly one per cent.

39. It is predicted that by 1999 there will be 3,300,000,000 people on earth.

Principle II - The conservation of natural resources is a logical consequence of man's understanding of the interrelationships among living things and between the living and nonliving parts of the environment.

MEAN SCORE .5 - 1.50

8. (Since) the human community is completely dependent upon the earth's crust and its resources, a prime objective human activity should be the wise use of these resources.

9. Outstanding geographers point out that any nation, if it is to support its population and maintain a high standard of living among its people, requires five classes of resources. First, it must have an abundance of fertile soil; second, an adequate supply of minerals; a sufficient and dependable supply of fuel and power; fourth, a sufficiency of timber; a relatively high proportion of its people must be of hereditarily high biological quality.

10. Of the resources listed fertile soil stands formost.

11. The food problems of the world with its ever-increasing population can be solved only in terms of the basic medium for food production, the soil.

12. Soil conservation (thus) becomes a matter of international concern, since the unchecked depletion of the soil resources through erosion and the consequent decrease in food supply are ever present invitations for social unrest and political upheaval.

18. Conservation through ecological engineering is of importance to human welfare, whether in terms of his food and nutritional needs or in terms of his mental and emotional well-being.

MEAN SCORE 1.51 - 2.00

1. An understanding of ecological relationships reveals the intricacy of the factors in the soil-water-plant-animal complex.

2. It should be obvious that the welfare of human life on earth is directly dependent upon an understanding of these factors.

3. The study of food chains and the phases of ecological succession reveals the fact that a disruption of any one of the links in a given sequence can seriously affect the entire complex.

4. Man, (therefore), in his agricultural and industrial pursuits must consider the biological and ecological principles which underlie his activities.

5. He (man) should remember that he cannot conquer nature.

7. He (man) should constantly be aware of the social, economic and political implications of man-initiated disruptions of the ecological pattern.

13. Peace with hunger cannot be peace for long.

14. Closely related to soil conservation is the conservation of forest, grasslands, water resources and wildlife. All are a part of the soil-water-plant-animal complex.

15. The wise use of our forest, grasslands, and the land under cultivation leads to better control of the water and wind forces causing erosion.

16. Where forest, grasslands, and hedgerows exist, one will find environmental conditions suitable for wildlife.

19. With regard to mineral, fuel, and power resources, it should be recognised by all that American has become great because of her original store of geographic goods and not necessarily because of her social and political institutions.

22. To promote successfully the conservation of our natural resources, whether soil, mineral, fuel, timber, or human, requires the development within each of us of an ecological conscience.

23. In the words of the late Aldo Leopold, "The practice of conservation must spring from a conviction of what is ethically and esthetically right, as well as what is economically expedient. A thing is right only when it tends to preserve the integrity, stability and beauty of the community and the community includes the soil, water, fauna and flora, as well as people.

MEAN SCORE 2.01 - 2.50

6. At best he (man) can merely cooperate with nature on the terms and under the conditions she sets forth.

17. Where wildlife abounds man has an unexcelled recreational outlet.

20. Her natural resources of coal, iron, copper, and other basic minerals together with her resources of oil, timber, and ground water were the greatest on earth and upon these resources was constructed the greatest industrial civilization known to man.

21. As a noted economist states it, "The greatness of American has been the greatness of our continent - its sweep, its varied resources, its abundant vitality. We have what other nations go to war to

AREA IX

Evolution

The Specific Objectives

1. To understand the development of the concept of organic evolution from the historical viewpoint.
2. To understand the history of the development of living things in the course of geologic time.
3. To recognize and appreciate the validity of the various sources of evidence supporting the fact of organic evolution.
4. To understand the Theory of Natural Selection.
5. To study the evolution of man.

Principles

1. Every kind of animal and plant living today has descended, with modifications, from organisms which have lived in the geologic past.
2. The evolution of living things is, in the broadest sense, progressive not regressive in nature.
3. Germinal variation is essential to the continuance of evolution.
4. The interaction of organisms with their environment results in a natural selection of certain organisms. The ultimate consequence of this selection is the origin of new species.

The Assignment

Biological Science Lecture Syllabus, pp. 217-293.

Principle I - Every kind of animal and plant living today has descended, with modifications, from organisms which have lived in the geologic past.

MEAN SCORE .5 - 1.50

1. Biological evolution is a principle which states that the kinds of animals and plants living today have descended from different forms that lived in the past.

2. The essential point (concerning biological evolution) is that species are not static but have changed in the past, are changing now, and will continue to change in the future.

3. Biological evolution is concerned with explaining the changes that have occurred in living forms from the first primitive living substance to modern organisms.

11. (These) preserved forms, the fossils, have told man most of what he knows concerning the evolutionary history of life.

308. The most direct evidence that all living things have developed by evolution is the evidence of fossils.

312. From the study of sequence (of fossils) it becomes readily apparent that the simpler forms of life appeared first and that more complex forms followed, to be followed in turn by organisms still more complex.

320. All other evidence (besides that based on the fossil record) that supports the principle of evolution is based on one fundamental assumption. It is that similarity of organisms indicates relationship and that the degree of closeness of similarity runs essentially parallel to the closeness of kinship.

322. On the basis of the assumption that similarity of structure indicates relationship due to inheritance from a common ancestor the entire system of classification is a genealogy of living forms.

330. Evidence from the study of comparative anatomy supports the theory that animals are basically alike and hence related even though they differ in superficial appearance.

MEAN SCORE 1.51 - 2.00

4. Biological evolution does not attempt to explain how life originated.

28. During the time when sedimentary rock is being formed, animals and plants are occasionally buried within the sediment. Some of these forms are preserved.

29. This (preservation) is particularly true of the hard skeletal parts of organisms, though sometimes even the softer body parts or their form are preserved.

32. By means of a study of the sequence in time in which the rock layers have been formed plus a study of the fossils contained in the rocks, it has been possible to trace the history of living things on earth.

33. By various means it has been possible to determine the approximate age of the rocks, with the result that a time scale has been made of the history of the earth's surface and of the history of life on the earth. This is known as the Geologic Time Scale.

35. What ever the cause or the manner of the origin of life it is generally agreed that the first forms of life were comparatively simple.

36. It has been suggested that these first living things were protein in nature and that they had the ability to use inorganic sources of energy.

39. The development of chlorophyll or a chlorophyll-like substance probably occurred very early.

43. (It is also reasonable to assume) that after the appearance of simple cellular plant-like forms, life divided into two streams. One of these streams produced the modern plants while the other resulted in the modern animals.

44. There are forms living today that are neither plant nor animal in the strict sense.

46. The first animals were the invertebrates and of these the single-celled Protozoa appeared first.

47. The sequence of development of the remaining invertebrate types is in doubt, but on the basis of structural complexity it was probably as follows. After the single-celled Protozoa came the colonial Protozoa.

68. One should not conclude from a discussion of the sequence of evolution that it occurred in strictly serial fashion, beginning with the protozoa. Such is not the case.

69. The exact sequence of evolution is unknown.

70. It is generally agreed that evolution has not proceeded in a straight line, but rather that it has branched like a tree.

137. In reptiles the land egg developed and they were freed forever from the necessity of visiting ponds and streams for reproduction.

152. The major structural changes that occurred during the evolution of birds are practically all adaptations to aid in flight.

226. All primates including man evolved from a common ancestor.

229. (Thus), man it should be understood, did not evolve from modern monkeys or apes, but both (man and modern apes) evolved along separate paths from a common ancestor.

291. Early in the history of life the stream of evolution divided into two branches, the animals and plants.

292. The separation of living things into two kinds occurred while life was still in its simple cellular stage.

293. The first plants were probably single cells that differed from their animal relatives by having chlorophyll.

309. Fossils are the remains of animals and plants that lived during the past ages.

310. (Fossils) may be foot prints, animal burrows, leaf prints or any sort of indications of past life.

311. It is possible to determine the approximate time when fossil forms lived and also to determine the sequence of their appearance on earth.

313. The order of appearance of animal forms is first the simpler invertebrates, then the more complex invertebrates.

314. The complex invertebrates were followed by the primitive vertebrates, the ostracoderms.

315. (Following the appearance of the ostracoderms) the fish then evolved and the amphibians came later, to be followed by the reptiles, birds and mammals.

316. Many of the forms that lived in the past are no longer present. It is true that representatives of all great animal groups can be found on the earth today, but countless forms related to each of the forms now living have ceased to exist.

317. Each major group evolved in its turn and produced a myriad of forms which spread over the earth into every available habitat. Then each group declined, leaving a few hardy members to continue the struggle for existence, but never again to flourish and to dominate the earth.

318. As each group declined in numbers and types, a new group would appear. It (the new group) would produce millions of individuals and many new forms and then it, too, would eventually decline.

319. (Finally), the mammals appeared and today man, as a representative of this group of animals, dominates the living scene.

321. The validity of this assumption (that similarity of organisms indicates relationship) is apparent when it is considered in relation to human kinship. It is well known that some identical twins are so alike that their friends and even their families have difficulty in distinguishing between them. This likeness is due to their common heredity. Identical twins have the same kinds of genes because they develop from the same fertilized egg. Thus both likeness and relationship are as close as they can possibly be in any two living organisms.

The next most closely related humans are offspring, not identical twins, of the same parents. These are known as siblings. They are less alike than identical twins and also their relationship is not quite so close because they develop from different zygotes. They receive many of the same kinds of genes but also many different kinds of genes.

Cousins represent a human relationship that is still farther removed from the identical twins. Their relationship is not so close as between either identical twins or siblings because their common ancestors are grandparents. They have fewer like genes in common, and they also have fewer characteristics in common.

Individuals of the same race have many characteristics in common, hence must have a common heredity from a common ancestor, but the ancestor lived many generations ago and the similarities are fewer than those found in cousins and siblings.

323. All individuals belonging to a species are alike, and being related, they all have a common ancestor.

324. (Likewise), all species that are alike are related.

325. This relationship (between species) is indicated in the system of classification by placing similar species in one genus. Hence, the animals or plants belonging to a genus are related. Genera that are alike are grouped into families and like families into orders. Like orders are grouped into classes and classes into phyla. Finally all animal phyla are grouped on the basis of similarities into the animal kingdom and all plants into the plant kingdom.

326. Even the plants and animals have some characteristics in common, such as cells and protoplasm, so that they too show relationships.

327. The logical conclusion (based on the genealogy of living forms) is that all living things are related.

328. Some (living forms) are more distantly related than others, but the evidence of a common ancestor is to be seen even in the most dissimilar of forms.

329. If this relationship (among living organisms) is accepted it follows that evolution must have occurred; for if no change had taken place all living things would be alike.

331. In some organisms the similarities are obscured by modifications of organs as a result of adaptations to the environment.

335. During the embryonic development of animals similarities appear that would never be suspected on the basis of a comparison of adults.

336. Animals that differ only slightly as adults such as the dog and wolf or man and ape are so similar during the early stages of development that it is impossible to tell them apart. They look exactly alike. During the later stages of development the differences that are visable in the adult begin to appear.

337. Animals that are widely different as adults are more easily distinguished as embryos, but some similarities remain in the early stages.

350. All animals including man have certain vestigial anatomical structures that have no apparent use.

354. By comparing (the) structure (of vestigial organs) with similar organs in related forms it becomes apparent that they are vestiges or remnants of fully developed useful organs.

MEAN SCORE 2.01 - 2.50

5. No one knows when or how the first forms of life appeared on earth, but there are several interesting theories.

6. The Special Creation Theory states that all living things were created within a short space of time immediately after the earth was made. All things were created at this time, and there has been no change in any of the living things since this time.

7. According to the Spontaneous Generation Theory it was once generally believed that, given suitable environmental conditions, non-living matter could form into complete, complex living things such as insects, frogs, and fish.

9. The Physico-chemical Evolution Theory assumes that at one time during the history of the world conditions were such that very simple forms of life arose through the combination of non-living matter.

10. The physico-chemical theory is somewhat similar to that of spontaneous generation. The difference is that according to spontaneous generation the production of living things from non-living occurs constantly while according to the physico-chemical evolution theory it occurred only at some remote time in the earth's history and has not happened since. Also spontaneous generation supposes that complex organisms arise from non-living matter, while the physico-chemical theory assumes that only very simple forms of life arose in this fashion and that all modern, complex forms have evolved from the primitive forms.

30. (These) preserved animal and plant remains are called fossils.

31. With the lifting of the continents the rocks containing the fossils become exposed to weathering and as the rocks wear away, some of these fossils are exposed so that man can find them and study them.

37. There are certain bacteria living today that do not need plant food (produced by the action of chlorophyll) as a source of energy, but can obtain the energy they require by causing certain chemical reactions in inorganic matter.

38. The first living organisms were probably of this sort (similar to the bacteria which do not depend upon plant food) and later evolved into forms that utilized the sun as a source of energy.

40. These forms (containing chlorophyll or a chlorophyll-like substance) were then able to capture the energy of the sun and to store this energy in the form of food.

41. No one knows at what stage the substance of these early living things became protoplasm as we know it today, nor can we say when this protoplasm became cellular.

42. The early stages of evolution are lost in antiquity, but it seems reasonable to assume that they occurred very early in world history.

45. (Euglena is an example of an organism that is neither plant nor animal in the strict sense). It has animal traits such as gullet and a food vacuole and also the characteristic plant trait, chlorophyll.

48. Colonial Protozoa are made up of aggregations of cells all of the same type (showing no differentiation).

49. The colonial stage was probably followed by a differentiation of certain of the cells (making up the colony) to bring about division of labor.

50. (Differentiation means that) within a cluster of cells making up the colony some would be specialized for food getting, others for reproduction and still others for other functions.

51. The next step (following differentiation) was the arrangement of these specialized cells into layers.

52. The sponges represent the stage in evolution in which specialized cells are arranged into layers, being made up of loosely integrated cells arranged in an outer and an inner layer.

55. (In Coelenterates) the cells within the two cell layers become more closely integrated so that they may be called tissues.

57. A third cell layer appears next between the original two to increase the complexity of the organisms. The modern flatworms are representatives of this evolutionary step.

62. The next evolutionary advance (over the flatworms) was the development of segmentation, as in modern annelid worms.

63. Segmentation is where the parts of the body are repeated in a serial pattern from anterior to posterior.

64. The arthropods such as the crab, crayfish, insects, and spiders probably evolved from the early primitive annelids, for they retain the segmentation of the annelids to a marked degree.

65. (The arthropods added many new features (to those of the annelids) including an external skeleton of chitin and jointed appendages.

66. The mollusks, such as the oyster and the clam, became specialized in the development of an outer protective shell.

67. The echinoderms evolved with a five-rayed body pattern and a special type of locomotion by means of tube feet.

71. Following the analogy of the tree, the earliest forms of life would represent the base of the trunk. The trunk immediately splits into two main stems, one stem becoming the first animal forms and the other stem the primitive plant forms. The base of the animal stem represents the primitive Protozoa from which a branch extends laterally to represent the development of the modern Protozoa. Another branch represents the modern appendages. The main stem continues upward as the primitive coelenterates and from here several branches diverge. One branch leads to the flatworms and roundworms, another to the annelids, another to the annelids, and another branches to form the echinoderms and the chordates which evolve into the vertebrates. The annelid branch separates into two smaller branches, one becoming the arthropods and the other the mollusks.

72. The vertebrates evolved from the invertebrates.

73. The vertebrates appeared early in the history of life on earth.

76. In general (vertebrate) evolution was directed toward a type of animal having greater locomotory powers than the invertebrates possessed.

77. The invertebrates were sluggish, slow-moving or sessile animals, while the vertebrates became fast moving and agile.

78. It is probable that the first vertebrates appeared in fast-flowing fresh water streams where swimming powers were essential to prevent being swept into the seas.

79. The adaptations that developed in the vertebrates include an internal supporting axis, the vertebral column, segmented body muscles that permitted a lateral bending of the body to attain forward propulsion and fins to give leverage for the muscular action.

96. The next advance (above the sharks) in the evolution of the vertebrates was the appearance of the bony fish.

97. (These) fish developed a skeleton of bone while the forms that evolved into modern cyclostomes and sharks retained the cartilage.

98. The fish that developed their skeletons of bone are important because they not only produced the myriads of modern fish and salt water fish, but also gave rise to the land living vertebrates including man.

99. The bones of these early (fish) forms made up the internal framework of the body and also covered the tops and sides of the skull.

100. The pattern of skull bones laid down in these (early) fish can be traced with modifications into almost every later vertebrate type.

101. Even the parts of the human skull can be compared with the individual bones of these early fish skulls.

102. An innovation just as important to vertebrate evolution as the bony skeleton appeared (in the primitive bony fish). This was the development of paired lungs.

118. The paired bones (below the humerous in lobe-finned fish) are similar in position to the hand and finger bones.

119. The paired bones (below the humerous in lobe-finned fish) is comparable to the radius and ulna (of land animals).

121. (Some of the lobe-finned fish) became adapted and evolved into amphibians.

123. In amphibians lungs replaced the ancestral gills.

129. While the success of amphibians in making the transition from water to land was a tremendous evolutionary step it was not quite complete. The amphibia started the parade to land, but they never quite succeeded in leaving the water completely, for when it came time to reproduce they had to return to water.

130. Modern amphibia, among them the frogs and toads, are still doing this (returning to water during breeding activity) while many of the salamanders live permanently in water.

131. Reproduction of any vertebrate animal must necessarily occur in water. Eggs and sperms need water to unite. The embryo needs water in which to develop.

132. The problem was to evolve a mechanism for creating this aquatic environment (necessary for vertebrate reproduction) on land so that reproduction and development could take place.

139. The (land) egg contained all of the environmental conditions normally found in ponds and streams and could be laid anywhere on land.

140. Internal copulation developed (in reptiles) as a necessary reproductive function to bring the sperms and eggs together in a moist medium.

141. The reptiles made use of the freedom provided by this new reproductive mechanism and evolved into many different types which entered practically all of the available land habitats.

143. The reptilian body as a whole became adapted to land living.

146. The birds evolved from the reptiles.

148. The only reason for identifying these skeletons as birds is the presence of a faint impression of feathers.

163. The first mammals were modifications of a primitive group of flesh eating reptiles.

164. The first mammals were small and probably were no bigger than modern mice and rats.

167. Some of the characteristics that developed in mammals include a modification of the reptilian mode of reproduction, warm blood, a better developed brain, and a change in the position of the limbs. Mammals retain their young within the body of the mother until they are quite well developed. They also have special glands, the mammary glands, which secrete milk for the nourishment of the young. They are warm blooded and have a four chambered heart so that the production of energy is higher than in reptiles. The brain is large, resulting in a high degree of intelligence, and the limbs are directly under the body with the knees directed forward and the elbows back. This position of the limbs supports the body and enables the development of rapid locomotion. The teeth of mammals are quite specialized, and the ear drums are sunk below the surface of the head. Hair is a characteristic body covering.

178. (In placental mammals) this longer period of development before birth presumably gave these mammals an advantage for they have flourished and evolved into many successful animal types, including man.

196. (The primate) brain is highly developed, resulting in a high degree of intelligence.

207. A well developed cerebrum is essential for intelligence.

218. Man differs from the apes in many ways, but the differences are all differences of proportion of basically similar parts.

219. The major differences (between man and the apes) are related to methods of locomotion and to the growth of the brain.

225. (The human) brain is much larger, being two or three times greater than in apes, and man is more intelligent.

227. (The common ancestor of all primates) was one of the most primitive of mammals, the aboreal insectivore.

228. Each of the modern types of primates evolved along a separate path resulting in lemurs, tarsius, monkeys, apes and men.

234. The most positive evidence of man's evolution consists of a number of human fossils.

235. (The human fossils) include the Piltdown man, (Eoanthropus dawsoni), the Heidelberg man (Homo heidelbergensis), the Java man (Pithecanthropus erectus), the Peking man (Sinanthropus pekinensis), the Neanderthal man (Homo neanderthalensis) and the Cro-Magnon man (Homo sapiens).

238. It is not certain that each of the fossil men represents a step in a single evolutionary path.

239. It is possible that early in human evolution there was a divergence so that two or more lines of human evolution may have occurred.

283. Modern man evolved during the late Pleistocene and became subdivided into several racial types or sub-species.

285. (While) most human beings fit into one or the other of these categories (Negroid, Mongoloid or Caucasoid), there are many intermediate types and it is probable that at present there is no such thing as a pure race.

294. The early plants lived in water.

295. Many of the descendents of the early plants, the thallophytes, still remain (living in water).

296. Some of the thallophytes (descendents of the early plants) have developed into large complex, many-celled structures, though many are still single-celled.

297. During the time (Devonian) when the lobe-finned fish were climbing out on land to evolve into the amphibians, plants were also moving out of water.

298. (In fact), it is very probable that the plants preceded the animals on land, for the animals could not have remained there had there been no food available.

307. Today they (flowering plants) are the dominant land plants, though representatives of other forms still exist.

332. (An example in which similarities are obscured as a result of adaptation can be seen in) the skeletal structure of the arm of man, the foreleg of a horse, the flipper of a whale, the wing of a bat and the wing of a bird. All are fundamentally the same but in each form the bones have become modified in relation to the particular function that each performs.

333. Structures that have a basic similarity but which have developed special functional adaptations are said to be homologus.

334. The study of embryology also contributes evidence of the fundamental similarity of animals.

338. For example (of similarities in the embryo) all animals begin development as a single cell, the zygote. All animals above the Protozoa go through a period of cell division which ends in the formation of a two layered gastrula. All animals from the flatworms up go through another common stage, which is the formation of the third layer of cells, the mesoderm.

339. Another very striking example of related but different organisms going through similar embryonic stages is that of the development of gill slits in the embryos of all vertebrates. In fish the gill slits appear in the embryo and remain in the adult as functional structures, but in amphibia, reptiles, birds and mammals they appear for a short time only during development and then disappear before birth.

340. The appearance of (these) gill slits in embryos indicates a genic complex causing their development. The only possible explanation of the presence of these genes in all vertebrate embryos is common ancestory.

341. On the basis of similarities found among all animals during embryonic development a theory has been proposed which states that during embryonic development every animal goes through developmental states that correspond to evolutionary stages which the ancestors of the animal have passed through. This is the Theory of Recapitulation.

342. An example to illustrate the Theory of Recapitulation follows: The human embryo starts as a single cell, the zygote. This zygote supposedly represents the single cell stage of evolution that occurred at the very beginning of life on earth. The next embryonic stage is cell division of the zygote into a "hollow ball of cells" stage called the blastula, which supposedly corresponds to the time in evolution when colonial Protozoa represented the highest development of life. In the following divisions of the zygote the embryo becomes a two-layered blastula, which corresponds to the two-layered animal stage represented in modern forms by the coelenterates. The next major embryonic step is the formation of mesoderm which presumably followed the evolutionary development of three-layered forms. The flatworms of today represent this evolutionary step. The appearance of gill slits in human embryos represents the fish stage of human evolution.

343. (Thus), it is possible to relate most of the stages of embryonic development with a corresponding stage in evolution and also with a modern animal type that apparently stopped its evolutionary development at one or another of the evolutionary steps.

344. The validity of this theory (of Recapitulation) is questioned, particularly in relation to its extension to include all embryonic stages and structures in an evolutionary sequence.

345. Obviously no animal can go through its entire evolutionary history in the short time it takes for embryonic development.

346. Many stages (in embryonic development) are telescoped and many more are left out entirely.

348. (Consequently), it is impossible to read the entire evolutionary history of an animal in its embryonic development.

349. (Nevertheless), it is probable that the embryo does repeat a few of the evolutionary stages of its ancestors, and in so far as it is possible to recognize these, the Theory of Recapitulation is valid.

351. The appendix in man is such a (vestigial anatomical) structure.

355. (For example), the human coccyx is a remnant that represents the tail vertebrae of other primates.

356. The development of the coccyx in any individual is due to genes which come from its ancestors.

357. (Presumably, therefore) man's ancestors had genes causing the development of a tail which in modern forms have been reduced in their effect so that a remnant only develops.

358. No other explanation (except a genetic one) is logical on the basis of our knowledge of inheritance.

MEAN SCORE 2.51 - 3.50

8. According to Van Helmont, a sixteenth century Dutch scientist, the combination of soiled linen and cheese would produce mice. The Nile river mud plus the heat of the sun supposedly was able to produce both mice and rats.

12. The earth is constructed of a central core and a crust that lies outside the core. The crust is a shell of rock that varies in thickness. In places it is covered with water forming oceans. In other places the rock is exposed, forming the continents.

13. The rock of the continents is exposed to the action of wind, rain, temperature changes, and plants and animals, which result in a gradual disintegration or "weathering" of the rock.

14. The loose material (thus) formed (by weathering action on rock) covers the earth as the soil.

15. Some (of this) soil is washed away by rain and streams and eventually deposited as sediment in lakes and oceans, where it settles to the bottom to form layers of mud or sand. As time passes more layers are added on top of the earlier-formed ones and eventually all of them become rock because of chemical changes and the compressing effect of weight.

16. Rock (formed by the deposition of water borne deposits is called sedimentary rock because of the materials out of which it is made and also is called stratified rock because it is formed in layers.

17. Weathering, when continued over millions of years, gradually wears away the exposed rocks and the continents become flattened.

18. As the continents wear away the edges of the oceans become filled with sediments and the water of the ocean gradually overflows the land.

19. The continents as a whole also rise and sink slowly over long intervals of time, and when they sink the water of the ocean inundates parts of the continent.

20. (Because of the changing relationship between land and water) great arms of the ocean cover vast areas of the continents.

21. (Hudson Bay is an example of an arm of the sea having moved in over a vast area of continent).

22. Into (these) shallow continental seas more sediment is carried and more sedimentary rock is formed. Eventually the continents rise again. The oceans recede from the continents and the sedimentary rock becomes dry land.

23. Usually during (these) periods of uprising continents, the earth's surface buckles in places and mountains are formed.

24. Following the rise of the continents and the formation of mountains weathering again begins its leveling action through rock disintegration and sedimentation.

25. This cycle of rising and sinking continents has occurred many times in the past history of the earth and during each cycle new layers of sedimentary rock are formed.

26. The layers of sedimentary rock laid down at the beginning of a cycle are always underneath those laid down later and also the layers of an earlier cycle are always beneath the layers of a later cycle.

27. Occasional exceptions to this rule (law of superposition) occur when, during mountain formation, the buckling of the earth results in a folding of the rock layers.

34. Copy of Geologic Time Scale as given on page 217 of Syllabus for Biological Science.

53. The inner layer (in animals with two cell-layers) functions mainly in food getting while the outer layer is primarily protective, but also contains sensitive cells that can respond to environmental stimuli.

54. The Coelenterates represent the next probable evolutionary advance (above the sponges).

56. (In Coelenterates) the outer layer is protective and sensitive, while the inner layer is concerned with digestion.

58. Flatworm embryos contain an external cell layer, the ectoderm, an internal cell layer, the entoderm, and a layer in between known as mesoderm.

59. The ectoderm (in flatworm embryos) develops into an outer layer which is still primarily protective in function and also retains its ability to receive stimuli from the external environment.

60. The inner ectoderm (in flatworm embryos) becomes the lining of the digestive tract and is digestive in function.

61. (In flatworms) the mesoderm in the middle develops into muscle and other internal body organs that make up the bulk of the organism.

74. The vertebrates appeared about 550,000,000 years ago.

75. The vertebrates appeared during the Paleozoic Era.

80. The ostracoderms are the most primitive vertebrates known.

81. The ostracoderms lived about 450,000,000 years ago.

83. The ostracoderms had fish-like bodies and tails that ranged from six inches to one foot in length, and they were covered with thick bony scales. The mouth was a transverse slit and jaws were absent.

84. In many ways the ostracoderms resembled the modern cyclostomes, which are the most primitive of modern fish.

89. Gill arches are cartilaginous or bony supports for the gills and lie just behind the mouth on each side.

90. (In sharks the first pair of gill arches) one on each side, moved forward, became hinged in the middle and took on the new function of opening and closing the mouth.

91. (In sharks) the scales lying near the edge of the mouth moved in to rest upon the jaws and become teeth.

92. The transition from gill arch to jaw bone is evident in the development of embryos and the similarity of scales to teeth can be seen on modern sharks.

93. The sharks also developed paired fins.

94. The acquisition of jaws, teeth, and paired fins enabled the sharks to leave the bottom of the streams and swim freely in the water. The fins made control of body movements possible and the jaws and teeth were useful in catching prey.

95. These modifications made greater freedom of movement possible and the sharks migrated into the oceans where they are found today.

103. It is probable that lungs developed during a time when seasonal climatic changes were extreme, resulting in a periodic drying up of streams and ponds.

105. The early bony fish with lungs branched into three groups, the ray-finned fish, the lung fish, and the lobe-finned fish.

106. The ray-finned fish evolved into the modern fish.

107. The lungs of the ancestors (of the modern fish) became modified into an air sac or bladder that moved to the dorsal side of the body cavity.

108. (The air sac or bladder in modern fish) is used to change the specific gravity of the body enabling the fish to change its elevation in the water with ease.

109. The lung fish of today include three forms. One type lives in Australia, the second in Africa and the third in South America.

110. (Modern lung fish) live in ponds and streams that dry up periodically and when this happens the fish burrow into the mud of the bottom. There they remain until water returns to the pond.

112. The characteristics of the lobe-finned fish that make possible the transition from water to land include the lungs, an open connection between the external nostrils and the throat, and fins that were rounded and strong, containing both bone and muscle.

113. The function of the lungs in an air breathing animal is apparent.

114. The internal connection of the nostrils to the throat (in the primitive lobe-finned fish) permitted breathing through the nostrils.

115. The bone-supported fins (of the primitive lobe-finned fish) gave sufficient support to permit locomotion across dry land.

116. (The structure of the skeletal support of the fins of the lobe-finned fish is as follows) one bone connects with the shoulder skeleton. Extending from the end of this bone within the fin are two bones lying side by side. From the ends of these bones a series of small bones branch to support the free end of the fin.

117. The single bone that connects with the pectoral girdle is comparable to the humerous of land animals including man.

120. The lobe-finned fish lived during a time when seasonal changes were great, and it is believed that some of them were forced to become adapted to living on land or die.

122. The amphibians which evolved from the lobe-finned fish ranged in size from about two feet in length to individuals equal in size to modern crocodiles. They had long, slim fish-like bodies with long tails. Paired limbs supported these bodies by means of an internal bone structure similar to that found in the human skeleton.

124. (In amphibians) air was forced into the lungs by swallowing.

125. The ear made its first appearance in amphibians.

126. One of the ancestral gill slits persisted as a tubular opening from the throat to the side of the head. This tubular opening known as the eustachian tube, was closed over at the outer surface by a membrane, the ear drum.

127. Just beneath the membrane a bony remnant of one of the gill arches served as a connecting link between the ear drum and the internal ear.

128. Vibrations of the ear drum were caused by sound waves and these vibrations caused movements in the ear bone, which in turn moved parts of the inner ear thus setting up nerve impulses which were carried to the brain.

133. Some amphibia lay eggs in moist burrows, some use rainfilled hollows in trees, and one modern toad deposits its eggs in little pits on its back.

134. None of the (amphibian) schemes (for obtaining an aquatic environment for fertilization) was very successful and the amphibia, which started the procession to land, fell backward in the evolutionary race.

135. It remained for the reptiles to solve the problem of reproducing on land.

138. The egg that developed in the reptiles consists of a water filled sac, the amnion, that surrounds the developing embryo, a yolk sac containing food suspended from the embryo, and another sac that serves as a respiratory organ. All of this is surrounded by a tough, porous protective shell.

142. Some reptiles developed wings and flew while others turned back into the water.

144. A thick, tough, horny body covering prevented excessive water evaporation. The heart became more efficient and the brain more highly developed, and many other internal organs advanced beyond those of the amphibians.

145. The oldest known birds were scarcely more than feathered reptiles.

147. The skeletons (of primitive birds) was typically reptilian, with a long tail and teeth attached to the jaws. Each wing had three fingers extending from it and these bore claws.

149. It is still questionable how flight evolved.

150. One theory (as to how flight evolved) states that these early birds lived in trees and learned to glide from branch to branch.

151. Another theory (as to how flight evolved) states that the ancestoral birds ran along the ground and with wings outstreched soared into the air.

153. Feathers serve to streamline the body and to act in the wings and tail as resistant surfaces to push against the air.

154. The feathers (of birds) are probably modified reptilian scales.

155. The brain (of the birds) enlarged, but without an increase in intelligence.

156. The parts of the brain that enlarged were concerned primarily with sight, balance and the muscular coordination needed for flight.

157. The sternum (of birds) increased in size to afford greater area for wing muscle attachment and the bones hollowed out, making the body lighter.

158. The eyes developed into efficient organs for sight. The teeth were lost and a beak developed.

159. The creatures (birds) also became warm blooded and correlated with this was the development of an efficient circulatory system that brought a good supply of oxygen to the tissues.

160. As a part of the circulatory system (of birds) a four chambered heart developed.

161. The four chambered heart effectively separated the oxygenated blood from the nonoxygenated blood and so increased the efficiency of oxygen distribution.

162. The reptiles had scarcely began their long evolutionary history on earth when the mammals first appeared.

165. (The early mammalian) teeth were sharp and adapted for flesh eating, but it is believed that they fed mostly on insects and worms.

166. The brains (of the early mammals) were better than those of the reptiles, but not particularly well developed in comparison with modern mammals.

168. There are three major groups of mammals: the monotremes, the marsupials and the placentals.

169. The monotremes are found only in Australia and Tasmania.

170. The monotremes are the most primitive of all mammals.

171. (The monotremes) still have many reptilian characteristics, including the habit of laying eggs which hatch in a nest.

172. The marsupials have a pouch on their abdomens in which they carry their young.

173. The young (of marsupials) are born prematurely and finish their development hanging onto a nipple within the pouch (on the mother's abdomen).

174. The kangaroo is the most generally known marsupial, though there are many others, including the opossum in the United States.

175. Practically all (of the marsupials), however, are confined to Australia and adjacent areas.

176. The placental mammals retain their young within the body of the mother longer than the monotremes and marsupials.

177. (In placental mammals) nourishment for the embryo is provided by the placenta.

179. The insectivores are small, primitive, insect eating placentals such as the mole and shrew.

180. The carnivores are the flesh eaters and include the seals, walruses, bears, cats, dogs, weasels, raccoons and others.

181. The herbivores are the hoofed animals.

182. Some (herbivores), such as the pig, cattle and deer, have two hoofs on each foot, while others, such as the horse have but one hoof per foot.

183. Bats are flying mammals.

184. (In bats), a flap of skin extends between the elongated finger bones and from the arm to the body to form the wings.

185. Whales are the largest of mammals.

186. Whales are entirely aquatic spending their entire life from birth to death in the water. The body has become streamlined and the fore limbs have become flippers. The hind legs are gone. A fish-like tail aids in swimming.

187. The primates are the group of mammals to which man belongs.

188. All of the primates are tree dwellers except a few forms like the baboon and man, who normally live on the ground.

189. The structural characteristics of primatesare adapted for a life in trees.

190. (The structural characteristics) of primates include flexible limbs that permit climbing and swinging through the trees. Both the hand and the foot are grasping organs. The thumb and big toe are opposable to the other fingers. Most primates have a tail that is used in some as a grasping organ, though in the man-like apes and man the external tail is missing. The teeth are reduced in number as compared with those found in other mammals.

191. The eyes of primates are well developed.

192. Stereoscopic vision, which permits the formation of a single image from the two eyes, appears (in the primates).

193. (Stereoscopic vision) gives greater depth of field and greater perspective.

194. In the monkeys, apes and man a special area, the central pit, is present on the retina that enables these animals to see greater detail.

195. (In the primates) the sense of smell is degenerate.

197. There are three main groups of primates: the lemurs, tarsius and the anthropoids.

198. The lemurs are small primitive primates.

199. The lemurs live in Asia and Africa.

200. Tarsius is (also) a (small primate).

201. Tarsius lives in East India.

202. Tarsius is intermediate in development between the lemurs and the anthropoids.

203. The anthropoids include the monkeys, the manlike apes, and man.

204. The monkeys are separated into two groups. One, the New World monkeys, lives in South America, the other group, the Old World monkeys, in Asia and Africa.

205. Monkeys are noted for their curiosity.

206. This (curiosity of monkeys) is due to a high degree of intellectual development that supposedly is the result of the combined effect of the well developed brain, the ability to sit up, the opposable thumb, and keen eyesight.

208. The ability to sit up supposedly has contributed to the development of intelligence by freeing the hands for use in handling objects.

209. The opposable thumb enables the monkey to handle objects.

210. The keen eyesight (of monkeys) enables him to see more things to be curious about.

211. Man also has all of these characteristics (which the monkey has), and it is believed that man's intelligence is the result of the further development of the same kinds of traits that are found in monkeys.

212. The manlike apes include the gibbon, orangutan, chimpansee and gorilla.

213. (The manlike apes) are the closest of all the primates to man in physical development.

214. The skeleton (of the manlike apes) is very similar to man's.

215. The chest (of the manlike apes) is braod rather than narrow as it is in the monkeys and other mammals.

216. (In the manlike apes) the arms are larger and the legs are shorter than in man and the big toe is opposable, but the hand is very similar to the human (hand).

217. These animals (manlike apes) have an erect posture when swinging through the trees, whereas on the ground they usually progress on all fours.

220. Man is erect and walks on the ground. This erect posture has resulted in a curved backbone that brings the trunk and head directly over the hips and thus centers the weight over the legs.

221. The foot (of man) is modified by a shortening of the toes and the expansion of the heel bone as a prep in back. The big toe is no longer opposable but it is in line with the other toes. Man's foot is adapted for walking and is no longer a grasping organ.

222. The hand (of man) differs less from the ape's hand. It is still primitive and very useful as a grasping organ. The thumb remains opposable.

223. Man's face is shorter than the apes; the nose is more prominent and a chin projects from the lower jaw.

224. The teeth (of man) are smaller and weaker than the ape's.

230. The earliest man probably originated during the Pliocene period of the Cenozoic era and evolved into modern man during the Pleistocene period.

231. The Pleistocene period was approximately one million years long and was characterized by periods of glaciation.

232. (During the Pleistocene period) there were probably four successive ice sheets, with long periods of temperate to warm climates between the periods of glaciation.

233. The warmer periods (of the Pleistocene) were from ten to hundreds of thousands of years in length.

236. This list (above) does not include all of the human fossils but does include the best known ones.

237. There is no final agreement as to the exact sequence in which these early men appeared.

240. The age of the rocks in which the fossils were found indicate that the Piltdown and the Heidelberg man lived during the early Pleistocene period.

241. The Java and Peking men were probably contemporaneous during the middle Pleistocene.

242. The Neanderthal and Cro-Magnon men lived during the late Pleistocene, with the Cro-Magnon man appearing somewhat later than the Neanderthal type.

243. The Piltdown man was found in Piltdown, Sussex, England in 1912.

244. The (Piltdown) fossil dates from the first interglacial stage in early Pleistocene and consists of pieces of skull, most of a lower jaw, nasal bones, a canine tooth and two cheek teeth.

245. A few crude tools were found associated with the bones (of Piltdown man).

246. The skull of Piltdown man is modern in type except for the bones, which are twice as thick as modern man.

247. The brain capacity (of Piltdown man) is 1300 ml.

248. The brain capacity of modern man ranges from 1200 to 1500 ml.

249. The jaw (of Piltdown man) is apelike and has a retreating chin.

250. The canine tooth (of Piltdown man) is also apelike while the cheek teeth are a type that could be found in either an ape or in a primitive man.

251. The Heidelberg man is represented by a lower jaw with attached teeth.

252. (The Heidelberg jaw) was found near Heidelberg, Germany.

253. (Heidelberg jaw) was recovered from rock of early Pleistocene formation.

254. (Heidelberg jaw) is apelike in that it is large in size and heavy in build and has no chin.

255. The teeth and dental arch (of Heidelberg jaw) are human in character.

256. (Heidelberg jaw) shows some similarities to the Java man and to the more recent Neanderthal man.

257. The Java man dates from the middle Pleistocene about 500,000 years ago.

258. The first find (of Java man) made in the East Indies included a skull cap, three teeth, and a femur.

259. Java man had some features that were human in character and some that were apelike.

260. The human characteristics of Java man are as follows: the brain capacity of the skull (940 ml.) is intermediate between apes (600 ml.) and modern humans (1200 to 1500 ml.). The median sagittal crest is absent. This is a prominent ridge of bone that extends from front to back along the middle of the skull in some apes. The femur has a straight shaft, and the position of the articular surfaces indicates that the muscle attachments were for an erect posture. The teeth are more human than apelike.

261. The apelike characteristics (of Java man) include heavy brow ridges. Also the forehead slopes back from the brow ridges which makes the vault of the skull low. The canine tooth of the lower jaw fits into a space between the teeth of the upper jaw. The wisdom teeth are not reduced. There is no chin, and the hole through which the spinal cord enters the cranium is visible from behind. This is not true of modern skulls.

262. The Peking man was found in a limestone cavern near Peking, China.

263. (At the Peking find) the remains of three dozen individuals of both sexes and both young and adults were discovered.

264. There are some differences between the Peking man and Java man, but they are not any greater than the differences among modern races of men.

265. The Peking man was a tool user because crude stone tools were found associated with the bones.

266. Likewise remnants of fires were found, indicating that the Peking man had learned its use.

267. Many brain cases had been opened from the bottom, evidently by man himself. This is interpreted to mean that the Peking man was a cannibal.

268. The Neanderthal man was the first human fossil discovered.

270. Since (the original discovery) many skeletons have been found in the following locations: Western Europe, Gibralter, North Africa, Italy, Croatia, Palestine, and Russia.

271. (The many locations in which Neanderthal finds have been made) indicates that the Neanderthal man had spread all over Europe.

272. (Neanderthal man) had heavy brow ridges, a receding forehead and a low vault to the brain case. There is no chin on the massive jaw.

273. The brain capacity (of Neanderthal man) was 1550 ml. which is as large as or larger than the cranial capacity of modern races, but it was due to increased capacity at the back of the skull rather than in the fore part as in modern man.

274. (Neanderthal) males were about 5 feet 4 inches tall and females about 4 feet 8 inches tall. The posture was stooped and the knees slightly bent.

275. Neanderthal man used flint tools.

276. Cro-Magnon man was first found in the Cro-Magnon vicinity of France.

277. (Cro-Magnon man) is believed to represent a race of man that replaced the Neanderthal type in Europe.

278. (Cro-Magnon man) was essentially modern. The head was large with no brow ridges, a high forehead, a prominent and narrow nose, and a well developed chin.

279. The cranial capacity (of Cro-Magnon man) was 1700 to 1800 ml.

280. The Cro-Magnon males were 6 feet or more in height.

281. The Cro-Magnon people disappeared at the end of the Pleistocene period and were replaced by modern man.

282. There is evidence that some of the people living in North Africa, Canary Islands, Iceland, North Germany, and Norway may be descendents of the Cro-Magnon man.

284. The major races are the Negroids, the Mongoloids and the Caucasoids.

286. Man has always been nomadic, with the result that no human group has remained isolated long enough to prevent interbreeding with other races.

287. The Negroid race includes the dark-skinned people who have curly hair and long heads.

288. The Mongoloids are the yellow and the red-skinned people of the world. They have broad heads and straight hair.

289. Indians, Chinese, Japanese, Malays and Eskimos are Mongoloids.

290. The Caucasoid race or Caucasians are usually white-skinned, though they also have some pigment in their skin. Their head shape may be long or bread and their hair form is generally wavy.

299. Some of the most prominent and successful of these early land forms were the seed ferns.

300. (Early seed ferns) grew to the size of modern trees, some of them having stems three feet in diameter.

301. (Early seed ferns) differed from modern ferns not only in size but also in producing seeds. Modern ferns do not produce seeds.

302. The seed ferns and their relatives, such as the tree-like horsetails and club mosses, flourished in wet, swampy ground. Many of them were preserved after death and changed through compression within the earth to form coal.

303. The gymnosperms, represented today by the evergreen, evolved after the ferns.

304. (The early gymnosperms) had straplike leaves rather than the needle-shaped leaves present in modern forms (of gymnosperms).

305. The true flowering plants appeared later, about the middle of the Mesozoic.

306. (The true flowering plants) were very successful land plants and spread over the entire earth.

347. (Furthermore), many embryos have developed special structures that have no evolutionary significance beyond the aid they give the embryo in survival.

352. The degenerate muscles by means of which a certain few human beings can wiggle their ears is another (example of a vestigial structure).

353. The coccyx or tail bones of the human skeleton represents another example of vestigial structures.

MEAN SCORE 3.51 - 4.50

Items number 82, 85, 86, 87, 88, 104, 111, and 269. Content may be obtained from Appendix II.

Principle II - The evolution of living things is, in the broadest sense, progressive and not regressive in nature.

MEAN SCORE 1.51 - 2.00

1. Evolution seems to be progressive.

2. Within the total picture, the evolution of individual forms tells the same story. For example, the horse began as a small five-toed creature that evolved in a more or less direct line into a large, single-toed animal.

3. The loss of toes (in the horse) was not sudden but gradual. During the millions of years that elapsed while the horse was evolving, some of the toes became gradually reduced in size and were lost, while one on each foot increased in size.

4. Other fossil animals and plants show this same progressive change (that the horse shows) by steps from one condition to another.

6. Another explanation of progressive evolution is natural selection.

9. Each generation produces many more offspring than can possibly survive primarily because of limited food supply.

10. The offspring vary in their ability to compete for the available food and consequently during this competition some perish.

11. The offspring that perish in the struggle for existence are the less fit, those that survive are the most fit.

12. (Thus) Natural Selection results in the survival of the fittest.

13. The survivors (at any given time) then overproduce another generation and the competition and selection goes on.

MEAN SCORE 2.01 - 2.50

5. One explanation of this progressive evolution is orthogenesis, which claims that there is some unknown force within the organism that guides its evolution.

8. According to the Theory of Natural Selection all organisms are engaged in a struggle for existence.

MEAN SCORE 2.51 - 3.50

7. The Theory of Natural Selection was proposed by Darwin.

Principle III - Germinal variation is essential to the continuance of evolution.

MEAN SCORE .5 - 1.50

1. In order that evolution can occur, it is necessary that different kinds of organisms be produced.

2. One source of new organisms is sexual reproduction.

3. Each generation of offspring of sexual parents differs in some respects from the preceding generation.

4. (Offspring of sexual parents differs from the preceding generation) due to the uniting of half of the genes from each parent in fertilization with the result that an organism somewhat different from the parents is produced.

6. (The) source of new organisms is limited because the number of different genes that can combine is limited.

7. Something besides sexual recombination of genes is necessary before evolution can continue indefinitely.

8. Some change in heredity must have occurred to produce the millions of different living things that have inhabited or still inhabit the earth.

9. The additional necessary factor (additional to sexual recombination if evolution is to continue) is mutation.

10. This change in heredity is the essence of evolution.

11. There are different kinds of mutations, all of which involve a change in the mechanism of heredity, but the most fundamental is gene mutation.

12. Gene mutation is a change in a gene that results in the development of a new inherited trait.

13. It is believed at the present time that (gene mutation) is the source of all variations that result in evolution.

22. We inherit but one thing and that is a complex of genes that is contained in the germ cells.

35. If one thinks of survival in terms of genes, it becomes obvious that the genes possessed by the survivors are the ones that are passed on to the next generation.

37. Add to this (concept of the survival of genes), the factors of isolation and mutation and it becomes evident how two or more different kinds of organisms can descend from a single common ancestor.

MEAN SCORE 1.51 - 2.00

5. It is known that according to the laws of heredity the degree of variation in organisms is limited.

23. Changes in the body such as the enlargement of muscle through exercise or the skill and coordination that results from long practice do not affect the genes in the germ cells.

25. Changes within the genes contained in the germ cells can be caused by a number of different things.

28. Most important of all environmental factors (in relationship to mutations) is irradiation by x-rays.

29. Earth radiation and cosmic rays also cause genes to change.

34. Natural selction results in the survival of the fittest (of the mutants).

36. The genes of the individuals that perish are lost and do not contribute to the evolution of the population.

MEAN SCORE 2.01 - 2.50

14. Years ago a Frenchman named Lamarck suggested that changes in the mechanism of heredity were brought about by the use or disuse of organs or parts of the body.

15. This (theory of Lamarck's) is known as the Theory of the Inheritance of Acquired Characters.

16. According to this theory (of Lamarck) the loss of toes that occurred during the evolution of the horse resulted from the lack of use of such toes.

17. How the use of an organ apparently resulted in its change can be illustrated by the long neck of the giraffe. It was supposed that the giraffe got its long neck by stretching upward in search of food in tall trees.

21. As attractive as (the Theory of the Inheritance of Acquired Characters) is, it is probably not true, because we do not inherit characteristics of the body that are developed as a result of the direct effect of the environment.

24. One can listen for a lifetime to good music and can practice day after day on a musical instrument and one's offspring will be no more musical than the genes will allow.

26. In one kind of plant it was found that aging of the seed would induce mutations.

27. In the fruit fly high temperatures will cause mutations.

31. (But) it was found that many more mutations occur than could be accounted for on the basis of the amount of irradiation present.

32. Something else (other than naturally occurring rays), still unknown, causes the bulk of the mutations.

33. Nobody knows what the unknown factor is that causes the bulk of mutations.

MEAN SCORE 2.51 - 3.50

18. This theory (of Lamarck) was very attractive because it explained so simply how animals and plants became adapted to their environments.

19. (According to Lamarck's explanation) many cave dwelling animals are blind because they did not use their eyes in the dark caverns.

20. Likewise (according to Lamarck), the whale became streamlined and developed flippers and a fish-like tail by living in the water where such body traits are useful.

30. After the discovery that irradiation caused gene mutation, it was thought that the naturally occurring rays that come from the earth and from space would be sufficient to account for all of the mutations that occur spontaneously in animals and plants.

Principle IV - The interaction of organisms with their environment results in a natural selection of certain organisms. The ultimate consequence of this selection is the origin of new species.

MEAN SCORE .5 - 1.50

1. According to the Theory of Natural Selection all organisms are engaged in a struggle for existence.

2. Each generation produces many more offspring than can possibly survive primarily because of limited food supply.

3. The offspring vary in their ability to compete for the available food and consequently during this competition some perish.

4. The offspring that perish in the struggle for existence are the less fit, those that survive are the more fit.

5. (Thus) Natural Selection results in the survival of the fittest.

6. The survivors (at any given time) then overproduce another generation and the competition and selection goes on.

7. If one thinks of survival in terms of genes, it becomes obvious that the genes possessed by the survivors are the ones that are passed on to the next generation.

8. The genes of the individuals that perish are lost and do not contribute to the evolution of the population.

9. Add to this (concept of survival of genes) the factors of isolation and mutation and it becomes evident that two or more different kinds of organisms can descend from a single common ancestor.

16. (When two groups of organisms of the same kind are separated) new mutations will occur in each group.

17. New genes (arising in separated groups) will be confined to the group in which they arose because there is no mating with other groups.

18. The result (in isolated groups) will be independent mutation and selection in each group and hence independent evolution.

19. If the environment of two isolated groups is the same the evolution may be parallel, but if it differs it is likely that the two lines of evolution will be different.

MEAN SCORE 1.51 - 2.00

10. Isolation means the separation of individuals of the same kind from each other so they cannot mate.

11. Isolation may result from migration where one group wanders off into new territory.

12. Isolation may result from physical changes in individuals within a single area so that such individuals cannot mate.

15. What ever the cause of isolation if two groups of organisms of the same kind are separated from each other they will evolve separately.

MEAN SCORE 2.01 - 2.50

13. An example (of physical change of individuals within a single area preventing mating) is the change that occurred in the copulatory organs of a type of fruit fly that prevented other flies from mating with it.

14. Social custom such as race prejudice that discourages interracial mating in human societies may result in a kind of isolation.

APPENDIX II

DIRECTIONS FOR AREA I ONLY

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact from Area I of the syllabus is to be evaluated in terms of the contribution which you believe it makes toward attainment of the specific objectives of Area I. The specific objectives for Area I were taken from the Study Guide for Biological Science. The statements to be evaluated were taken from the syllabus. Will you rate each fact or statement according to the following key ?

Mark space 1 if you believe that knowledge of the fact is essential to attainment of the objectives.
Mark space 2 if you believe that knowledge of the fact is quite important to attainment of the objectives.
Mark space 3 if you believe that knowledge of the fact is of average importance to attainment of the objectives.
Mark space 4 if you believe that knowledge of the fact is relatively unimportant to attainment of the objectives.
Mark space 5 if you believe that knowledge of the fact is unrelated to the attainment of the objectives.

(specific objectives of Area I on next page)

THE SPECIFIC OBJECTIVES OF AREA I

1. To understand the objectives of general education.
2. To understand the place of biological science in a general education program.
3. To realize the significance of scientific methods in effective living.

1. Man's behavior has been guided since the beginning of human life by two basic requirements, food and reproduction.
2. Primitive man developed forms of cooperation with other men which resulted in the satisfaction of his basic requirements.
3. Out of primitive man's cooperation with other men grew a complex society which has evolved into our modern complex civilization.
4. For an individual to succeed in obtaining his basic requirements he must have certain skills that enable him to do some special task.
5. Special education is necessary to prepare the individual to do the special tasks that enable him to satisfy his basic requirements with the result that there are schools of business, trade schools, schools of medicine, schools of agriculture and many others.
6. Success of the individual as a member of society depends upon other skills and other knowledge (than ability to handle a special tasks). He must know how to cooperate, how to compromise his own particular needs and desires with those of others for the common good. He must understand the workings of society and the function of each individual within it. For this understanding he must know the origin, growth and development of society. He must appreciate the value of different parts of society, and above all he must learn to think in terms of the part he can play in promoting the welfare of mankind.
7. General education courses teach the skills and knowledge that are necessary for successful group living.
8. The welfare of the modern world depends in large measure on the success of the general education program in its efforts to teach people to live together.
9. Man is a biological organism.
10. Man's primary activities are biological because without food he could not live and without reproduction human life would cease to exist.
11. Man competes with other biological organisms for his food and frequently for his life. He struggles for his existence just as other organisms do.
12. Man has one advantage not enjoyed by his competitors (in the struggle for existence. This advantage is his ability to learn to a greater extent than any other organism and to profit by that learning.

13. Man can learn how his body functions and how his life is dependent on matter and energy derived from the earth, from the sun, and from other living organisms. He can learn the nature of the universal interrelationships and interdependencies of living things and so better control them for his benefit. He can learn the nature and habits of his competitors and he also must learn that to match successfully the strength of his competitors he must work with other members of his group.
14. The battle against disease, insects, and erosion is no task for a single individual. Rather it is a task requiring the united effort of all the people.
15. Biological Science is designed to give the student an understanding of basic biological principles so that he may better understand his own nature and that of all living things.
16. With an understanding of his own nature and that of all living things the individual can live more effectively as an individual and as a member of a group.
17. A science is a body of knowledge that is obtained by means of the scientific method concerning any part of the universe.
18. In using the scientific method, one makes observations concerning natural phenomena.
19. The results of these observations concerning natural phenomena (data) are recorded, classified, and analyzed, and from this information relationships are determined.
20. The observations (of natural phenomena) to be useful must be made with great accuracy.
21. To increase the accuracy (of observations) , various measuring devices are employed and the senses are extended by means of microscopes, telescopes, X-ray machines, and many other instruments.
22. Results of the observations (data) are classified in an orderly manner.
23. The order (in the process of classifying data) is developed in accordance with what man thinks is logical and meaningful.
24. In the classification of data facts that appear related are grouped together.
25. The classified data are thought over in the search for relationships.
26. It is in the search for relationships that the ability to think logically and brilliantly is of paramount importance.
27. The great scientist of the past were great because they could see relationships not apparent to most men.
28. Our modern"greats" (in science) qualify in the same manner (as the greats of the past).
29. Formulation of an hypothesis is a technique of the scientific method that aids in the search for relationships or generalizations.
30. The hypothesis is a statement of relationships that goes beyond known facts.
31. An hypothesis is made on the basis of too few facts to be accepted as proved and is no more than a reasonable guess concerning a possible relationship that seems to exist.

32. The hypothesis must be tested.
33. The hypothesis is tested by the collection through observation of more data that relate to the hypothesis.
34. The testing of the hypothesis may include experimentation, which is a controlled observation.
35. In experimentation the emphasis is on the relationship between cause and effect. Two similar events are observed, both of which are exactly alike except for one factor. If the observed results of the events differ, the difference must have been due to the variable factor.
36. An hypothesis that has been tested may still stand as the best statement of the relationship abailable or it may be found to be totally incorrect, in which case it is discarded.
37. If the hypothesis proves incorrect a revaluation of all the facts, including those brought out in the testing, is made and a new hypothesis is stated.
38. As a third alternative the original hypothesis may be partly correct and in need only of modification.
39. A theory is an hypothesis that has withstood repeated tests, but which has not been tested sufficiently to be accepted as true with a very high degree of probability.
40. A principle is a relationship or generalization that is supported by such a wealth of data that its truth is very highly probable.
41. It must be emphasized that no scientific fact, hypothesis, theory, or principle is ever proved absolutely true.
42. Scientific truth is a matter of probability.
43. The hypothesis, being based on a few facts only, has the least chance of being a true statement of relationships. Furthur observation may easily show that the hypothesis is untenable.
45. The principle (law or doctrine) has the greatest chance of surviving as a statement of relationshops among natural phenomena because it is the result of the accumulation of years of repeated observations and tests by many scientists.
46. Because there are so many observations or facts that support the principle, the possibility that any facts will ever be discovered that disprove it is remote.
47. It should be remembered also that the relationships are man-made and are what seem to be logical explanations of the observed phenomena of nature.
48. The scientific method may also be used in everyday life.
49. Every individual holds certain things to be true or false, good or evil.
50. These are opinions (judgments of good, evil, true, false) and on the basis of them all people make decisions that govern the course of their action.
51. Every individual must make many decisions during the course of his life, and the welfare of the individual, his family, and society as a whole depends on how well these decisions are made.
52. The scientific method is useful in arriving at opinions that guide the course of action.
53. In terms of the scientific method the opinion is the hypothesis and a person trained in this method will be aware of the basis (facts) on which the opinion (hypothesis) has

been made. His degree of confidence in the opinion will vary according to the adequacy of the facts used in its formulation.

54. An opinion based on many verified facts will be given more weight than one without much substantiation.

55. When an opinion has been accepted it will not be accepted unconditionally, but further information will be sought in order to revaluate it (the opinion).

56. In terms of the scientific method the hypothesis (opinion) will be tested. If this further information supports the original opinion, more confidence can be placed in it. However, if it disagrees with the opinion, all of the information must be re-examined in order to formulate a new one. A new hypothesis is made to fit all of the facts.

57. A person using the scientific method is open-minded.

58. A person who uses the scientific method open-mindedly has the ability to view his opinions in the light of facts and is willing to change his opinions in the light of new information. Such a person also reserves judgment if after considering the facts he realizes that they are not sufficient for the formulation of an opinion.

59. Many people are faced with the necessity of making a decision without adequate information to do it scientifically. They may lack both time and facilities for gathering the needed information; but the decision must be made neverthel

60. In cases where a decision must be made without adequate information the scientifically trained person seeks the advic of some one whose opinions are based on adequate informatio

61. The ability to recognize a competent authority and the willingness to be guided by his opinions are very important factors in living more scientifically.

AREA 3 - CHARACTERISTICS COMMON TO ALL LIVING THINGS

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 3

1. To learn the characteristics of living things.
2. To understand the fundamental organization of plants and animals.
3. To understand the basic significance of respiration to living things.

PRINCIPLE I

Protoplasm is a consequence of the organization of matter and energy.

1. Living things assimilate and utilize materials and energy.
2. Living things take into their bodies non-living materials that are synthesized chemically into living protoplasm or oxidized to release energy that is used in the living process.
3. Life can be maintained only when a constant stream of materials and energy is passing through the living organism.
4. All of the substances in protoplasm are combined into a complex organization in which chemical and physical processes occur that result in life.

PRINCIPLE II

The bodies of plants and animals are composed of cells or the products of cells.

1. Each individual organism is made of the same material, which is a complex kind of fluid substance known as protoplasm.
2. Protoplasm usually takes the form of small blocks or spheres called cells.
3. In the smallest organisms the entire structure is composed of one cell, while in the larger more complex living things such as man the cells are multiplied millions of times to form the complete individual.
4. Complex organisms are made of many millions of cells which are differentiated into various kinds. In complex organisms the cells are grouped on the basis of structure and function into tissues and these are combined to form organs. The organs are united into systems.
5. Groups of cells of similar structure which perform specialized functions are called tissues.
6. The bodies of man and other complex animals as well as the bodies of vascular plants are composed of several kinds of tissues.
7. Organs in both plants and animals are composed of tissues that work together to perform a specific function in maintaining life.
8. Organs that work together to accomplish one of the primary functions of the individual compose the organ systems.

PRINCIPLE III

Life processes are the activities of protoplasm.

1. Each individual is made of protoplasm organized into cells.
2. Every process or function of a living organism, such as digestion, movement, seeing or thinking is the result of the action of cells.
3. The protoplasm of which cells are made is from 60 to 90 per cent water. The rest is composed of proteins, carbohydrates, fats, minerals and enzymes in varying proportions.
4. All of the substances in protoplasm are combined into a complex organization in which chemical and physical processes occur that result in life.
5. Living things assimilate and utilize materials and energy.
6. Living things grow.
7. Living things reproduce.
8. Living things are adapted to their environment.
9. Living things move.

PRINCIPLE IV

Living things have a common structural pattern.

1. Superficially no common pattern is apparant, but the common pattern is there.
2. Each individual is made of the same material, which is a complex kind of fluid substance known as protoplasm.

3. In living organisms protoplasm usually takes the form of small blocks or spheres called cells.
4. The cell is the unit of structure and function of all living things.
5. Every process or function of a living organism, such as digestion, movement, seeing or thinking is the result of the action of cells.
6. A cell is made of protoplasm and has two major parts, the nucleus and the cytoplasm.
7. The nucleus is usually a spherical structure and located near the center of the cell and limited by a thin, protoplasmic membrane known as the nuclear membrane.
8. Inside of the nuclear membrane the nucleus is filled with another kind of protoplasm called nucleoplasm.
9. Nucleoplasm is a thin, watery liquid in which is immersed a loose irregular network of chromatin granules.
10. A large spherical body, the nucleolus, is also found in the nucleus.
11. The remainder of the cell surrounding the nucleus is the cytoplasm.
12. A thin, tough protoplasmic membrane, the cell membrane, surrounds the entire cell.
13. Between the cell membrane and the nuclear membrane is the watery cytoplasm which contains a variety of structures such as vacuoles, food granules, cell products and wastes.
14. Plant cells have a wall made of cellulose outside of the cell membrane.
15. Groups of cells of similar structure which perform specialized function are called tissues.
16. The bodies of man and other complex animals as well as the bodies of vascular plants, are composed of several kinds of tissues.
17. Epithelial tissue is thin and sheet-like and serves to cover surfaces and to line cavities.
18. The outer layer of the skin which covers the body is an epithelium, as are the linings of the digestive tract, the abdominal cavity, and the chest cavity.
19. Every cavity, duct and vessel in the body is lined with epithelial tissue.
20. Connective and supporting tissue holds the parts of the body together and gives support.
21. Several types of tissue are considered as connective and supporting tissue. They are white fiberous tissue, elastic tissue, fatty or adipose tissue, cartilage and bone.
22. The connecting and supporting tissues are characterized by the presence of cells plus a non-cellular substance known as matrix that lies outside the cells.
23. Muscle tissue contracts and in so doing moves body parts.
24. There are three kinds of muscle: striated or skeletal muscle, smooth or visceral muscle, and heart or cardiac muscle.
25. Striated muscle makes up the mass of the body and moves the skeletal parts.
26. Striated muscle is composed of elongated cells with many nuclei and with alternating light and dark bands across the cells.

27. The light and dark bands (striations) on skeletal muscle is thought to be related to the contracting power of the tissue and gives it its name.
28. Smooth muscle is so called because it lacks the striations of skeletal muscle.
29. Smooth muscle cells are spindle-shaped and contain but one nucleus.
30. In smooth muscle the spindle-shaped cells lie parallel and form sheets of tissue that form the walls of various tubes and ducts of the body.
31. The intestine contains two layers of smooth muscle which contract and move the food along.
32. Cardiac muscle is found in the heart.
33. Cardiac muscle is made of branching, striated cells.
34. The cardiac muscle cells contract and relax rhythmically to produce the pumping action so essential to the function of the heart.
35. Nerve tissue is made up of nerve cells (neurons).
36. Neurons have a rounded or triangular cell body to which are attached fibers, the dendrites and axons.
37. The dendrites and axons interconnect parts of the body and conduct nerve impulses.
38. Bundles of nerve fibers make up the nerves.
39. Blood is a fluid tissue and consist of a liquid plasma and floating cellular elements.
40. The cells of blood include the red cells and the white cells.
41. Blood tissue transports materials throughout the body and aids in disease resistance.
42. Meristem tissue consists of small, thin-walled cells which have the ability to divide repeatedly.
43. Meristem tissue is found at the tips of stems and roots and in vascular bundles where growth takes place.
44. The cells of meristem tissue differentiate or change into all of the other tissues of the plant body.
45. Epidermal tissue of plants is similar to epithelial tissue of animals in that it covers surfaces.
46. Epidermal tissue cells are usually small and arranged in a single layer.
47. In leaf epidermis the outer cell walls are thick and covered with a waxy layer which reduces water evaporation, while in root epidermis they are thin-walled and permit the absorption of water.
48. Some epidermal cells of roots have slender projections that extend between the soil particles. These are the root hairs.
49. Parenchyma tissue is made of large, thin-walled, unspecialized cells.
50. Some parenchyma cells are colorless and used mainly for storage, while others, in leaves and near the surface of green stems, contain chloroplast and are used mainly for food manufacture.
51. Two kinds of supporting tissue in plants are fibers and wood.
52. Fibers are extremely thick-walled, elongated cells with pointed ends. When mature they contain no protoplasm.
53. The overlaping of the pointed ends of the fiber cells give great flexibility and strength to the tissue.

AREA 4 - TRANSFORMATION OF SOLAR ENERGY: PHOTOSYNTHESIS

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.
Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.
Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.
Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.
Mark space 5 if you believe that knowledge of the fact is unrelated to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 4

1. To gain some understanding of the nature of matter and energy.
2. To study the energy relationships in living organisms.
3. To understand photosynthesis and to realize the significance of this process to all living things.
4. To study the physical basis for the movement of water and dissolved materials in plants.

PRINCIPLE I

Matter is the substance of the universe.

1. Matter occupies space, has inertia, and attracts other matter with a force called gravity. It can be seen, felt, tasted and smelled.
2. Matter is composed of atoms.
3. The idea that matter is composed of atoms was conceived by the ancient Greeks 2000 years ago.

(continued)

4. There are thousands of different kinds of matter, but this does not mean that there are thousands of different kinds of atoms, for atoms can combine and form substances that have characteristics entirely different from those of the atoms composing them.
5. There are 92 kinds of atoms in nature and some unstable atoms produced in the laboratory, each of which is called a chemical element.
6. The combinations of these elements (atoms) produce all of the kinds of matter that make up the universe.
7. This matter (of the universe) is usually in the form of molecules, which is the name given to the particle formed by the union of two or more atoms.
8. Examples of atoms or elements are carbon, hydrogen, oxygen and nitrogen.
9. Examples of molecules are water, carbon dioxide, sugar, lard and gelatin.
10. A molecule of water is formed when two atoms of hydrogen combine with one atom of oxygen. This reaction does not occur quite as simply as this, but for illustration can be written: $2H + O \rightarrow H_2O$
11. If one atom of carbon unites with two atoms of oxygen the result is a molecule of carbon dioxide.
$$C + O_2 \rightarrow CO_2$$
12. Molecules can also be combined to form larger molecules. For example, 6 molecules of carbon dioxide (CO_2) can be united with 6 molecules of water(H_2O) to form a molecule of glucose ($C_6H_{12}O_6$). In this reaction there are 6 more molecules of oxygen (O_2) than are required in the glucose molecule, so they are given off as molecular oxygen. The equation as written in chemical shorthand is:
$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$
carbon dioxide water glucose oxygen
13. Fat, another kind of food, is also formed by the combination of carbon, hydrogen and oxygen.
14. Protein, another food, is formed by the combination of carbon, hydrogen, oxygen, nitrogen, and frequently other elements such as sulfur, phosphorus and occasionally magnesium and iron.
15. Vitamins also contain carbon, hydrogen, and oxygen.

PRINCIPLE II

The ultimate source of energy available to living organisms within our planetary system is the radiation from the sun.

1. Stored chemical energy is the source of all energy used by living things
2. Green plants have the ability to take the light energy of the sun and convert it into chemical energy.

(continued)

3. The energy that is used by living things to carry on the process of life is chemical energy stored in molecules of carbohydrates, fats and proteins. The ultimate source of this stored energy is sunlight, which is changed from light energy to stored or potential chemical energy.

4. Only green plants can store energy (from the sun) in this fashion, so the source of all energy used by living things is the green plant.

5. Sunlight consist of light waves of different lengths which can be separated by passing through a prism to form a minature rainbow consisting of the following colors: red, orange, yellow, green, blue, indigo and violet.
6. The light waves which produce the red, blue, and violet regions of the spectrum are absorbed by the chlorophyll in the palisade and spongy cells, and the energy is used in combination with water and carbon dioxide to produce glucose.

PRINCIPLE III

Life is a result of the organization of matter and energy in a dynamic equilibrium that can be maintained only by the constant utilization of matter and energy.

1. Within the organism, matter and energy become a part of a complex, integrated mechanism that lives.
2. The organization of the matter and energy is stable so long as life continues, but it is a dynamic sort of organization in which both matter and energy are continually being utilized.
3. Life ceases if non-living materials and energy are not constantly being fed into the living protoplasm.
4. The stored chemical energy in organic foods is the source of all energy used by living things.
5. To use (this) stored energy, living things break the bonds that hold the atoms of the molecule together and the energy is released.
6. Oxygen is necessary for this process (of releasing energy from stored food) which explains why living organisms need a constant supply(of oxygen). The equation for this energy releasing reaction is:

$$C_6H_{12}O_6 + 6\ O_2 \longrightarrow \text{Energy} + 6CO_2 + 6\ H_2O$$

PRINCIPLE IV

Energy and matter are neither created nor destroyed in life processes.

1. In order to maintain life, non-living matter must be taken from the environment and built into the structure of the body.

(continued)

2. Energy must also be taken from the environment and used to carry on the living functions.
3. Within the organism matter and energy become a part of a complex, integrated mechanism that lives.
4. The organization of the matter and energy is stable so long as life continues, but is a dynamic sort of organization in which both matter and energy are continually being utilized.
5. Energy appears in several forms and can be changed from one form to another.
6. In all (of these) forms of energy one type of motion replaces another.
7. The energy of motion is called kinetic energy.
8. Energy can be stored.
9. Stored energy is called potential energy.
10. Stored chemical energy is the source of all energy used by living things.

PRINCIPLE V

In photosynthesis radiant energy is transformed to chemical energy.

1. Photosynthesis is the process whereby water, carbon dioxide, and light energy are combined through the aid of chlorophyll to produce carbohydrate food.
2. Chlorophyll in a living cell is essential in this reaction (photosynthesis) because it alone can make use of the radiant energy of the sun to separate certain of the carbon atoms from the oxygen in the carbon dioxide molecule; to separate certain of the hydrogen atoms from the water molecule, and to recombine these atoms to form glucose, a simple sugar.
3. The chlorophyll probably acts as a catalyst in this reaction(photosynthesis), but the details of the process are still obscure.
4. (In the photosynthesis reaction) six molecules of carbon dioxide combine with six molecules of water to produce one molecule of glucose. The equation written in chemical shorthand is:

$$6\ CO_2 + 6\ H_2O + (\text{energy}) \longrightarrow C_6H_{12}O_6 + 6\ O_2$$

5. Six molecules of oxygen are not utilized in the process (of photosynthesis) and diffuse to the atmosphere. This is the primary source of oxygen for cellular respiration in animals and plants.
6. Photosynthesis serves not only as the source of energy-yielding food for all living things but also supplies the oxygen which is necessary to release the energy so that it can be used by living organisms.
7. The glucose formed within the plant cell (by photosynthesis) may be oxidized (combined with free oxygen), and the chemical energy which is released is used by the plant.

(continued)

8. The energy used by plants cannot be taken directly from the sunlight but must be released by oxidation from a food molecule just as in animals.

PRINCIPLE VI

Only green plants, those containing chlorophyll, can utilize solar energy for the manufacture of foods.

1. Green plants have the ability to take the light energy of the sun and convert it into chemical energy.
2. They(green plants) use carbon dioxide and water and combine them into molecules of glucose.
3. Within the glucose molecule is the energy which has been converted from light energy into chemical energy. The equation for this process is:

$$6\ CO_2 + 6H_2O + \text{Energy} \rightarrow C_6H_{12}O_6 + 6\ O_2$$

4. The ultimate source of stored energy (in food) is sunlight which is changed from light energy to stored or potential chemical energy. Only green plants can store energy in this fashion, so the source of all energy used by living things is the green plant.
5. The green plant is the source of all energy-yielding foods and also of most of the foods that do not contain energy. Water and some minerals may be obtained from nonplant sources.
6. The more common flowering plants are composed of roots, stems, leaves, flowers and fruits.
7. The roots extend into the ground where they serve to anchor the plant and to absorb and conduct water and inorganic minerals.
8. The root may be composed of a single long process that extends downward into the ground from which smaller secondary processes extend laterally. This type is called the tap root system.
9. Another type (of root system) is the fibrous root system in which there is no main process, but rather many, of similar length and thickness, that extend in the soil downward and laterally in all directions.
10. A single root is composed of many cells.
11. The outside covering of the root is the epidermis which is composed of flattened, rectangular cells, each of which may have a protoplasmic projection, the root hair, extending between the soil particles.
12. Beneath the epidermis(of the root) is the cortex which is composed of parenchyma cells.
13. In the center of the root is the vascular tissue.
14. In the central portion of the root is the xylem tissue and between the xylem and the cortex lies the phloem (tissue).
15. At the tip of the root are found meristem cells, which divide and cause growth of the root.

(continued)

16. The root cap, covering the extreme tip of the root, protects the growing tissue as the root pushes into the soil.
17. The cells of the root cap are destroyed and sloughed off during root growth and must constantly be replaced from the meristem tissue.
18. The stems hold the plant upright and support the branches and leaves.
19. The stems also conduct water, minerals and other foods.
20. The stem has an outer single layer of cells again called the epidermis.
21. Beneath this(the epidermis of the stem) is the cortex made of parenchyma cells.
22. Inside of the cortex(of the stem) is the central cylinder of vascular tissue.
23. Inside the circle of vascular bundles(of the stem) is a central core of pith.
24. The pith (of the stem) is also composed of parenchyma cells.
25. Each vascular bundle has three parts: the phloem, meristem tissue, and xylem.
26. The phloem lies on the outside of the vascular bundle near the cortex.
27. The xylem lies on the inner side near the pith.
28. The meristem tissue(of the stem) is between the phloem and the xylem.
29. The leaves are the food-making organs of the plant.
30. The leaf is usually of two parts, the leaf stem and the blade.
31. The leaf stem supports the blade and contains conducting tissue.
32. The blade is usually broad, flat and thin.
33. A waxy cuticle covers the surface of the leaf, beneath which is a single layer of cells, the epidermis.
34. Inside the leaf are two cell layers, the palisade layer and the spongy layer.
35. The cells of both layers (palisade and spongy layers) contain chloroplast.
36. The palisade layer is made of irregular and somewhat elongated cells that stand more or less close together.
37. The spongy cells are more or less irregular in shape and have air spaces between them which are interconnected throughout the leaf.
38. On both upper and lower surfaces of most leaves are tiny openings, the stomates.
39. These(the stomates) permit air from the atmosphere to enter the air spaces of the leaf.
40. The stomates are usually more numerous on the under surface of the leaf than on the upper surface.
41. Each stomate is surrounded by guard cells which regulate the size of the opening.
42. Veins extending throughout the leaf, are extensions of the vascular bundles of the roots, stems, branches and leaf stems.

PRINCIPLE VII

Diffusion is the basic mechanism of transport operating in the physical activities of organisms assisted by the movement of fluids.

1. Plants absorb water from the soil by means of the root hairs.
2. The roots and attached root hairs lie between soil particles which are immersed in water.
3. The water enters the cells of the root by a form of diffusion known as osmosis.
4. Diffusion is a process whereby one substance becomes spread throughout another substance.
5. An example of diffusion is sugar and water. When sugar is added to water the sugar becomes dissolved and in so doing it gradually spreads throughout the water until it is equally distributed.
6. The force which causes the sugar to spread is a molecular force.
7. Molecules are subject to two opposing forces. Attraction tends to hold them together and their motion causes them to separate.
8. This separating force(acting on molecules) is heat energy.
9. When sugar(for example) is dry, the attractive or cohesive force of the molecules on each other is greater than the dispersing force and they cling together in crystals of sugar.
10. When the crystals (of sugar) are moistened with water, the bonds that hold the molecules together are loosened and they separate.
11. (When the molecules separate) each molecule moves in a straight line away from its neighboring molecules until it is stopped, by collision either with another sugar molecule, with the wall of the container, with the surface of the liquid, or with the water molecules.
12. Whenever collision occurs the molecule moves in another direction, in a straight line again, until it bumps into something else.
13. Because the molecules move in a straight line until stopped and then immediately start off in another straight line, it is obvious that the molecules will tend to move away from the area of greater concentration to one of lesser concentration. Repeated collisions in congested areas prevent any great movement toward this area but in sparsely occupied areas progress is not impeded.
14. Finally the molecules fill all of the available space and become equally distributed among the water molecules.
15. Osmosis is diffusion of water through a membrane so constructed that it permits molecules of water to pass through but does not permit molecules of a dissolved substance to pass through. Such a membrane is differentially permeable.

(Continued)

16. If a vessel is so constructed that a differentially permeable membrane separates a solution of pure water and a solution of sugar and water, the water molecules can move both ways through the membrane but the sugar molecules cannot because the membrane permits the water molecules to move through but prevents the sugar molecules from doing the same.
17. The movement of the water molecules is entirely independent of the sugar molecules and they move in accordance with the laws of diffusion: that is, they move from an area of greater concentration of water to one of lesser concentration of water.
18. (In an osmotic system) the water molecules are more concentrated for any given space within the pure water side than they are on the sugar side of the membrane. This is due to the presence of sugar molecules which by occupying space among the water molecules cause them to be farther apart than they would be in a pure solution.
19. Hence, the water moves by diffusion from the pure water side to the sugar solution side of the membrane.
20. The sugar molecules would move by diffusion through the membrane to the pure water side likewise, but they are prevented from doing so by the membrane.
21. Osmosis plays an important part in the absorption and transport of water by a plant.
22. The roots (of plants) with their root hairs lie between particles of soil immersed in water.
23. The protoplasm within the epidermal cells, including the root hairs, contains more substances in solution, such as sugars and organic acids, than the water in the soil (in which the root hairs are immersed).
24. The cell membrane (of the root hair cells) acts as a differentially permeable membrane which permits the flow of water through it, but does not permit the dissolved substances of the cell to flow out. The result is that the water diffuses into the cell by osmosis through the cell membrane.
25. The water (that passes through the root hair cell membrane) moves first into the root hair cells and other epidermal cells that surround the root. This increases the water concentration of these cells over that of the cells next to them inside of the root. Osmosis again occurs and water moves through the epidermal cells into these adjacent cells.
26. A repitition of this process of osmosis from cell to cell toward the center of the root brings the water eventually to the xylem cells of the vascular bundle in the center of the root.
27. The water is conducted upward by capillarity, root pressure, and other forces through the xylem of the root to the xylem of the stem, through the xylem of the stem, branches, and leaf stems until it eventually reaches the leaves.

28. The water evaporates from the surface of the spongy and palisade cells of the leaf. This evaporation is known as transpiration.
29. When transpiration occurs from the surface of the palisade and spongy cells, the water within these cells diffuses to the surface and replaces that lost by evaporation, with the result that the concentration of water within the cell is decreased below that in adjacent cells not exposed to the air. Osmosis results and the water moves from these adjacent cells into the cells lining the air spaces. This reduces the water content of these cells, which in turn causes water to move by osmosis from the cells next in line. This is repeated from cell to cell starting with the cells lining the air spaces and ending with the cells surrounding the xylem of the veins.
30. The cells surrounding the xylem of the vein(of the leaf) receive water from the xylem.
31. The xylem of the veins(of the leaf) is connected directly with that of the leaf-stem which is connected with the xylem of the stem. The stem xylem is connected with the root xylem.
32. Movement of the water upward through the xylem ducts is due in part to capillarity, root pressure, and other forces not fully understood.
33. Minerals that are in solution in the soil water move by diffusion into the epidermal cells of the roots and then into the xylem.
34. Minerals are conducted upward into the leaves by the xylem of the roots, stems, leaf-stems, and veins.
35. In the leaves minerals in solution move from the veins into the palisade and spongy cells by diffusion.
36. Plants receive carbon dioxide from the air, which diffuses into the leaves through the stomates and then into the palisade and spongy cells.

PRINCIPLE VIII

The synthesis of fats and proteins and carbohydrates other than glucose is a sequel to photosynthesis which makes matter and energy available to living things.

1. The glucose formed within the plant cell(by photosynthesis) may be oxidized(combined with free oxygen), and the chemical energy which is released is used by the plant.
2. The energy used by plants cannot be taken directly from the sunlight but must be released by oxidation from a food molecule just as in animals.
3. The glucose may also be changed directly into double sugar or starch and stored in the leaves or it may be transported in the phloem to some other part of the plant and there stored as sugar or starch.
4. (The glucose) may also be changed into fat, which may be stored.

(continued)

5. Finally other chemical elements may be added and the glucose changed into protein, which is used to build more protoplasm for the plant cells or stored.
6. In normal growth and development of plants food is stored in roots, stems, leaves and fruits.

AREA 5 - UTILIZATION OF MATTER AND ENERGY

UNIT 1 - **Foods and Digestion**

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is essential to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is quite important to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of average importance to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is relatively unimportant to an understanding of the principle.

Mark Space 5 if you believe that knowledge of the fact is unrelated to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 5, UNIT 1

1. To classify energy-containing foods as to their general characteristics and their specific actions.
2. To realize the significance of vitamins and the importance of water and mineral salts in the diet.
3. To understand the basic significance of the digestive processes.

PRINCIPLE I

Food is the only form in which matter can be utilized by living things.

1. Food is any material that can be used by living things to maintain the normal state of protoplasm.
2. Some foods furnish energy and some foods provide building materials, while others aid in different ways in the metabolism of the body.

3. Foods include the organic foods- carbohydrates, fats, proteins and vitamins- and the inorganic foods- minerals, water, oxygen and carbon dioxide.
4. Common foods such as meat, fruits and vegetables are mixtures of the basic food substances.
5. The carbohydrates supply living things with their main source of energy.
6. Carbohydrates include sugars, starches, glycogens and celluloses.
7. Chemically the carbohydrates are all fundamentally alike in that they are all composed of the three elements- carbon, hydrogen and oxygen.
8. There are usually six (or multiples of six) molecules of carbon in the carbohydrate molecule and the hydrogen and oxygen are usually present in the same proportion as in water, that is, 2 parts of hydrogen to 1 of oxygen (H_2O).
9. The formula for glucose ($C_6H_{12}O_6$), which is a simple sugar, illustrates this molecular relationship(in the carbohydrate molecule).
10. There are three classes of carbohydrates- simple sugars, double sugars, and complex carbohydrates.
11. Glucose, fructose and galactose are simple sugars and have the formula $C_6H_{12}O_6$.
12. Maltose, lactose and sucrose or cane sugar are double sugars and have the formula $C_{12}H_{22}O_{11}$.
13. Starch, glycogen and cellulose are complex carbohydrates and have the formula $(C_6H_{10}O_5)_n$.
14. Two molecules of a simple sugar can combine to form one molecule of a double sugar. In this process one molecule of water is released.
15. When two molecules of a simple sugar combine to form one molecule of a double sugar the reaction can be written in chemical shorthand as follows:

$$\underset{\text{simple sugar}}{C_6H_{12}O_6} + \underset{\text{simple sugar}}{C_6H_{12}O_6} \rightarrow \underset{\text{double sugar}}{C_{12}H_{22}O_{11}} + \underset{\text{water}}{H_2O}$$

16. By combining many simple sugar molecules in the same fashion complex molecules of starch, glycogen or cellulose can be formed.
17. The "n" in the formula for a complex carbohydrate $(C_6H_{10}O_5)n$ represents a high number (from 20 to 300) of simple sugar molecules that have combined to form the complex carbohydrate.
18. Fats are another good source of energy for living organisms.
19. Fats are contained in quantities in such foods as vegetable oils, nuts, butter, cream, lard, bacon and other fatty meats.
20. The elements carbon, hydrogen and oxygen make up the fat molecule, but the hydrogen and oxygen are not in the ratio of H_2O as in carbohydrates.
21. In fats there is less oxygen in proportion to the hydrogen than in the case of carbohydrates.

22. Because fats are less oxidized than carbohydrates, they contain more energy per unit of weight.
23. Fats are characterized also by being soluble in alcohol and ether and they feel greasy to the touch.
24. Fats are formed by the union of fatty acids and glycerol, which are relatively simple molecules that have the building-block relationship to complex fat molecules that the simple sugar molecules, such as glucose or fructose have to the complex carbohydrates.
25. Proteins are used as building materials for the protoplasm of the body but may also be used as a source of energy.
26. Foods high in protein content are lean meats, eggs, gelatin, cheese and nuts.
27. Proteins contain the chemical element nitrogen as well as carbon, hydrogen and oxygen.
28. Phosphorus and sulfur are often contained in the molecules(of protein).
29. The molecules (of proteins) are formed by the union of simpler molecules called amino acids.
30. The amino acids have the same relationship to protein molecules that the simple sugars have to complex carbohydrates and that fatty acids and glycerol have to fats.
31. Amino acids combine in infinite ways to form the large and complex protein molecules that make up the major proportion of living protoplasm.
32. Amino acids are recognized chemically by the grouping together of nitrogen and hydrogen as NH_2.
33. NH_2 is known as the amino group.
34. There are about twenty-three amino acids known.
35. The amino acids combine in different proportions to form many different kinds of proteins found in living things.
36. In man the proteins in the cells of different organs vary one from another.
37. There are also certain differences apparant in proteins of different individuals.
38. The proteins found in differat species of animals and plants differ greatly.
39. Vitamins are organic compounds required of living organisms in very minute amounts, but whose absence causes nutritive deficiency diseases.
40. The vitamins were first named alphabetically A, B, C, D, E and K, but these names are gradually being replaced by the chemical name of the substance as these become known.
41. Several of the vitamins have been synthesized in the laboratory and manufactured for commercial sale.
42. With the exception of vitamin D, the primary source of vitamins in nature is plants.
43. Vitamin A is found in animal products such as egg yolk, butter, and cod-liver oil.
44. Certain pigmented plants such as carrots, squash, sweet potato and yellow corn contain a yellow pigment, carotene, which can be transformed by some animals into vitamin A.

45. Vitamin A is essential for normal growth, for the maintenance of healthy epithelial tissues, and for the prevention of night blindness.
46. Vitamin B is found in many plants, particularly in bran, wheat embryo and yeast.
47. Vitamin B is a complex of several chemical substances.
48. Milk, oysters and lean pork are animal sources of vitamin B.
49. Vitamin B is necessary for normal metabolism, for the prevention of pellagra and to maintain healthy nerves.
50. Vitamin B causes root growth in plants.
51. The effects of a deficiency of vitamin B on the nervous system vary from mild nervous disorders to the more severe symptoms found in beriberi.
52. Vitamin C is also known as ascorbic acid.
53. Vitamin C is present in fresh fruits, particularly citrus fruits.
54. In the absence of vitamin C, scurvy develops.
55. Scurvy is a degenerative disease affecting many parts, including the teeth and bones.
56. Vitamin D is known as calciferol.
57. Vitamin D is abundant in the liver oils of various fish, particularly cod and halibut.
58. Irradiation of milk, yeast and certain plant and animal fats will produce calciferol.
59. Human beings can synthesize vitamin D if the skin is exposed to direct sunlight.
60. Vitamin D is necessary for the absorption of calcium and phosphate from the intestine.
61. The absence of vitamin D results in a bone disease known as rickets.
62. Vitamin E is known chemically as tocopherol.
63. Vitamin E is probably essential for the maintenance of normal reproductive activities.
64. Vitamin E is found in wheat germ oil and in germ oil of other grains.
65. The normal diet contains ample quantities of vitamin E.
66. Vitamin K is essential for the normal clotting of blood.
67. Vitamin K is used to reduce bleeding in modern surgery.
68. Vitamin K is formed in the intestine by the action of bacteria on food residues and consequently is not needed as part of the diet.
69. Water and minerals are the essential inorganic minerals.
70. Life as we know it would be impossible without water.
71. The minerals necessary for organisms include calcium, magnesium, potassium, and sodium in combination with chloride, phosphate and carbonate.
72. Small amounts of iron, copper, cobalt, iodine, fluorine, manganese, and zinc are also necessary (in the diet).

PRINCIPLE II

The chemical energy of organic food is the only form in which energy is utilizable by the metabolic activities of organisms.

1. Chemical energy can be stored in molecules.
2. Green plants have the ability to take the light energy of the sun and convert it into chemical energy.
3. Green plants use carbon dioxide and water and combine them into molecules of glucose.
4. Within the glucose molecule produced by the green plant is the energy which has been converted from light energy into chemical energy.
5. Fats and proteins also contain stored energy.
6. To use this stored energy(in organic foods) living things break the bonds that hold the atoms of the molecule together and the energy is released.
7. Thus the energy that is used by living things to carry on the process of life is the chemical energy stored in molecules of carbohydrates, fats and proteins.

PRINCIPLE III

Solubility and diffusibility are prerequisites for the absorption of foods.

1. Food is stored in the form of large, complex, insoluble molecules in both plants and animals and cannot be used until the molecules are made simpler and soluble in water.
2. Neither plants nor animals can transport food material through the body except in a soluble form.
3. Food cannot be used for energy nor for building protoplasm unless it is in a simple molecular form.
4. Splitting complex molecules into simple ones, which makes them soluble in water, is called digestion.

PRINCIPLE IV

Digestion results in organic food being changed into their soluble and diffusible components.

1. Splitting complex molecules into simple ones, which makes them soluble in water is called digestion.
2. Digestion is essentially the same in both plants and animals.
3. The process of digestion is facilitated by the action of enzymes.
4. Enzymes are organic catalyst produced by living cells which speed up or slow down chemical reactions without themselves being used up.

5. In the process of digestion enzymes speed up the chemical reactions.
6. In the process of digestion enzymes enable the chemical reactions to take place at relatively low temperatures.
7. In digestion water is added chemically.
8. The chemical equation for the digestion of starch is:

$$\underset{\text{starch}}{(C_6H_{10}O_5)n} + \underset{\text{water}}{nH_2O} \longrightarrow \underset{\text{simple sugar}}{nC_6H_{12}O_6}$$

9. There is no digestive system in plants.
10. In plants digestion occurs through enzyme action wherever food is stored.
11. Digestion in plants may occur in the roots, stems, leaves or seeds.
12. After digestion the food is soluble and can be transported, usually through the phloem, to the part of the plant that needs the energy or building material.
13. The growing tips of roots or stems are the usual destination of such soluble energy-containing foods.
14. The process of digestion in animals is fundamentally the same in all forms.
15. Before digestion can take place in an animal, it must eat either plant material or another animal that has already fed on plants.
16. The simplest illustration of the fundamentals of food intake and digestion is found in a single celled animal, the ameba.
17. The ameba is microscipic in size, lives in water, is composed of one cell only, and moves by a flowing of the protoplasm.
18. When the ameba moves, parts of the cell project forward as blunt, finger-like processes called pseudopodia. The rest of the protoplasm flows into these processes. Other pseudopodia are them projected and again the rest of the cell flows into them.
19. When a food particle is met in the wanderings of the ameba, two or more protoplasmic processes move toward and around the food until it is completely surrounded. The processes also close over the top and bottom of the food until it is completely surrounded.
20. The surrounding of the food particle by the protoplasm of the ameba forms a space inside the cell which contains water and the food particle. This space is known as the food vacuole.
21. The food vacuole of the ameba acts as a digestive structure.
22. The ameba protoplasm surrounding the food vacuole secretes digestive enzymes into the vacuole which digest the food and thus make it soluble.
23. In the ameba, digested food in the vacuole is then absorbed through the vacuolar membrane into the protoplasm, where it is utilized for energy production or to build more protoplasm.

24. The essential features of the processes associated with food getting in the ameba are (1) food intake (2) secretion of digestive enzymes by the protoplasm through the membrane surrounding the vacuole, (3) breakdown of complex food molecules by the enzymes into simpler soluble molecules, (4) absorption of the soluble molecules through the vacuolar membrane into the protoplasm of the cell.

PRINCIPLE V

Water is a basic medium for life processes.

1. The protoplasm of which cells are made is from 60 to 90 percent water.
2. Food is stored in the form of large, complex, insoluble molecules in both plants and animals, and cannot be used until the molecules are made simpler and soluble in water.
3. All forms(of life) require a certain amount of water, but some require less than others.
4. Chemicals dissolved in water also have an effect on the kinds of organisms living in any area.
5. Water comprises over 60% of the human body by weight.
6. Water is part of the protoplasm and of all body fluids.
7. Life as we know it would be impossible without water.

AREA 5 - UTILIZATION OF MATTER AND ENERGY

UNIT 2 - Organ Systems

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

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Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 5, UNIT 2

1. To understand the structural characteristics of the digestive, respiratory and excretory systems which function directly in the intake-outgo activities of living things.
2. To understand the significance of these organ systems to the organism as a whole.

PRINCIPLE I

The exchange of matter between organisms and the environment is accomplished in the simpler organisms by the physical process of diffusion almost exclusively. In the complex multicellular animals, supplementary specializations of tissues and organs evolved to effect the intake-outgo activities.

(continued)

1. Man is a complex animal made of billions of cells, some of which are specialized and combined to form a digestive system.
2. The digestive system(in man) is a tube extending from mouth to anus through which the food must pass to be digested.
3. Associated with the digestive tube(in man) are several glands, which secrete enzymes and other essential materials necessary for digestion.
4. Practically all animals must take in free oxygen and must get rid of carbon dioxide.
5. The immediate source of oxygen and the place of disposal for carbon dioxide is air for land animals and water for aquatic animals.
6. The fundamental method of obtaining oxygen and removing carbon dioxide is the same for both land and water animals, though the details of the mechanism may differ.
7. The fundamental method of obtaining oxygen and removing carbon dioxide in both land and aquatic animals is diffusion through a moist cell membrane.
8. The cell membrane must be moist or diffusion through it cannot occur.
9. The simplest example of the mechanism(of diffusion) is a single-celled organism, such as the ameba.
10. The cell membrane of the ameba is covered with water in which the ameba normally lives, and this water contains oxygen dissolved in it.
11. Oxygen is also present within the cell, where it is used in cellular respiration.
12. Cellular respiration in the ameba removes the free oxygen from the cell with the result that the concentration of oxygen within the cell is below that of oxygen in the water outside. Therefore, the oxygen diffuses from the water through the moist cell membrane into the protoplasm of the cell.
13. Cellular respiration in the ameba also produces carbon dioxide, which accumulates within the cell in quantities greater than those present in the water outside the cell membrane. Therefore, carbon dioxide diffuses out of the cell through the moist cell membrane into the surrounding water.

PRINCIPLE II

The specializations in the digestive process which evolved to meet the organism's requirements are those involved in (1) the mechanical subdivision of foods (2) the increased secretion of digestive fluids (3) the stirring of the digestive tract contents (4) the absorption of the end products of digestion and (5) the reabsorption of water from the fecal wastes.

1. The(human) digestive system is a tube extending from mouth to anus through which the food must pass to be digested.
2. Associated with the tube are several glands, which secrete enzymes and other essential materials necessary for digestion.
3. The(digestive) tube is divided into the following parts: Mouth, throat, esophagus, stomach, small intestine, large intestine, rectum and anus.
4. The major glands that secrete into the tube are salivary glands, gastric glands, liver, pancreas, and intestinal glands.
5. The lips form the anterior(forward) boundry of the mouth. The palate forms the roof and the cheeks form the side walls. The floor is occupied by the tongue.
6. Posteriorly(to the rear) the mouth opens into the pharynx or throat.
7. Food is taken into the mouth, where it is broken up by the chewing action of teeth, tongue, and cheeks.
8. Food in the mouth is partly digested by the action of an enzyme secreted by the salivary glands.
9. Chewing increases the area exposed to the action of enzymes and speeds up digestion.
10. The salivary glands also secrete mucin, which mixes with the food to make the particles stick together in small balls and to slide more easily down the throat.
11. The tongue is a muscular organ that fills the floor of the mouth.
12. The tongue aids in chewing by pushing the food between the teeth. The cheeks function in the same manner on the other side of the teeth.
13. The upper surface of the tongue is rough and contains numerous papillae, at the base of which are taste buds.
14. There are four taste: sweet, sour, salt and bitter.
15. There are three pairs of salivary glands.
16. One pair(of salivary glands) lies below and in front of the ears.
17. A duct from each(of the salivary glands lying below and in front of the ears) opens into the mouth opposite the second upper molar tooth.
18. The second pair(of salivary glands) lies in the posterior part of the floor of the mouth.
19. A duct from each gland(lying in the posterior part of the floor of the mouth) opens into the mouth beneath the free end of the tongue.

20. The third pair(of salivary glands) lies beneath the tongue.
21. The salivary glands beneath the tongue have a number of ducts that open along the side of the tongue.
22. The pharynx lies just behind the mouth.
23. The pharynx is a common passage way for food and air.
24. The tonsils and adenoids are embedded in the walls of the pharynx.
25. The esophagus is a tube that connects the pharynx with the stomach.
26. The esophagus is lined with an epithelium.
27. The esophagus contains two layers of muscle tissue in its walls.
28. Swallowing moves the food from the mouth into the esophagus and then into the stomach.
29. When swallowing occurs the food is moved to the back of the tongue. The throat muscles contract and push it into the esophagus, which in turn pushes it into the stomach.
30. The movement of the food through the esophagus is caused by the action of the muscle layers in the wall of the esophagus.
31. The action of the muscle layers of the wall of the esophagus is called peristalsis and is the same sort of action that occurs when one squeezes toothpaste out of a tube.
32. (During peristalsis) the muscles in front of the moving ball of food relax, while those behind it contract.
33. Both relaxation and contraction start at the upper end of the esophagus and continue toward the stomach. The food is pushed along by the squeezing action of the contracted wall of the esophagus.
34. The stomach is an enlarged portion of the digestive tube.
35. The stomach acts in part as a sac or reservoir for the temporary storage of food.
36. The inside of the stomach is lined with an epithelium and thousands of glands.
37. The glands of the stomach are of two kinds, those that secrete digestive enzymes and those that secrete hydrochloric acid.
38. The wall of the stomach contains three layers of smooth muscle tissue.
39. The muscle tissue in the wall of the stomach squeezes the stomach into a variety of shapes.
40. The squeezing action(of the stomach) churns the food and breaks it up even more than occured in the mouth.
41. The squeezing action of the stomach also forces the food into the small intestine.
42. The enzymes secreted by the glands in the stomach wall act on proteins only.
43. The enzyems produced by the glands in the wall of the stomach act only in an acid medium, hence the necessity of hydrochloric acid in the stomach.
44. Practically no food is absorbed in the stomach.

45. After the food has remained in the stomach for three or four hours and has been churned and acted upon by enzymes it is forced into the small intestine by a peristaltic wave of the stomach wall.
46. The small intestine is a continuation of the digestive tube.
47. The small intestine is smaller, though longer, than the stomach.
48. The pylorus, a ring-like band of muscle, separates the stomach and the small intestine.
49. The pylorus controls the passage of food from the stomach to the small intestine.
50. The small intestine is lined, like the stomach, with an epithelium.
51. Digestive glands lie in the wall(of the small intestine) beneath the epithelium and secrete into the cavity of the tube.
52. The inside walls(of the small intestine) are folded and on these folds finger-like villi project into the intestinal cavity.
53. The folds and villi serve to increase the surface area of the (intestinal) epithelium, and thus to increase the digestive and absorptive capacity of the intestine.
54. The intestinal walls contain two layers of smooth muscle.
55. The intestinal walls contain many blood vessels and nerves.
56. Connective tissue binds the various structures of the small intestine together.
57. The food and digestive juices are thoroughly mixed and churned in the small intestine by peristalsis and the pumping action of the villi.
58. After a period of churning(in the small intestine) the food is pushed along toward the large intestine.
59. The liver is a large gland that lies in the anterior portion of the abdominal cavity.
60. One of the liver's many functions is to secrete bile into the small intestine by way of the bile duct.
61. The bile mixes with the food as it enters the small intestine from the stomach.
62. Bile emulsifies the fats, breaking them up into small droplets.
63. The emulsification process increases the surface area of the fat globules and thus aids the fat digesting enzymes in their work.
64. The pancreas lies between the anterior portion of the small intestine and the stomach.
65. The pancreas is connected to the small intestine by a duct.
66. The pancreas secretes three kinds of digestive enzymes into the small intestine. They are protein-digesting, fat-digesting, and carbohydrate-digesting enzymes.
67. Glands in the walls of the intestine also secrete protein and carbohydrate-digesting enzymes.

68. Digestion of protein changes them to amino acids.
69. Digestion of carbohydrate produces glucose and other simple sugars.
70. Digestion of fats results in glycerol and fatty acids.
71. The amino acids and simple sugars are absorbed through the epithelium of the small intestine, into small blood vessels, the capillaries.
72. Glycerol and fatty acids go not into the capillaries, but into the branches of the lymphatic system located in the villi.
73. The lymphatic system is part of the circulatory system.
74. The amount of absorption possible (from the small intestine) is dependent on the surface area of the epithelium.
75. Because the amount of absorption from the small intestine is dependent on the surface area of the epithelium, the folded inner lining of the intestine and the finger-like villi are significant. They increase the surface area.
76. After digestion and absorption have taken place, the undigested residue plus some unabsorbed food and water pass into the large intestine.
77. The structure of the large intestine is basically the same as the small intestine.
78. The large intestine has an epithelium lining the wall and two layers of smooth muscle tissue that make up the bulk of the wall of the tube.
79. There are no villi in the large intestine.
80. The junction of the small and large intestines is not a direct end to end union, for the small intestine connects with the large intestine a short way up from the anterior end of the large intestine.
81. The end of the large intestine that extends beyond the connection(with the small intestine) has a small finger-like appendage called the vermiform appendix.
82. No digestive enzymes are produced by the large intestine.
83. Some digestion and absorption occurs in the large intestine.
84. A certain amount of undigested food plus the enzymes pass into the large intestine. The enzyes continue to act and the digested foods afe absorbed through its walls.
85. However, a more important function of the large intestine (than the absorption of digested food) is the absorption of water.
86. Absorption removes most of the water from the large intestine.
87. The food residues become fecal matter (feces).
88. The large intestine contains a large number of bacteria that act upon and break down further whatever is left over after digestion.
89. The residue (in the large intestine) varies with the diet but usually consists of cellulose from plant foods, tough connective tissue from meat, and some fats.
90. The odor of feces is due to the products of bacterial action.

91. Peristalsis moves the fecal matter into the lower end of the intestine and into the rectum at the posterior end of the digestive tube.
92. This (movement of feces into the rectum) exerts a pressure on the walls of the rectum which causes a peristaltic wave to pass over the entire large intestine to the anus.
93. Straining adds to the pressure on the feces by contraction of the diaphragm and the abdominal muscles.
94. (Peristalsis and straining provide the stimulus), the anal sphincter relaxes and the fecal matter then passes through the anus.

PRINCIPLE III

Respiratory organ systems evolved to effect adequate gaseous exchanges between the organism and the environment. All respiratory organs are characterized by having sufficiently large areas of thin, moist membranes richly supplied with blood vessels to meet the oxygen intake and carbon dioxide outgo demands of the organism. The air-breathing organisms possess a system of tubes which permit a more ready diffusion of gases to and from the respiratory surfaces.

1. Practically all animals must take in free oxygen and must get rid of carbon dioxide.
2. The immediate source of oxygen and the place of disposal of carbon dioxide is air for land animals and water for aquatic animals.
3. The fundamental method of obtaining oxygen and removing carbon dioxide is the same for both types(land and aquatic animals) though the details of the mechanism may differ.
4. The fundamental method of obtaining oxygen and removing carbon dioxide is diffusion through a moist cell membrane.
5. The cell membrane must be moist or diffusion through it cannot occur.
6. The simplest example of the mechanism(of gaseous exchange) is a single-celled organism such as the ameba.
7. The cell membrane of ameba is covered with the water in which the ameba normally lives, and this water contains oxygen dissolved in it.
8. Oxygen is also present in the cell(body of the ameba) where it is used in cellular respiration. Cellular respiration removes the free oxygen from the cell with the result that the concentration of oxygen within the cell is below that of the oxygen in the water outside. Therefore, the oxygen diffuses from the water through the moist cell membrane into the protoplasm of the cell.

9. Cellular respiration(also) produces carbon dioxide, which accumulates within the cell in quantities greater than those present in the water outside the cell membrane. Therefore, carbon dioxide diffuses out of the cell through the moist cell membrane into the surrounding water.
10. Some aquatic animals such as fish and lobsters have special structures called gills for obtaining oxygen from the water and for releasing carbon dioxide.
11. Gills are composed of many finger-like filaments through which blood flows in capillaries.
12. The outer layer of a (gill) filament is composed of a thin, cellular membrane that lies over and is adjacent to the cellular wall of the capillary.
13. The aquatic animal lives in water which contains dissolved oxygen. This water flows over the surface of the filaments. The concentration of oxygen in the water is greater than in the blood flowing through the capillaries, so diffusion of oxygen takes place from the water through the moist cellular surface of the filament and through the equally moist cellular wall of the capillary into the blood.
14. Carbon dioxide is more concentrated in the capillary blood (of the gill filaments) than in the surrounding water and therefore diffuses out(into the surrounding water).
15. Several moist cell membranes are involved in this mechanism (of gaseous exchange in a gill bearing animal), but the underlying principle is the same as in the single-celled organism.
16. When blood leaves the gills by way of the vessels it carries oxygen to the tissues of the body.
17. The cells of these (body) tissues use oxygen in cellular respiration and thereby keep the concentration of oxygen in the cells reduced below that of the blood flowing through the adjacent capillaries. Diffusion again occurs and oxygen moves from the blood through the capillary wall, then through the cell membrane to the protoplasm of the cell.
18. Tissue fluids surrounds both capillaries and cells, so the oxygen diffuses through this tissue fluid to the cell.
19. Carbon dioxide is produced by cellular respiration(in aquatic gill bearing animals) just as in the case of the ameba, with the result that the concentration in the cell is higher than in the blood flowing through the capillaries. Diffusion takes place from the cell to the capillary blood.
20. The blood is returned (from all parts of the body) to the gills, where carbon dioxide diffuses out into the surrounding water.
21. Lungs are sacs contained within the thorax and their inner walls are lined with a thin, moist, cellular membrane.
22. Just beneath the moist cellular lining(of the lungs) are millions of blood capillaries.

23. The lining of the lungs is kept moist by the tissue fluid which always surrounds cells within the body.
24. The lungs of land animals differ in complexity but all are basically alike.
25. The human respiratory system is a type of complex respiratory mechanism.
26. The human respiratory system is composed of two major parts, the first is a series of tubular structures that serve to transport air into and out of the lungs. The second is a paired organ for absorption of oxygen and elimination of carbon dioxide. The two parts of this paired organ comprise the lungs.
27. Inside of the nose and extending back into the head is the paired nasal cavity.
28. The paired nasal cavity is lined with a moist epithelium.
29. The nasal cavity opens into the pharynx.
30. The pharynx(throat) is a common passageway for air and food.
31. The larynx opens into the pharynx just in front of the esophagus.
32. The larynx is a cylindrical structure with cartilage in its walls.
33. In the male some of these cartilages(in the larynx) protrude, forming the adam's apple.
34. Within the larynx are the vocal cords, which are connective tissue bands which stretch across the cavity of the larynx.
35. The glottis is the opening of the larynx into the pharynx.
36. The epiglottis is a flap of cartilage that extends upward for a short distance into the pharynx.
37. During swallowing the epiglottis forms a cover for the glottis and prevents food or water from entering the larynx.
38. The trachea is a cylindrical tube that extends from the larynx into the chest cavity.
39. The walls of the trachea contain C-shaped cartilagenous rings that keep the trachea permanently open.
40. The trachea is lined with a moist, ciliated epithelium.
41. The microscopic cilia on the epithelium beat toward the pharynx and remove inhaled foreign particles.
42. The trachea branches within the chest cavity into right and left primary bronchii, which are smaller, but otherwise similar to the trachea.
43. The primary bronchi branch into secondary bronchi, which branch and rebranch, eventually forming microscopic tubules.
44. The microscopic air tubules end in small air sacs.
45. The air sacs attached to the microscopic tubules superficially resemble a bunch of grapes.
46. The walls of the air sacs(of the lungs) are thin and contain millions of blood capillaries.

47. The capillaries in the walls of the air spaces of the lungs are supported by connective tissue, some of which is elastic.
48. Whether the air sacs(of the lungs) are lined with an epithelium is an open question.
49. The exchange of oxygen and carbon dioxide in the lungs takes place in the lining of the air sacs.
50. The thoracic cavity contains the lungs.
51. The thoracic cavity is divided into right and left pleural cavities by a thick median partition.
52. Each pleural cavity contains a lung.
53. The muscular diaphragm forms the floor of the thoracic cavity and separates it from the abdominal cavity.
54. Breathing consist of inhaling and exhaling, or the movement of air into and out of the lungs.
55. Inhalation results when the air pressure within the lungs falls below atmospheric pressure, with the consequence that atmospheric pressure pushes air into the lungs.
56. The pressure within the lungs is lowered by enlarging the thoracic cavity.
57. Enlarging the thoracic cavity is accomplished by moving the walls of the thoracic cavity out and by lowering the floor.
58. The ribs lie within the walls of the thoracic cavity. Contraction of certain chest muscles which are attached to the ribs causes the ribs to swing out and produce a lateral enlargement of the cavity.
59. The floor of the thoracic cavity is made up of the muscular diaphragm. It is dome shaped, with the dome extending upward into the cavity. Contraction of the diaphragm flattens the dome and enlarges the space within the cavity.
60. Exhalation is accomplished by the collapse of the lungs.
61. The lungs contain elastic tissue which stretches when they expand during inhalation. When the chest muscles and the diaphragm relax, both the walls and the floor of the chest cavity return to their original position. This releases the stretching pressure on the lungs and they collapse much like a leaky balloon.
62. The analogy with the balloon is not quite exact because each air sac increases and decreases in size during breathing. The entire lung increases and decreases in size accordingly.
63. The lungs are not to be thought of as empty sacs similar to one rubber balloon, but rather to millions of tiny balloons held together in a compact mass. Each of the tiny balloons has an air tube connecting it to the main passageway.
64. The inhaled air eventually reaches the air sacs, whose walls are thin and moist and contain capillaries. The air contains a greater concentration of oxygen than does the blood flowing through the capillaries, so the oxygen diffuses into the blood.

65. The concentration of carbon dioxide in the air sacs of the lungs is less than that in the blood, so it(the carbon dioxide) diffuses in the opposite direction, that is, from the blood of the capillaries to the air spaces in the air sacs.
66. Oxygen is transported by the hemoglobin contained in the red blood corpuscles.
67. Hemoglobin is a red pigment that unites easily with oxygen, forming the compound oxyhemoglobin.
68. The oxygen also becomes separated from the hemoglobin easily under certain conditions.
69. In the lung capillaries the oxygen combines with hemoglobin, forming oxyhemoglobin and as such travels back to the heart to be distributed throughout the body.
70. Finally it(the oxyhemoglobin) reaches the tissues of the body where there is little or no oxygen. The oxygen then separates from the hemoglobin and diffuses into the cells.
71. (After the oxygen separates from the hemoglobin) the hemoglobin in the red cells continues on into the veins through the heart and back to the lungs; where it picks up another load of oxygen and carries it to the tissues again.
72. Carbon dioxide is transported in the blood by both red corpuscles and plasma.
73. Carbon dioxide is produced in the cells of the body, where it is picked up by the blood; then it is carried to the lung capillaries. From the lung capillaries it diffuses into the air spaces of the air sacs and is breathed out.
74. The xylem and phloem which make up the vascular bundles are the main conducting tissues in plants.
75. There are no special structures to transport gases in plants though there are openings such as the stomates in leaves and lenticels in bark which permit the air to enter and leave.
76. In plants, the transport of oxygen to respiring cells and the transport of carbon dioxide away from them is by diffusion.
77. The carbon dioxide that the plant cells use in photosynthesis also is transported by diffusion.

PRINCIPLE IV

Excretory organ systems evolved to maintain normality in the chemical composition of fluids comprising the internal environment of the organism. In the multicellular animals this is accomplished by a system of tubes and channels of varying degrees of complexity which permit the outgo of metabolic wastes filtered from the blood or other body fluids to the external environment.

1. Metabolic processes in the body result in the production of useless or harmful materials that must be eliminated.
2. Carbon dioxide produced in the cells is eliminated by the lungs.

3. Food residue is eliminated as feces from the digestive tract.
4. The nitrogen-containing wastes are excreted by the kidneys and leave the body as urine.
5. The kidneys also regulate the composition of the blood, particularly with respect to water and glucose.
6. The(human) urinary system consist of two kidneys, two ducts known as ureters, which drain urine from the kidneys, the bladder, which is a reservoir for urine, and a single duct, the urethra, which carries urine from the bladder to the outside of the body.
7. The kidneys are bean-shaped structures about four and one-half inches in length that lie along the dorsal wall of the abdominal cavity.
8. Each kidney is composed of many small renal units which collectively secrete the urine.
9. Each renal unit consists of a small ball of capillaries, the glomerulus, through which blood containing nitrogenous waste flows.
10. The glomerulus is surrounded by a microscopid cup-shaped structure, the glomerular capsule.
11. A small tube, the renal tube is attached to the glomerular capsule.
12. Each renal tubule connedts with other renal tubules which come from other capsules to form a larger duct that empties into a chamber in the central part of the kidney.
13. The ureter is attached to the central chamber of the kidney.
14. The blood carries waste materials from the body cells to the kidneys.
15. Within the kidneys the blood(containing nitrogenous wastes) flows through the glomeruli within the many glomerular capsules.
16. The pressure of the blood causes the fluid of the blood plus the wastes and other substances in solution(mainly glucose) to filter through the capillary walls into the cavity of the capsule.
17. This liquid(glomerular filterate), which is really blood minus the cells and the larger plasma proteins, passes into the tubule that drains the capsule.
18. As the liquid(glomerular filterate) passes through the tubule the cells lining its walls extract most of the water and dissolved substances, leaving the wastes and some water. This is urine.
19. It(urine) leaves the kidneys by way of the ureter which carries it to the bladder.
20. The urethra carries it(urine) from the bladder to the outside(of the body).
21. Plants have no special system to carry on the function of excretion.

22. The excess oxygen produced during photosynthesis diffuses out through the stomates of the leaves.
23. Carbon dioxide produced by cellular respiration may be eliminated also by diffusion it it is not used in photosynthesis.
24. Other wastes are stored in various parts of the plant.
25. These wastes(of the plant) include oils, gums, resins, organic acids, tannins, alkaloids, pigments and certain useless minerals.

AREA 6 - UTILIZATION OF MATTER AND ENERGY

UNIT 3 - Cells and the Internal Environment

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 6, UNIT 3

1. To gain an understanding of the structure and function of blood.
2. To know the substances transported by blood and the functions of these substances.
3. To understand the relationship between the evolutionary development of organisms toward greater complexity and the development of transport systems.

PRINCIPLE I

Transport is a means of bringing food, gases, hormones and antibodies to place of utilization. It is also a means of removing wastes.

1. The food that organisms use as a source of energy and for building body structures must be transported from the place of digestion and absorption to the various parts of the body where it is used.

2. The oxygen that is used to release the chemical energy contained in food must be transported from its place of entry to the many places of use.
3. Many other substances essential to normal functioning of the body must be carried from place to place.
4. Finally, the wastes products of living processes must be removed.
5. The chief method of transport used by all organisms, both plant and animal, is diffusion.
6. In some small organisms this(diffusion) alone is sufficient, but in larger forms diffusion is not fast enough and addition al means of transport are necessary.
7. These(additional means of transport) include the blood and blood vessels of animals, the air tubes of land animals, and the conducting tissues of plants.
8. Blood is made of a liquid portion, the plasma, and a cellular part, the corpuscles.
9. The plasma is mainly water containing several substances dissolved in it, among them blood proteins, mineral salts, food, wastes products, hormones, antibodies, and gases such as carbon dioxide and oxygen.
10. The blood proteins are a part of the blood and are not to be considered as food being transported.
11. One of the blood proteins is firbinogen, which is important in blood clotting.
12. Plasma with fibrinogen removed is called serum.
13. Lymph is a part of the blood that has left the vessels and filtered out into the tissues.
14. The volume of blood in an adult averages five or six quarts, depending on the size of the individual.
15. The blood corpuscles include the red corpuscles, the white corpuscles, and the platelets.
16. The red corpuscles are small circular discs shaped somewhat like a doughnut.
17. There is no nucleus in the red corpuscles of mammals.
18. A red pigment known as hemoglobin, is contained within the corpuscles and is the means of transporting oxygen.
19. When free oxygen is abundant it readily forms with hemoglobin a loose chemical union which is as readily broken when the corpuscles enter areas in the body where there is a scarcity of oxygen.
20. The red corpuscles originate in the red bone marrow.
21. During development they(red corpuscles) possess a nucleus which is lost before the cells reach the circulating blood stream.
22. Red corpuscles are fairly constant in number.
23. In certain diseases the number(of red corpuscles) falls below normal. Such a condition is known as anemia.
24. The white corpuscles are larger than the red, have a nucleus and contain no hemoglobin, and some can move under their own power.
25. White corpuscles originate in red bone marrow and lymph nodes.

26. There are fewer white cells in the blood than red cells and they vary more in number.
27. The variability(of white cells) in number is linked up with their primary function, which is to aid the body in combating infection.
28. When bacteria enter the body, the white corpuscles cluster around and ingest them.
29. The white corpuscles move from place to place in the body within the blood stream, but also they can leave the blood vessels and move through the tissues.
30. White corpuscles move by means of pseudopodia or protoplasmic processes in the same manner as an ameba.
31. The white corpuscles also engulf and digest bacteria as an ameba does food.
32. When an infection is present (in the body) the number of white corpuscles increases.
33. The increase in white blood corpuscles is used by the physician to determine whether a suspected infection is present, such as in the diagnosis of appendicitis.
34. The platelets are small, colorless, round or spindle-shaped bodies about one third the size of red corpuscles.
35. The platelets have an important function in blood clotting.
36. A solid, crusty plug forms over a wound shortly after the blood leaves the vessels and flows over the skin. This plug stops the leakage of blood from the vessels and is known as a clot.
37. The chemical changes that result in the formation of the clot from the liquid blood start when the platelets disintegrate.
38. The platelets are very fragile and burst whenever they come in contact with a rough surface.
39. When the platelets disintegrate they release a substance which reacts with the blood plasma to produce thrombin, an enzyme-like substance, which in turn reacts with fibrinogen, a normal protein constituent of the blood. The fibrinogen is changed into insoluble fibrin. The red cells are caught in the meshwork to form a blood clot.
40. The steps in the clotting of blood are as follows:

    Thrombin + Fibrinogen → Fibrin

    Fibrin + Cells → Clot
41. A thrombus is a blood clot in a blood vessel.
42. An embolus is a thrombus that is moving freely in the blood stream.
43. Coronary thrombosis is the cause of many heart attacks, a thrombus or embolus plugging one of the blood vessels of the heart and stopping the flow of blood.
44. Stopping the flow of blood in one of the blood vessels of the heart prevents oxygen and food from getting to the heart muscle tissue.
45. A stroke may be caused by an embolus, or a thrombus, becoming lodged in one of the blood vessels of the brain.

46. Hemophilia is a disease in which a person's blood does not clot quickly enough to prevent severe and sometimes fatal bleeding.
47. One type of hemophilia is hereditary and is thought to be due to the lack of fragility of the platelets.
48. In the hereditary type of hemophilia the platelets do not disintegrate rapidly enough to initiate the chemical reactions normally involved in blood clotting.
49. The blood of human beings differs, so it cannot be mixed indiscriminately in transfusion. If different types are mixed, the red corpuscles may clump or agglutinate and cause death. They may also disintegrate with equally fatal results.
50. The differences in human blood cause blood to be categorized into groups. These are known as the O group, the A group, the B group and the AB group.
51. Another type of blood group wich is important in transfusion is known as the Rh. The Rh group is not related in action to the O, A, B and AB groups and must be considered separately.
52. Understanding of the importance of the blood groups in transfusion depends on an understanding of the antigen-antibody reaction.
53. This(antibody-antigen reaction) is based on the fact that when a foreign protein is injected into an animal, the injected animal's body reacts by manufacturing a chemical substance to counteract the effect of the injected protein. The substance injected is called an antigen and the substance produced because of the presence of the antigen is called an antibody.
54. The antibody-antigen reaction is the basis for immunization against such diseases as smallpox, diphtheria, whooping cough and typhoid fever.
55. To illustrate (the antibody-antigen reaction), diphtheria is caused by a germ that produces a poison known as toxin. if the toxin in injected into a human being or if it enters naturally because of an infection, it acts as an antigen and stimulates the body to produce an antibody known as antitoxin. The antitoxin neutralizes the toxin.
56. The fatalities that result from mixing different types of blood in transfusions are due to an antibody-antigen reaction.
57. The antigen-antibody process differs in the blood groups from the reaction described in the diphtheria example in that the antigens do not stimulate the production of the antibodies.
58. Both antigens and antibodies are present in normal blood, having been produced during embryonic development.
59. Certain hereditary determiners, the genes, cause development of both antigens and antibodies(concerned in ordinary blood groups).
60. The antigens are present in the red blood corpuscles.
61. There are two kinds of antigens, A and B.

62. A person may have A antigen only, or he may have the B antigen only, or he may have both A and B. It is also possible for a person to have no antigens in the red corpuscles.
63. If he has antigen A he belongs to blood group A. If he has antigen B, he belongs to blood group B. If he has neither A or B antigen, he belongs to group O.
64. The antibodies are of two kinds and are known as "a" and "b".
65. When red cells containing the A antigen are mixed with serum containing the "a" antibody the blood cells clump.
66. Likewise clumping occurs when B antigen is mixed with "b" antibody.
67. It is obvious (from this) that a normal person of blood group A having antigen A does not have antibody "a". If he did the red corpuscles would clump.
68. However, he (a person with blood of group A) does have antibody "b".
69. A B-group individual lacks "b" antibody but has antibody "a".
70. An AB individual has neither "a" nor "b" (antibodies).
71. A person belonging to group O has both "a" and "b" antibodies.
72. It is impossible to mix any two kinds of blood without uniting either A with "a" or B with "b". Nevertheless, blood types are mixed in transfusion and one of them, known as the universal recipient type, is able to take any of the other types. Another type, the universal donor, can be used in transfusion to any of the others.
73. How is this (mixing of A with "a" or B with "b")possible? The answer is to be found in the difference in quantity of blood between the donor and recipient. The quantity of the donor's blood that is transfused is much less than that of a recipient and is quickly diluted by the recipient's blood in the blood vessels. The antibodies of the donor are thus diluted to such an extent that their effect is negligible.
74. The donor's red corpuscles, however, are very quickly acted upon by the antibodies of the recipient because of the relatively large quantity of the recipient's antibodies.
75. In a transfusion it is necessary to be sure that the donor's red corpuscles do not contain an antigen that will react with the recipient's antibodies.
76. The universal donor is group O because its red blood cells contain neither antigen (A nor B).
77. The universal recipient is group AB because its serum contains neither antibody ("a" nor "b").
78. The Rh blood group is caused by the presence of an antigen known as the Rh factor in the red corpuscles.
79. As it(the Rh factor) acts independently of the A, B, AB and O groups a person may have the Rh factor plus any of the A or B combinations.

80. There is no normal antibody to the Rh antigen but it may cause antibody production if blood of an Rh positive person(having Rh antigen in red cells) is transfused into an Rh negative person.
81. If at some future time a second transfusion of Rh positive blood is made(into an Rh negative individual who has received a previous transfusion of Rh positive blood), the Rh antigen reacts with the antibodies and death may result.
82. Another serious consequence is caused when an Rh-negative expectant mother carries an Rh-positive child. A few of the red corpuscles containing the Rh antigen leave the blood stream of the unborn child, get into the mother's blood stream and stimulate the production of antibodies. The antibodies of the mother diffuse into the blood stream of the embryo and destroy the red corpuscles.
83. Rh antibodies usually do not affect the first child, but subsequent offspring may suffer.
84. Death of the embryo may result(from affects of Rh incompatibility) or, if death does not occur, development may be impaired and an anemic or feebleminded child may result.
85. The(human) circulatory system consist of heart, blood, blood vessels, and lymph vessels.
86. The heart pumps the blood through the blood vessels to all parts of the body and back again.
87. There are two circuits (to the circulatory system), the pulmonary and the systemic.
88. The pulmonary circuit carries the blood to the lungs and back to the heart.
89. The systemic circuit carries the blood to all other parts of the body including the head, visceral organs, arms, legs and body muscles. The blood following this circuit also returns to the heart.
90. The heart is a muscular pumping organ.
91. It(the heart) is a little larger than the person's fist and lies in the thorax, the tip extending to the left of the mid-line.
92. The heart is constructed of four chambers called the right and left auricles and right and left ventricles. A muscular wall separates the right and left sides of the heart.
93. The right auricle receives blood from the systemic circuit and sends it into the right ventricle.
94. From the right ventricle the blood is pumped to the lungs.
95. The left auricle receives the blood returning from the lungs and sends it into the left ventricle, which pumps it into the systemic circuit.
96. Valves guard the openings between the auricles and ventricles.
97. These valves(between auricles and ventricles) consists of flaps of tissue that act like an ordinary door; that is, they open in one direction only.

98. When the blood flows from the auricles to the ventricles, the valves are pushed open by the flow of blood, but when the ventricles contract, the blood cannot flow into the auricles because the valves are forced shut.
99. The arteries that carry blood away from the ventricles also contain valves.
100. The pulmonary valve is in the pulmonary artery and the aortic valve in the aorta.
101. These valves(in the arteries) open when blood flows out of the ventricles, but close when the blood attempts to flow back into the heart.
102. The walls of the heart are composed of a type of muscle tissue called cardiac muscle.
103. The outstanding feature of this(cardiac) muscle is that it contracts and relaxes alternately and rhythmically.
104. The contraction(of cardiac muscle) sends the blood into the vessels and relaxation permits the heart to fill with blood again.
105. The arteries carry blood away from the heart.
106. The arteries are thick-walled blood vessels composed of three layers. The innermost layer is a thin, cellular layer called the endothelium. The middle layer is thicker and is composed of smooth muscle. The outside layer is composed of connective tissue.
107. In the larger arteries there is a large amount of elastic connective tissue.
108. The largest arteries are those leading from the ventricles.
109. The larger arteries branch and rebranch, gradually getting smaller and smaller until they are quite minute in the tissues.
110. The smallest(arteries) connect directly to the capillaries in the tissues of the body.
111. The major systemic artery is the aorta that carries blood from the left ventricle.
112. The aorta extends forward from the heart and then bends backward to continue to the posterior part of the body along the mid-line of the back just under the vertebral column.
113. Branches from the aorta at the bend carry blood into the head. One branch goes up the right side of the neck and another up the left side.
114. The arteries that go to the arms also leave the aorta in this region(of the backward bend of the aorta).
115. Several arteries leave the aorta along the back and carry blood to the stomach, intestine, and other organs in the abdominal cavity.
116. In the pelvic region the aorta branches into two arteries which extend into the legs.
117. The pulmonary artery carries blood from the right ventricle to the lungs, where the artery breaks up into minute capillaries.
118. The veins carry blood back to the heart.

119. Veins have the same three layers that are present in arteries, but they(veins) are much thinner walled.
120. There is little muscle or elastic connective tissue in veins.
121. Valves that prevent the blood from flowing in a direction away from the heart are found at intervals along the veins.
122. Blood flowing through capillaries in the tissues is collected by the smallest veins. These connect to larger veins which in turn connect to still larger ones. The largest veins flow into the auricles of the heart.
123. Blood returns to the heart from the head by way of the jugular veins.
124. Blood returning to the heart from the head and arms is carried by veins that meet in the thorax to form the anterior vena cava which opens into the right auricle.
125. The blood from the legs and back muscles and abdominal organs returns to the heart by way of veins that join to form the posterior vena cava, which lies along the mid-line of the back parallel to the aorta.
126. The posterior vena cava empties into the right auricle.
127. The blood that picks up food from the digestive tract flows to the liver.
128. In the liver the blood from the digestive tract passes through a network of capillaries before it returns to the heart.
129. This(the fact that the blood from the digestive tract flows through capillaries in the liver) enables the liver to remove the excess glucose and amino acids before the blood goes to other parts of the body.
130. The capillaries are thin walled vessels that form an extensive network throughout all body tissues.
131. The capillary walls are a single cell in thickness.
132. The capillary tubes are so small that red corpuscles must pass through them in single file.
133. The number of capillaries in any given area of tissue is very large.
134. There are 2,000 capillaries in each square millimeter of muscle.
135. It is because of the large number of capillaries that oxygen and food can be quickly and efficiently transported to cells and wastes products can be carried away.
136. Scattered through the tissues along with the blood capillaries are the lymph capillaries.
137. The lymph capillaries are constructed in the same way as blood capillaries, but they differ in that they are closed at one end.
138. At their open ends the lymph capillaries interconnect like the twigs of a tree, forming a branch which forms larger lymph vessels which in turn unite to form large lymph ducts.
139. The lymph ducts empty into certain large veins near the heart.

140. At intervals along the lymph vessels are lymph nodes or glands.
141. The lymph nodes are little masses of connective tissue filled with white blood cells.
142. The function of the lymph glands is to serve as a place for the production of white blood cells.
143. Lymph glands also filter out and destroy bacteria contained in the lymph that flows through the vessels.
144. The lymph capillaries drain some of the tissue fluid from the spaces between the cells.
145. The lymph capillaries also carry fat from the small intestine.

PRINCIPLE II

The fluids of the transport system constitute the immediate environment of living cells.

1. The capillaries lie immersed in tissue fluid that also surrounds every cell in the body.
2. Oxygen and food materials diffuse from the blood through the capillary walls into the tissue fluid.
3. From the tissue fluid it(oxygen and food materials) diffuse into the cells.
4. Carbon dioxide and other waste materials diffuse from the cells through tissue fluid into the blood of the capillaries.
5. Tissue fluid is a part of the blood that filters through capillary walls.
6. It(tissue fluid) bathes the cells of the body and then passes into the lymph vessels or back into the capillaries.
7. The lymph capillaries drain some of the tissue fluid from the spaces between the cells.

PRINCIPLE III

The evolutionary development of transport systems in organisms is correlated with an increase in organism size.

1. The chief method of transport used by all organisms, both plant and animal, is diffusion.
2. In some small organisms this(diffusion) alone is sufficient, but in larger forms diffusion is not fast enough and additional means of transport are necessary.
3. These (additional means of transport) include the blood and blood vessels of animals, the air tubes of land animals, and the conducting tissues of plants.
4. Unicellular animals such as ameba live entirely surrounded by water that contains in solution the oxygen that the organism needs. This oxygen diffuses from the water into the protoplasm (of the ameba).

5. Since the ameba is small, the oxygen(that diffuses into the ameba's protoplasm) must travel only a short distance to reach all parts of the individual. For this short distance the rate of diffusion is adequate to keep the ameba continuously supplied with oxygen.
6. Carbon dioxide, a waste product of metabolism, diffuses out of the cell(ameba) into the surrounding water.
7. Food diffuses in a similar manner. If the food is in solution outside the organism, it diffuses in. If it is not in solution, it is digested in a food vacuole within the cell and from this vacuole it diffuses to all parts of the cell.

AREA VI. COORDINATION AND ADJUSTMENT

UNIT 1 - Nervous Coordination

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you blieve it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 6, UNIT 1

1. To understand that irritability is a fundamental characteristic of living matter.
2. To know that the structural and functional unit of the nervous system of most animals is the neuron.
3. To understand how nervous tissue functions to receive, conduct, and associate nerve impulses set up as responses to specific environmental stimuli.
4. To understand that animal behavior has its basis in the quality and degree of organization and association of nervous elements.
5. To realize that human intelligence is a consequence of the quality and degree of organization and association of nervous elements.

PRINCIPLE I

A characteristic property of protoplasm is its capacity to respond to stimuli of various kinds.

1. The ability to receive stimulation and respond to it is called irritability.
2. Irritability is inherent in all living things.

PRINCIPLE II

The ability of organisms to adjust to their surroundings is dependent upon the fundamental property of irritability in living things.

1. Living things adjust to the environment.
2. Living things are sensitive to their surroundings and respond to them.
3. The ability to receive stimulation and respond to it is called irritability.
4. Irritability is inherent in all living things.
5. Unicellular animals and plants respond to environmental stimuli, though in general they have no structures specialized for this purpose.

PRINCIPLE III

The nervous system is a mechanism which regulates and coordinates the activities of various parts of the animal body, making it possible for the animal to act as an integrated unit.

1. Life is characterized by activity.
2. (The activity of life) may be the activity of growth, such as the growth of roots and stems or the growth of man from infancy to adult; or it may be the activity of parts of an organism; or it may be the activity of an animal moving from place to place.
3. All (life) activity (of organisms) must be controlled and coordinated.
4. All animals including man have specialized tissues that aid in adjusting the individual to the environment.
5. (These specialized) tissues which also coordinate the parts of the body are the nervous and endocrine tissues, which in higher animals are evolved into nervous and endocrine systems.
6. The nervous system of man and other vertebrates has three major parts: (1) the central nervous system, (2) the peripheral nervous system, and (3) the autonomic nervous system.
7. These three systems are interconnected, extend to all parts of the body, and function something like a telephone system in a city.

8. Messages received at any point can be quickly relayed to any other part of the body.
9. (But) just as a telephone message must go through "central," so all nervous messages must go through the central nervous system before passing on to their intended destination.
10. The central nervous system is composed of the brain and spinal cord.
11. The brain lies in the head, entirely surrounded by a bony covering, the cranium.
12. The spinal cord connects with the brain and extends down the middle of the back within the vertebral column.
13. Nerves leave the brain and spinal cord and connect to muscles and glands in all parts of the body just as telephone wires extend from "central" to telephones in all parts of a city.
14. The peripheral nervous system comprises the nerves that extend from the brain and spinal cord to muscles and glands in the outlying parts of the body.
15. The autonomic nervous system consists of nerves that connect the brain and spinal cord to the internal organs of the body such as the heart, the stomach, and the intestines.
16. The specialized cells that make up the nervous tissue and the nervous system are the neurons.
17. Each neuron has a cell body containing cytoplasm and a nucleus.
18. From this cell body two kinds of protoplasmic fibers extend. These are the dendrites and the axon.
19. The dendrites usually extend away from the cell body in one direction, while the single axon stretches off in the opposite direction.
20. The axon connects with the dendrites of another neuron whose axon, in turn, connects with the dendrites of another cell.
21. (In this manner) a chain of neurons is formed that may reach from the brain to the foot or to any other part of the body.
22. Along(such) chains of nerve cells the messages (nerve impulses) pass.
23. The connection between an axon and a dendrite is known as a synapse.
24. The simplest type of nervous interconnection within the body is the reflex arc.
25. (The reflex arc) illustrates the principle of nervous function.
26. The reflex arc is composed of two neurons, a sensory neuron and a motor neuron.
27. The sensory neuron has a long dendrite, the end of which lies near the surface of the body.
28. It(the dendrite of the sensory neuron) extends from there (near the surface of the body) to near the spinal cord where it enters the cell body(of the sensory neuron).
29. The axon of the sensory neuron leaves the cell body and extends into the spinal cord.

30. Within the spinal cord it(the axon of the sensory neuron) connects with a dendrite of the motor neuron. This connection is the synapse.
31. The dendrite of the motor neuron is short and is almost immediately connected with its cell body, which also lies within the spinal cord.
32. The axon of the motor nerve passes out of the spinal cord to connect with a muscle within the body.
33. When an appropriate stimulus is applied to the end of the dendrite near the surface of the body, a nervous impulse travels along the dendrite from the point of stimulation to the cell body near the spinal cord.
34. (The impulse) goes through the cell body to and through the axon.
35. At the synapse it(the impulse) passes to the dendrite of the motor neuron and passes along it, through the cell body, and then through the axon of the motor nerve.
36. At the end of the motor axon it(the impulse) stimulates the muscle to action. The muscle then contracts.
37. This action(as described) is purely automatic like pushing a doorbell, which initiates the passage of an electric current through a wire. When the electric current reaches the doorbell, the bell rings.
38. The nerves are groups of nerve-cell fibers which extend from the brain and spinal cord to all parts of the body.
39. The nerves enter and leave both sides of the central nervous system at intervals.
40. The twelve pairs of cranial nerves extend from the brain to various organs in the head region such as the eyes, ears, throat.
41. The spinal nerves extend from the spinal cord to other parts of the body.
42. There are 31 pairs of spinal nerves in man.
43. Each (spinal) nerve is attached to the spinal cord by two roots.
44. The dorsal root (of the spinal nerves) contains sensory fibers that bring impulses into the cord and the ventral root contains motor fibers that carry impulses away from the cord.
45. The dorsal sensory root has a ganglion containing the cell bodies of the sensory neurons.
46. The spinal cord is composed of two parts, the inner gray matter and the outer white matter.
47. The gray matter contains the cell bodies of the motor neurons.
48. The white matter is composed of cell fibers that extend up and down the cord.
49. The white color (of the white matter) is due to a fatty covering material, called myelin, which surrounds each cell fiber.
50. The axons of the motor neurons extend out of the cord within the ventral motor spinal nerves.

51. Both the cell bodies and the dendrites of these neurons (motor neurons) lie within the gray matter of the cord.
52. The axons of the dorsal sensory spinal nerves enter the cord from the spinal ganglion and may connect directly with the dendrites of the motor neuron.
53. Usually, however, there are one or more connective neurons between (the axons of the sensory neurons and the dendrites of the motor neurons.
54. The connective neurons may extend from the sensory axon to the motor dendrite at the same level and on the same side of the spinal cord.
55. They(the connective neurons) also may extend across the cord to a motor neuron on the other side, or they may go up or down the cord and connect with a motor neuron at a different level.
56. Some(connective neurons) extend up into the brain.
57. (Thus) nerve impulses that enter the spinal cord by way of the sensory nerves may go to any motor neuron within the central nervous system.
58. (However) none of the impulses that enter the spinal cord goes to all of the motor neurons.
59. Something controls the direction taken by any impulse, and this control makes possible integrated action within the organism.
60. If nothing controlled the pathway taken by nerve impulses, the various parts of the body would react haphazardly with no relation to the action of other parts. Controlled, coordinated action would be impossible.
61. The structure which determines the direction that the impulse takes is the synapse.
62. When an impulse reaches a synapse it is either reinforced or inhibited.
63. The brain is a large mass of nervous tissue at the anterior end of the spinal cord.
64. It (the brain) contains both gray and white matter.
65. The gray matter (of the brain) is composed of cell bodies and the white matter consist of axons and dendrites.
66. All of the neurons of the brain are interconnected and all are connected with the neurons of the spinal cord.
67. The brain has three major parts, the brain stem, the cerebellum and the cerebrum.
68. The brain stem is made up mostly of axons and dendrites that extend from the spinal cord to the cerebellum and cerebrum.
69. The medulla is the part of the brain stem that connects directly with the spinal cord.
70; The cerebellum is a mass of nervous tissue that lies at the back of the brain over the medulla and behind the cerebrum.
71.

71. The cerebellum has an inner branching core of white matter and an outer cortex of gray matter.
72. The white matter (of the cerebellum) contains nerve fibers that connect to cell bodies in the gray matter.
73. The cerebrum also contains a core of white matter containing nerve fibers and a cortex of gray matter.
74. The cerebrum is divided into two halves, the right and left hemispheres.
75. The brain functions in controlling and coordinating the actions of the entire body.
76. All voluntary action is initiated in the cerebrum.
77. One area (of the cerebrum) known as the motor area controls all muscular action.
78. Another area (of the cerebrum) is concerned with vision, another with smell, and another with taste.
79. Hearing also is dependent on the proper function of a certain area of the cerebrum.
80. The cerebellum functions in coordinating muscular action.
81. In many organisms special organs have developed that function in receiving stimuli.
82. Structures that function primarily to receive stimuli are called receptors.
83. External receptors which receive stimuli from the external environment include the eyes, the ears, the nose, the taste buds and the sensory areas of the skin.
84. Internal receptors receive stimuli from within the body and include those in the tendons of the muscles and the semicircular canals of the inner ear.
85. The eyes receive light stimuli, which activate nerve impulses in the optic nerve.
86. These nerve impulses (in the optic nerve) when carried to the cerebrum, result in the sensation of light.
87. The ears receive sound waves, which stimulate nerve impulses in the auditory nerve.
88. The auditory nerves carry the impulses to the brain, which interprets them as sound.
89. Cells lining the epithelium of the nose are sensitive to chemical substances that become dissolved in the nasal fluids.
90. When stimulated by chemical substances in solution in the nasal fluids nerve impulses go to the brain by way of the olfactory nerve and the brain interprets these impulses as smell.
91. Taste is closely linked to smell.
92. The taste buds are on the tongue and are responsive to chemical substances in solution.
93. The skin contains receptors for touch, pain, pressure, and the sensations of cold and hot.
94. The skin receptors are localized in certain areas.
95. It is possible to find them (skin receptors) by touching the skin in different places with a fine pointed instrument.
96. The sensation of cold will be perceived only if a cold needle touches a cold receptor. It it misses the cold receptor, no sensation results unless it is one of pressure or touch.

97. The same thing is true for any of the other skin senses (that is true for cold receptors).
98. The effectors are the organs of the body that respond with action whenever they are stimulated by nerve impulses.
99. There are two kinds of effectors - muscles and glands.
100. There are three kinds of muscles: skeletal, heart and smooth.
101. The skeletal muscles are usually attached to the bones.
102. They (the skeletal muscles) work in pairs, one of the pair pulling a bone one way and the other pulling it in the opposite direction.
103. Skeletal muscle is make up of elongated cells with many nuclei scattered along the prriphery of the cell.
104. A muscle cell is also called a muscle fiber.
105. Each (muscle) cell has many fine protoplasmic strands running lengthwise through it. On these strands are alternating light and dark areas. Since these light and dark areas correspond in position in all of the strands in the cell, the entire cell looks as though it had cross striations on it. For this reason it is sometimes called striated muscle.
106. Each muscle is made up of many (of these) cells, some lying side by side and some end to end.
107. The (muscle) cells are held together by connective tissue that continues beyond the muscle cells at each end to form a tendon.
108. The tendon is a tough cord of connective-tissue fibers and attaches the muscles to bone.
109. When a muscle contracts, the muscle cells shorter, and this shortens the entire muscle and pulls on the tendons attached to each end.
110. Usually one end (of the muscle) remains fixed while the other end moves.
111. Every muscle in the body contains one or more nerve endings.
112. The nerve endings (in muscle cells) are the ends of nerves that bring nerve impulses from the central nervous system.
113. A muscle contracts normally only when a nerve impulse is discharged into it.
114. The heart is composed of cardiac muscle.
115. The (muscle) cells (in the heart) are striated like skeletal muscle but they differ in that individual cells are branched and each cell has one nucleus.
116. Heart muscle contracts rhythmically.
117. Heart muscle can contract without nervous stimulation, though there are nerve endings in the heart.
118. The nerves that supply the heart function mainly in controlling the rate of heart beat.
119. One type of nerve carries impulses that stimulate the heart to beat faster, and another type carries impulses that stimulate it to beat more slowly.
120. The walls of the body tubes such as the digestive tract, blood vessels, and bladder are composed primarily of sheets of smooth muscle tissue.

121. These (smooth) muscle cells are not striated and each cell has but one nucleus.
122. Each (smooth muscle) cell tapers at the ends.
123. Nerves also connect with smooth muscle (cells).
124. Glands are composed of epithelial cells which produce particular substances that have a definite function in relation to maintaining life functions.
125. The digestive glands that secrete digestive enzymes are examples (of glands).
126. Glands may be one-celled or many celled.
127. (Glands) may secrete their substances into a tube and then into some special organ or they may be without tubes or ducts and secrete directly into the blood stream.
128. The endocrine glands are without ducts and, hence, are frequently called ductless glands.

PRINCIPLE IV

Nervous tissue has the capacity to "store up" the effects of previous reactions to stimuli. This capacity is basic to the establishment of instincts, habits and memory in animals.

1. Coordinated actions constitute behavior.
2. The nervous system works as a unit and coordinates all of the actions of the body.
3. Much (of this) integration is automatic and is the result of inheritance, while some kinds of coordination are learned.
4. The inherited type of coordination is illustrated by the simple reflex such as the knee jerk.
5. If one sits with the lower leg hanging freely, a sharp tap with a blunt instrument just below the knee will cause the leg to jerk forward.
6. The impulses stimulated by the blow travel up the leg along a sensory neuron to the spinal cord. Within the cord they cross a synapse to a motor neuron that carries the impulses to the leg muscles, which contract and cause the leg to move.
7. Other examples of automatic behavior are the visceral reflexes that control breathing, the action of digestive tract and the heart.
8. Most of the lower animals depend entirely upon automatic reflexes to coordinate their responses to environmental stimuli.
9. Bees build intricate honeycombs without learning.
10. Birds build nest exactly like their ancestors did, even though they have never seen them built before.
11. Human infants suckle at the breast without learning and they show a fear reaction if startled.
12. They (human infants) also cry without training.
13. Learning consists of developing new modes of behavior which replace inherited behavior or are superimposed upon it.

14. Every organism starts life with an inherited behavior pattern. This pattern is changed by learning, either by the suppression of the inherited behavior or by the addition to it of new types of behavior.
15. The cerebrum is essential for this process (of learning).
16. How the cerebrum works in accomplishing learning, no one knows for sure, but it involves receiving impulses from the separate senses and coordinating these into a meaningful whole.
17. The conditioned reflex offers a clue to the mechanism of the learning process.
18. The classical example of a conditioned reflex is that of salivation in the dog.
19. Normally a hungry dog will secrete a quantity of saliva when food is seen or smelled. This is a reflex which involves the reception of the stimulus through the eyes or nose, the conduction of that stimulus to the brain, and the transmission of the stimulus to the salivary glands. The glands are stimulated to secrete saliva, which flows into the mouth.
20. If a bell is rung at the same time that food is presented to the dog, he will associate the ringing of the bell with the ppesence of food.
21. After repeated trials, the ringing of the bell without the presence of the food will cause the dog to secrete saliva.
22. (Thus) a new association of stimulus and response has been formed.
23. (This new association of stimulus and response) is a conditioned reflex and also a learned response.
24. It is believed that almost all learning is dependent on this basic mechanism.

AREA 6 - COORDINATION AND ADJUSTMENT

UNIT 2 - Chemical Coordination

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 6, UNIT 1

1. To understand that special chemical compounds called hormones produced by certain tissues can modify the functional activities of other tissues in the animal and plant body.
2. To realize that hormones act as chemical coordinators and in conjunction with the nervous system of animals control and integrate the life processes of organisms.
3. To understand that hormones influence behavior in definite ways.

PRINCIPLE I

Hormones function in the coordination and integration of life processes, such as metabolism, growth and reproduction, which require prolonged stimulation rather than the rapid stimulation characteristic of nervous action.

1. Adjustment of an organism to its environment involves not only the proper response to external stimuli, but also the coordination of activities within the body.

2. The sense organs and certain effectors and the central and peripheral nervous system take care of the adjustment of the whole organism with its external environment.
3. The autonomic nervous system and the endocrone system coordinate internal activities.
4. The autonomic nervous system is concerned primarily with the mechanical processes such as breathing, circulation, and peristalsis.
5. The endocrine system coordinates the chemical processes.
6. Examples of these chemical activities (coordinated by the autonomic system) include the oxidation of carbohydrates for the release of energy, the maintenance of the proper amount of calcium in the blood and the stimulation and inhibition of the growth processes.
7. In general, endocrine responses are slow, cumulative ones which stretch over considerable periods of time in contrast to nervous responses which are almost instantaneous.
8. The endocrine system is made up of several glands.
9. (The endocrine) glands have no ducts.
10. (The endocrine) glands secrete chemical substances directly into the blood that flows through the glands.
11. The chemical substances secreted by endocrine glands are called hormones.
12. The hormones are carried by the blood to all parts of the body.
13. The hormones affect only certain organs of the body.
14. In these organs (affected by the hormones) they produce a specific type of reaction.
15. There are many different hormones, and each hormone usually produces one kind of reaction.
16. The action of the hormone secretin illustrates the way in which hormones coordinate chemical processes in the body.
17. Secretin coordinates the action of parts of the digestive system.
18. The stomach mixes hydrochloric acid with food and digestive enzymes and eventually forces this mixture into the small intestine. The pancreas secretes digestive enzymes into the small intestine, where they digest the food
19. If these two activities, the entrance of the food into the small intestine and the secretion of the digestive enzymes by the pancreas, occured at different times, the food and the enzymes would not mix and digestion would not take place. A hormone, secretin, coordinates the two events so that they occur approximately at the same time.
20. The hydrochloric acid from the stomach stimulates the cells of the small intestine to produce secretin, which passes into the blood stream and is carried to the heart and then to all parts of the body including the pancreas.
21. Here (kn the pancreas) the secretin stimulates the cells of the pancreas to secrete digestive enzymes that immediately pass into the intestine by way of the pancreatic duct.
22. The major endocrine glands of man are the pancreas, thyroid, parathyroid, adrenal, pituitary, and gonads.

23. The pancreas has two functions. One is to secrete digestive enzymes and the other is to secrete a hormone, insulin.
24. The endocrine part of the pancreas consists of small islands of cells scattered among the cells that secrete enzymes.
25. No ducts lead away from the islet cells, so the hormone is secreted into the blood capillaries that course through the pancreas.
26. A constant supply of islet hormone, insulin, is necessary for the proper oxidation of glucose in cellular respiration.
27. Insulin also plays an essential part in the storage of glucose in the liver.
28. The disease diabetes results if too little insulin is produced.
29. The thyroid is a paired gland that lies near the trachea in the neck region.
30. (The thyroid) secretes the hormone thyroxin, which regulates the rate of metabolism of the body.
31. The lack of a sufficient quantity of thyroxin in an infant or child results in cretinism.
32. Cretins are stunted. They have short legs and in extreme cases they waddle when they walk. Their skin is leathery and their teeth are defective. They also are retarded mentally.
33. Thyroxin deficiency in an adult causes an individual to be overweight and to be mentally sluggish. The heart rate is slower than normal and the entire rate of metabolism of the individual is slower than normal.
34. One type of goiter is associated with thyroxin deficiency.
35. The production of thyroxin by the thyroid gland is dependent upon a sufficient supply of iodine.
36. When iodine is deficient in the diet, the thyroid gland produces less thyroxin than normal and also increases in bulk.
37. The goiter is the overgrown (thyroid) gland.
38. An overproduction of thyroxin increases the basal metabolic rate.
39. The individual (with an overactive thyroid) becomes irritable, nervous, and overactive. The eyes bulge and the heart beats irregularly.
40. The parathyroids are usually four in number.
41. Each (parathyroid) gland is about the size of a pea.
42. (Each parathyroid gland) lies imbedded in or beside the thyroid gland.
43. The hormone produced by these (parathyroid) glands is called parathormone.
44. It (parathormone) regulates the calcium metabolism of the body.
45. Removal of the parathyroids causes the level of blood calcium to go down, which in turn causes the muscles to contract spasmodically.
46. Death results (following removal of parathyroids) if calcium is not supplied.

47. The overproduction of parathormone causes calcium to be removed from bones and teeth.
48. The adrenal glands lie near the kidneys.
49. (The adrenal glands) have two parts.
50. One part (of the adrenal gland) is a central core of cells called the medulla.
51. The other part (of the adrenal gland) is an outer layer of cells called the cortex.
52. During times of stress such as in fright or anger the medulla (of the adrenal gland) pours adrenalin into the blood.
53. This (adrenalin in the blood during times of stress) stimulates the heart to beat faster and causes the liver to release glucose. The intake of oxygen is increased also.
54. The net result (of the affect of adrenalin in the blood during stress is to increase carbohydrate metabolism and thus to increase the muscular efficiency of the body.
55. The autonomic nervous system is connected to the medulla and stimulates the production of adrenalin.
56. If the medulla is removed the autonomic nervous system takes over its function.
57. The adrenal cortex produces a hormone, cortin.
58. Cortin regulates the sodium and potassium level of the blood and tissues.
59. The removal of the cortex (of the adrenal gland) inevitably results in death.
60. The pituitary gland lies at the base of the brain.
61. (The pituitary gland) is called the master gland because its hormones regulate and coordinate many of the other endocrine glands of the body.
62. It is believed at the present time that twenty or more hormones are produced by the pituitary gland.
63. An excess of one of the hormones (from the pituitary) during early growth stages results in the production of giants.
64. (Some giants resulting from an excess of one of the pituitary hormones during early growth stages) attain a height of nine feet.
65. The growth of these(pituitary)giants is symmetrical.
66. If the excess of (pituitary growth) hormone production occurs after normal growth has ceased the individual develops the fatal disease, acromegaly.
67. In this disease (acromegaly) the bones of the hands, feet and face increase in thickness.
68. A deficiency of the pituitary hormone during early growth stages results in the production of normally proportioned midgets.
69. The intellectual development of such undersized people (pituitary midgets) is normal.
70. The pituitary hormones regulate the performance of other endocrine glands, such as the thyroid, adrenal and sex gland.

71. They (pituitary hormones) control the secretion of milk by the mammary glands.
72. They (pituitary hormones) also regulate the metabolism of carbohydrates, fats and proteins.
73. The gonads are the reproductive glands, ovaries and testis.
74. Both (ovaries and testis) produce reproductive cells, but they also produce hormones.
75. The testes in the male contain two kinds of tissue. One kind is concerned with the production of sperms. The other kind produces the hormone testosterone.
76. The cells of the testis that produce testosterone are called interstitial cells.
77. The normal development of the secondary sex characteristics in the male is dependent upon the development of testosterone.
78. The secondary sex characters include all of those physical and mental traits that are associated with maleness, other than the gonads, which are primary sex characters.
79. The ovaries of the female produce an estrogenic hormone.
80. The ovaries of the female produce progesterone.
81. The estrogenic hormone is responsible for the development of female secondary sex characters.
82. Both the estrogenic hormone and progesterone play essential parts in the reproductive cycle.
83. Plants produce hormones that are essential for growth.
84. Plant hormones are known as auxins.
85. At the tips of stems, roots and buds and in young leaves cells divide repeatedly and produce some growth.
86. However, most growth (in plants) results from the elongation of cells behind the tip.
87. This elongation of cells (behind the tip) cannot occur unless auxin is present.
88. It (auxin) is produced in the dividing cells, at the tip of the stems and roots, and diffuses to the cells behind the tip.
89. (As a result of stumulation by auxin) these cells (behind the tip) elongate and growth results.
90. However, if the concentration of auxin is too great (in the region of elongation), growth is retarded.
91. Stems can withstand a higher concentration(of auxin) than buds.
92. Roots can withstand the least concentration (of auxin).

PRINCIPLE II

The systems of chemical and nervous coordination are interdependent to a considerable degree.

1. The autonomic nervous system and the endocrine system coordinate internal activities.
2. The autonomic system is concerned primarily with the mechanical processes such as breathing, circulation and peristalsis.
3. The endocrine system coordinates the chemical processes of the body.
4. The autonomic nervous system is connected to the(adrenal) medulla and stimulates the production of adrenalin.
5. If the adrenal medulla is removed the autonomic nervous system takes over its function.

AREA 7 - MAINTENANCE OF THE SPECIES

UNIT 1 - Reproduction and Development

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 7, UNIT 1

1. To understand the processes of cell division and their biological significance.
2. To realize the significance of the fact that all life comes from pre-existing life under present environmental conditions.
3. To understand the essential difference between sexual and asexual reproduction.
4. To understand the essentials of the structure and functioning of the male and female reproductive systems.
5. To realize the importance of hormones in coordinating the process of reproduction in animals.
6. To understand the essentials of human development.
7. To understand the important features of reproduction and development in plants.

PRINCIPLE I

New living organisms arise as the product of living organisms of the same kind.

1. Organisms age and die, and thus it is essential that new individuals be produced.
2. Years ago it was thought that life could arise spontaneously out of non-living matter, such as worms from putrefying flesh or frogs from mud.
3. Now it is believed that living things come only from other living things.
4. The process of producing new individuals is called reproduction.
5. Some organisms reproduce sexually and others asexually.
6. Asexual reproduction consists of the production of two or more individuals by the division of one.
7. In some cases (of asexual reproduction) the parent organism divides into two offspring of equal size. This is known as fission.
8. In other cases the offspring separates from the parent as a smaller-sized replica. This is budding.
9. There are some other forms of asexual reproduction (besides budding and fission), but all of them are modifications of the same fundamental mechanism, which is cell division (mitosis).

PRINCIPLE II

The basis for all reproduction is cell division.

1. The process of producing new individuals is called reproduction.
2. Some organisms repnoduce sexually and others asexually.
3. Asexual reproduction consists of the production of two or more individuals by the division of one.
4. In some cases (of asexual reproduction) the parent organism divides into two offspring of equal size. This is known as fission.
5. In other cases (of asexual reproduction) the offspring separates from the parent as a smaller-sized replica. This is budding.
6. There are some other forms of asexual reproduction (besides budding and fission), but all of them are modifications of the same fundamental mechanism, which is cell division (mitosis)
7. Sexual reproduction is similar to asexual reproduction in that cells separate from the parent to develop into offspring, but it differs in two respects.
8. (First), the cells that separate from the parent (in sexual reproduction) are special cells that go through an intricate process of development before they are ready for reproduction.

9. (Second), the two kinds of cells (gametes) must unite in a process called fertilization before offspring can develop.
10. There are two kinds of reproductive cells. One is the sperm and the other is the egg.
11. There are a few exceptional cases where the eggs can develop without union, but this does not invalidate the general rule that in sexual reproduction the usual procedure is for sperms and eggs to unite before development of young can occur.
12. Gametes are germ cells (eggs and sperms).
13. Gametes or germ cells are produced in special organs called gonads.
14. The sperms are produced in testes in the male.
15. The eggs or ova are produced in ovaries in the female.
16. The sperms are usually small and motile.
17. The eggs are usually comparatively large and non-motile.
18. The sperms and eggs are produced in organs within the body cavity of the male or female and must be transported to the outside of the body.
19. This (transport of gametes to the outside of the body) is accomplished by ducts or tubes that extend from the body cavity to an opening at the surface of the body.
20. In the male the ducts that transport the sperms are connected directly to the testis.
21. In the female the ducts do not connect directly to the ovaries, but open within the body cavity.
22. In some forms (of female animal) the open end of the tube is some distance from the ovary so the egg drops from the ovary into the body cavity and must be transported within the cavity to the open end of the duct that carries it to the outside.
23. In other (forms of females), such as the human being, the open end of the duct is so close to the ovary that the egg normally drops right into the tube.
24. The union of the sperm and egg is called fertilization.
25. In the process of fertilization the sperm penetrates the egg and the nuclear material of both unite.
26. The fertilized egg is called the zygote.
27. Fertilization is external (outside of the body) in aquatic animals such as fish and in amphibians (frogs and toads), which reproduce in the water.
28. In these forms (fish and amphibians) the males and females come together in the water during the mating period. While they are together the female extrudes her eggs into the water and the male releases his sperms. This results in a mixing of the sperms and eggs, during which time the sperms swim to the eggs and unite with them.
29. Generally only one sperm unites with one egg (in the process of fertilization).
30. Many sperms may attempt to penetrate one egg, but after one has entered the egg a fertilization membrane raises from the surface of the egg and prevents other sperms from entering.
31. In internal fertilization the sperms and eggs unite within the body of the female.

32. This (internal fertilization) is usually accomplished by a mechanism which injects the sperms into the reproductive ducts of the female.
33. The male usually inserts the penis into the reproductive opening of the female and releases the sperms into the duct, which normally branches and leads to the ovaries.
34. The eggs are released from the ovaries and travel down the reproductive ducts to meet the sperms coming up.
35. Fertilization (internal) occurs within the ducts (of the female reproductive system)
36. Inasmuch as the linings of the reproductive ducts are moist and the sperms leave the male in a fluid known as semen, the sperms can move upward within the tube at least partly by swimming.
37. (Thus), internal fertilization is fundamentally the same as external fertilization in that water is the medium in which the sperms and eggs unite.
38. Only those animals in which there is internal fertilization, such as reptiles, birds and mammals have become permanent land dwellers.
39. The amphibians that live on land part of the time must return to ponds and streams to reproduce because fertilization is external and can be accomplished in water only.
40. Variations in the usual form of sexual reproduction include hermaphroditism and parthenogenesis.
41. In hermaphroditism there are no distinct males and females.
42. Instead (of separate sexes), ovaries that produce eggs and testes that produce sperm are both present in the same individual.
43. (In hermaphroditism) usually two individuals are necessary for reproduction. An exchange of sperms occurs between the two individuals and the eggs of both individuals are fertilized.
44. (However), self-fertilization is sometimes possible (among hermaphrodites).
45. In some animals the females produce eggs that do not require fertilization for development.
46. The development of eggs without fertilization is called parthenogenesis.
47. The queen honey bee, (for example), produces eggs that may or may not be fertilized.
48. If the eggs (of the queen honey bee) are fertilized, they develop into females. If they are not fertilized they develop into males.
49. In aphids two kinds of females develop. One kind produces eggs that require fertilization for development to take place; the other kind produces eggs that develop without fertilization.
50. Human reproduction is sexual. The male produces the sperms and the female produces the eggs or ova.
51. The primary reproductive organs of the male are the two testes.
52. The testes lie within the scrotum suspended from the lower abdomen between the legs.

53. Each testis contains a number of coiled tubules in which the sperms are produced.
54. The walls of each tubule (in the testes) contain reproductive cells in various stages of development.
55. The (immature sperm) cells near the outer edge (of the tubules) are the least developed, those lying at the inner surface near the cavity of the tube are the most developed, and the cells in between are at various intermediate stages.
56. The undeveloped germ cells are more or less spehrical and have the normal amount of cytoplasm.
57. The undeveloped germ cells have the full complement of chromatin material.
58. When the reproductive cells are fully matured they have lost most of their cytoplasm and half, or approximately half of the chromatin.
59. The details of the chromatin loss (during maturation) are important to heredity.
60. The mature male reproductive cell is known as the sperm cell.
61. It (mature sperm) has a head containing the chromatin tightly packed inside, a middle piece containing a spiral filament, and a long tail composed of cytoplasm.
62. The head (of the mature sperm) is oval as seen from the top or bottom and flattened as seen from the side.
63. In each testis the tubules containing the sperms converge toward one side into a network of small tubes.
64. From this netword (of small tubes) a number of small ducts lead out of the testis and join the sperm duct.
65. The sperm duct passes upward into the abdominal cavity.
66. Within the abdominal cavity it (sperm duct) curves forward to meet the sperm duct from the other testis.
67. Just before the union (of the sperm ducts) a duct from a seminal vesicle opens into each sperm duct.
68. The fluid secretions of the two seminal vesicles make up part of the semen.
69. The semen is a fluid in which ejaculated sperms are immersed.
70. The two sperm ducts open into the urethra.
71. The urethra passes through the penis and opens at the end.
72. The prostate and bulbo-urethral glands secrete fluids into the reproductive ducts.
73. The secretions of the prostate and bulbo-urethral glands added to those of the seminal vesicles make up the semen.
74. The prostate gland lies at the juncture of the sperm ducts and the urethra.
75. The bulbo-urethral glands lie along side of the urethra.
76. The sperms produced in the testes pass through the small tubules into the epididymis.
77. The sperms remain in the epididymis until ejaculated.
78. When this (ejaculation) occurs they pass through the sperm duct and then through the urethra to the outside.
79. (When ejaculation occurs) fluid from the seminal vesicles, prostate, and bulbo-urethral glands is added as the sperms pass these glands.

80. Each ejaculate is said to contain 200 to 300 million sperms.
81. The female reproductive system consists of ovaries and reproductive ducts.
82. The two ovariesof the female are flattened,oval bodies about an inch in length.
83. The ovaries lie attached to the side wall in the pelvic region of the abdominal cavity.
84. Each ovary is filled with connective tissue cells and eggs in various stages of development.
85. An epithelium of undeveloped reproductive cells covers the surface (of each ovary).
86. At intervals groups of the epithelial cells sink into the connective tissue of the ovary. One of them (epithelial cells) becomes the reproductive cell while the rest cluster about it and become follicle cells.
87. The reproductive cell increases in size while the follicle cells increase in number and form a large ball of cells, the follicle.
88. A fluid filled cavity appears within the follicle. The reproductive cell lies on one side of this cavity surrounded by a group of follicle cells.
89. Growth of the follicle continues while it moves into the ovary and then back toward the surface (of the ovary).
90. It (the follicle) eventually reaches the surface, from which it projects as a bulge. It is now a mature follicle and the reproductive cell is ready to be released.
91. In the female the reproductive ducts consists of a vagina, a uterus or womb and two oviducts.
92. The vagina is a tube about three inches long which opens at the surface of the body at one end and connects with the uterus at the other end.
93. The uterus is also about three inches in length. It is a pear-shaped organ with thick, muscular walls and a glanduiar lining.
94. The cervix is a projection of one end of the uterus into the vagina.
95. At the opposite end of the uterus from the cervix, two oviducts lead off to the ovaries.
96. The oviducts do not connect directly to the ovaries but lead into the body cavity adjacent to them.
97. Finger-like processes surround the open ends of the oviducts, some of which attach directly to the surface of the ovary.
98. The discharge of the female reproductive cell, the egg, from the ovary is known as ovulation.
99. (When ovulation occurs) the follicle ruptures and the egg is squeezed out.
100. (After ovulation) the egg is drawn into the open end of the oviduct almost immediately, apparantly through the action of cilia or hair-like processes that line the walls of the oviducts and beat toward the uterus.
101. In the human female ovulation begins at puberty, about the fourteenth year, and ends at menopause, about the forty-seventh year.

102. Generally one egg is released each month between these years (of puberty and menopause).
103. The two ovaries alternate irregularly in producing mature eggs.
104. Sometimes two or more ova are expelled at one time and if fertilized produce fraternal twins or triplets.
105. After the egg leaves the follicle the cells that line the follicle increase in number and develop into a large, yellowish, glandular structure known as the corpus luteum.
106. If pregnancy occurs the corpus luteum persist until the latter part of the pregnant period.
107. If no pregnancy occurs the corpus luteum degenerates in about two weeks.
108. The egg moves down the oviduct toward the uterus.
109. If the egg is fertilized it begins development into an embryo and travels to the uterus, where it remains until development is complete.
110. If the egg is not fertilized it degenerates before reaching the uterus.
111. The human egg looses its ability to be fertilized within a relatively short time after ovulation.
112. The act of placing the penis of the male into the vagina of the female is coitus or copulation.
113. The purpose of copulation is to introduce semen into the vagina.
114. After the sperms are deposited in the vagina, they may be drawn into the uterus within a minute or two by the muscular action of the cervix.
115. The sperms move through the uterus into the oviducts.
116. If ovulation has occured, a sperm meets and fertilizes the egg in the upper part of the oviduct.
117. Sperms retain their vitality within the oviducts usually for no longer than one or two days.
118. In the human female uterine bleeding known as menstruation occurs at intervals of four weeks.
119. Menstruation occurs in other primates as well (as in humans).
120. Menstruation begins (in humans) between the twelfth and fourteenth years and continues until the menopause.
121. The duration of any one menstrual period varies from one to five days.
122. The average interval between periods is twenty-eight days.
123. There is no exact regularity in the interval between periods.
124. The onset of menstruation coincides with the beginning of ovulation at puberty.
125. The cessation of both menstruation and ovulation usually occurs simultaneously at the menopause.
126. Cases are known where ovulation has occured after the menopause.
127. The relation of ovulation to menstruation is not mere coincidence.
128. Both ovulation and menstruation are intimately linked in a series of events related to the reproductive function of the female.

129. We may consider the menstrual cycle as beginning when the pituitary gland that lies at the base of the brain secretes a hormone that stimulates the development of a follicle within the ovary.
130. If the pituitary gland is removed the ovary ceases to produce reproductive cells.
131. As the follicle (in the ovary) develops it produces an estrogenic hormone.
132. The estrogenic hormone is carried by the blood stream to the uterus, where it acts upon the uterine lining.
133. The estrogenic hormone causes the lining of the uterus to grow and develop.
134. The growth and development of the uterine lining involves a thickening of the lining and an increase in the number, size, and secretory activity of the glands.
135. Under the stimulus of the estrogenic hormone the glands secrete a nutritive substance which fills and dilates them.
136. Blood vessels bring a copious supply of blood to the lining of the uterus during the period of the thickening of its walls.
137. The pituitary gland produces another important hormone, the luteinizing hormone.
138. The luteinizing hormone directly affects the development of corpus luteum tissue.
139. The corpus luteum tissue replaces the follicle after ovulation.
140. The occurance of ovulation causes reduction of the supply of estrogenic hormone (which has been providing the stimulus for uterine development and thickening).
141. With the reduction in the supply of estrogenic hormone, another hormone, progestrone, carries on the work of stimulating the development of the uterine lining.
142. Progesterone is produced by the newly formed corpus luteum.
143. If the egg produced by the ovary is not fertilized the corpus luteum maintains its production of progesterone for about two weeks, after which it degenerates and ceases its endocrine function.
144. As a result of the absence of the corpus luteum hormone, the arteries that carry blood to the lining of the uterus constrict.
145. The constriction of the arteries to the uterus stops the flow of blood and cuts off the supply of food and oxygen to the tissues of the uterus.
146. As a consequence of the lack of food and oxygen, the cells of the uterine lining degenerate, they begin to slough off, blood vessels rupture, and the bleeding and destruction of the uterine lining begins.
147. The menstrual flow continues from one to five days, after which it ceases and the lining of the uterus is repaired to begin the cycle all over again.
148. The beginning of repair coincides with the development of a new follicle in the ovary and the renewed production of estrogenic hormone.

149. The estrogenic hormone stimulates the repair of the uterus.
150. During the growth of the ovarian follicle, the estrogenic hormone stimulates the development of the uterine lining, so that it becomes gorged with the nutritive secretion of the uterine gland.

NOTE: AT THIS POINT PLEASE TURN TO THE NEXT ANSWER SHEET AND CONTINUE WITH NUMBER 151.

151. When the egg is released from the ovary, the corpus luteum hormone takes over and keeps the lining of the uterus in condition while the egg travels down the oviduct.
152. If the egg is fertilized in the oviduct it begins to develop into an embryo that passes to the uterus and there becomes attached to the wall.
153. The embryo uses energy for growth and development and lacking an adequate supply of yolk, it must find its nourishment else where. It finds it in the lining of the uterus.
154. The nutritive material secreted by the glands nourishes the embryo, which at first attaches to the uterine wall and later sinks into it.
155. The periodic growth and development of the uterine lining coincides with ovulation, with the result that the young embryo has a favorable environment in which to develop.
156. The timing of the development of the uterine lining so that it coincides with the release of the egg and the descent of the embryo is the function of the estrogenic hormone and progesterone.
157. If no pergnancy occurs, the uterus looses its developed lining and starts all over again to be ready for the next ovulation.
158. If pregnancy does occur, the corpus luteum continues to produce its hormone long enough to insure the establishment of the embryo within the uterus.
159. Plants reproduce in the same manner as animals, that is, asexually and sexually.
160. Fission occurs in the unicellular algae and bacteria.
161. Budding occurs in yeast.
162. Some plants, such as the strawberry, send out long, leafless stems or runners, which develop roots and separate from the parent plant.
163. The potato is a tuber or underground stem that will produce a new plant when planted.
164. Practically all plants develop spores or small cells with a protective coat.
165. (The spores or small cells with a protective coat)separate from the parent plant and develop into a new individual when conditions favor growth.
166. Reproduction involving sex is found in almost all plants.
167. As in animals, sexual reproduction in plants involves the union of two gametes to produce a zygote which develops into a new individual.
168. The flower is the reproductive organ of the flowering plant.

169. The flower is attached to the end of the stem.
170. The flower consists of sepals, petals, stamens, and the pistils.
171. The sepals are usually green, leaflike structures which enclose the base of the petals at their point of attachment to the stem.
172. The petals are modified leaves.
173. The petals may be white or colored.
174. The petals are attached at the end of the stem in the form of a circle just within the attachment of the sepals.
175. The stamens form a circle within the petals and around the pistil.
176. The pistil occupies the center of the stem end.
177. The parts of the flower concerned directly with reproduction are the stamen and the pistil.
178. Each stamen has two parts: the anther and a long upright support, the filament, which holds the anther aloft.
179. The pistil is usually flaskshaped, having a bulbous base, the ovulary, from which the necklike style projects upward.
180. The tip of the style is called the stigma.
181. The ovulary contains one or more ovules.
182. In each ovule a reproductive structure develops.
183. The reproductive structure that develops in the ovule contains a number of cells, the most important of which are the endosperm cells and the egg cell.
184. The anther contains cells that develop into pollen grains.
185. Each pollen grain consists of a generative cell and a tube cell and is covered by a drought-resisting coat.
186. When the pollen grains are mature the anther breaks open and the pollen is freed.
187. The wind blows the pollen of some flowers to other flowers.
188. In other plants visiting insects become covered with the pollen and transport it to other flowers.
189. When the pollen reaches a flower, some of the grains land on the stigma of the pistil. This is known as pollination.
190. Following pollination the tube cell of the pollen begins to grow downward into the stigma and through the style until it reaches the center of the ovule.
191. The tube nucleus moves along the pollen tube just behind the growing tip.
192. The generative cell follows the tube nucleus through the cytoplasm of the pollen tube.
193. The nucleus of the generative cell divides, producing two nuclei which become the male gamete nuclei.
194. When the pollen tube reaches the ovule, the end of the tube ruptures and some of its contents enter the ovule.
195. One of the male gamete nuclei unites with the egg to form the zygote. This is fertilization.
196. The other male gamete nucleus unites with the endosperm nuclei.
197. The zygote develops into the embryo.
198. The outer layer or layers of the ovule develop into the protective covering.

199. The embryo and the endosperm surrounded by the protective covering comprise the seed.
200. The embryo is composed of one or two large embryonic leaves (the cotyledons), one embryonic root and one embryonic stem.
201. When the seed is mature and environmental conditions are favorable it will germinate.
202. Germination involves growth and development of the embryonic root into the ground and growth and development of the embryonic stem into the air above the ground.
203. Growth of the embryonic plant requires energy which is obtained from food stored in the embryonic leaves.
204. The cotyledons or embryonic leaves are thick with stored food which is digested by enzymes.
205. After digestion the food is transported to the growing root and stem, where it is used for energy and building of protoplasm.
206. Development of both roots and stems involves the differentiation of embryonic (meristem) tissues into the mature tissues found in adult roots and stems.
207. The adult tissues of the plant include parenchyma, xylem, phloem and supporting tissue.
208. Leaves develop on the stem (of the plant).

PRINCIPLE III

There is an inverse relationship between the number of reproductive elements produced by an organism and the degree to which the offspring are protected and cared for.

(No material in the assignment from the syllabus for this area)

PRINCIPLE IV

The embryonic development of any organism is directed by the interaction between the kind of protoplasm of the organism and the intrinsic and extrinsic environmental factors.

1. The fertilized egg or zygote develops by a process of cell division, growth and differentiation into a new individual.
2. Food is necessary to supply materials and energy for development(of the zygote).
3. During the early stages of development the embryo's energy requirements are met largely by means of yolk stored in the egg.
4. In all animals yolk is manufactured in the ovary and included within the egg prior to fertilization.
5. Some animals such as the fish and the frog have relatively little yolk, and this is used up during the early stages of development.
6. After the yolk is gone the young embryo must depend on its environment for food.

7. (In forms having very little yolk) a mouth and intestine develop very early, with the result that they begin to feed quite early in development on small particles of food in the water.
8. Other forms, (such as reptiles and birds) produce eggs that have sufficient yolk to last them throughout their period of development.
9. Some animals, including man and other mammals, produce very little yolk for nourishment of the embryo.
10. (In mammals) the problem of nourishing the developing zygote is solved by the retention of the embryo within the body of the mother and the development of a temporary organ, the placenta, that connects the embryo with the tissues of the mother. The embryo gets its nourishment directly from the mother.
11. Both the mother's blood stream and that of the embryo flow into the placenta. The two blood streams do not unite, but flow side by side, and food originally eaten by the mother and carried in her blood stream diffuses into the blood of the embryo to be carried to its tissues.
12. Mammals have special milk-secreting glands, the mammary glands, that function to nourish the young after birth.
13. The mammary glands are located on the ventral surface of the body.
14. Embryos obtain the energy they use for growth and development by oxidation of food in the same manner as adult organisms.
15. Cellular respiration (in embryos) could not go on without a continuous supply of oxygen.
16. The carbon dioxide produced by embryos must be excreted.
17. In aquatic animals whose young develop in the water, the oxygen (required by the embryo) comes(directly) from the water and diffuses into the cells of the embryo.
18. Eventually gills develop in aquatic animals, but prior to their development the oxygen diffuses from the surrounding water directly into each individual cell.
19. Carbon dioxide diffuses out of the cells (of aquatic embryos) into the water.
20. In land animals such as birds and reptiles, the eggs are not immersed in water but are laid on land.
21. In land animals the air of the atmosphere is the source of oxygen and the place of disposal of carbon dioxide.
22. The eggs of birds and reptiles are surrounded by a porous shell that permits the air to enter and leave the egg.
23. In the earliest stages of development (of the land egg) the oxygen of the air diffuses directly into the cells and the carbon dioxide diffuses out, but eventually a respiratory organ develops that serves to receive oxygen for the embryo from the atmosphere and to remove the carbon dioxide.
24. This (respiratory)structure (in the land egg) consists of a sac-like membrane that grows out of the embryo and comes to lie just beneath the porous shell. Blood vessels of the embryo carry blood to and away from it. While the blood flows through the membrane, oxygen diffuses into it from the air and carbon dioxide diffuses out.

25. The saclike membrane (under the shell of the land egg) is also a receptacle for the disposition of other waste products.
26. When the young bird or reptile hatches, the membrane (beneath the shell) is separated and discarded.
27. In mammals, among which the young develop within the body of the mother, the saclike membrane starts to develop, but it never becomes functional.
28. In mammals the placenta serves as the respiratory organ for the embryo.
29. In mammals, the mother's blood, which flows into the placenta, carriesoxygen as well as food and this oxygen diffuses into the embryo's blood stream. Carbon dioxide diffuses into the placenta in the opposite direction.
30. All developing embryos produce waste materials other than carbon dioxide and these must be removed from the body.
31. In aquatic animals waste diffuses out of the embryo into the surrounding water.
32. In birds and reptiles the saclike membrane (just beneath the shell) serves as a receptacle for such (metabolic) wastes.
33. In mammals the placenta serves to permit wastes in the embryo's blood stream to pass into the mother's blood stream.
34. The kidneys of the mother excrete (the metabolic wastes from the embryo's body).
35. All animal embryos, from the simplest forms to the most complex, must develop in water to prevent dessication and to insure that pressures will be equal from all sides.
36. Normal symmetrical development would be impossible unless the pressure of the environment were equally distributed over the surface of the embryo.
37. The buoyant action of water plus its fluidity makes it an ideal medium for maintaining equal pressures.
38. Land animals do not develop in ponds and streams, but they too develop surrounded by water.
39. Early in development in all land animals including reptiles, birds and mammals, a saclike membrane grows out and surrounds the embryo. This sac is called the amnion.
40. The amnion fulls with water and immersed in this water is the embryo.
41. It is the "bag of waters" that burst prior to the birth of the human child.
42. The outer covering of the zygotes varies in different animal forms.
43. Many fish have no covering of any sort over their fertilized eggs.
44. Frogs, toads and other amphibians secrete a jelly-like substance that swells in contact with water and serves as a protective layer for the early stages of development.
45. Reptile eggs are covered with a leathery shell.
46. Bird's eggs have a hard, brittle shell.
47. Mammals do not have a protective cover immediately surrounding the zygote, but the embryo develops within the body of the mother, which serves ably as a protective cover.

48. The first step in the development of a human embryo is fertilization.
49. The sperm unites with the egg in the upper third of the oviduct.
50. The fertilized egg is called the zygote.
51. After fertilization, the zygote continues to move down the oviduct to the uterus.
52. During its passage down the duct it (the zygote) goes through a process of cell division.
53. The first division of the zygote results in the formation of two cells of equal size. These divide in turn to produce four cells.
54. By the time the embryo has reached the uterus repeated cell divisions have resulted in the formation of a ball of cells, all approximately equal in size.
55. A cavity appears in the center of the ball of cells, which is now called a blastula.
56. The blastula differentiates at this time into an inner cell mass and an outer layer of cells.
57. The outer layer of cells forms a hollow sphere within which the inner cell mass is suspended.
58. The inner cell mass eventually gives rise to the body of the human embryo and the outer cell layer develops into membranes surrounding the embryonic body.
59. Soon after entering the uterus the embryo attaches itself to the wall of the uterus.
60. The point of attachment (of the embryo to the uterus) varies, but usually it occurs high on either the front or back wall.
61. This (attachment of the embryo) happens on the ninth or tenth day after fertilization.
62. It is suspected that the embryo secretes an enzyme that digest the uterine tissue, for the wall of the uterus disintegrates beneath the embryo.
63. The embryo promptly sinks into the depression so formed.
64. It takes about one day for the embryo to penetrate completely into the wall of the uterus.
65. A clot fills the depression above the embryo, which is now effectively sealed in.
66. Disintegration of the uterus continues (until) the embryo becomes surrounded with digested uterine tissue, which is absorbed and used to nourish the growing embryo.
67. Up until the time the embryo penetrates the uterine lining, it remains the same size as the original zygote.
68. This (failure of the embryo to increase in size) is due to the limited amount of food the original egg contained.
69. Upon entering the uterine wall (the embryo) begins to grow, obtaining its nourishment from the dissolved uterine lining.
70. As it (the embryo) grows, it continues to destroy the tissue around it and expands into the space thus provided.
71. Gastrulation involves the differentiation of the inner cell mass into endoderm and ectoderm.
72. The endoderm is formed when the outer layer of cells separates from the rest of the inner cell mass.

73. The ectoderm differentiates at the same time (as the endoderm) and is made up of the cells remaining after the endoderm has split off.
74. The endoderm forms a hollow sphere that remains attached to the inner cell mass along the surface from which it separates.
75. This endodermal sphere is called the yolk sac.
76. The ectodermal cells of the inner cell mass hollow out so that two hollow balls of cells lie adjacent to each other.
77. The area where the ectoderm lies next to the endoderm is known as the embryonic disc.
78. The embryonic disc is a circular disc-shaped structure composed of the two layers, ectoderm and endoderm.
79. The human embryo and eventually the human infant develops from the embryonic disc.
80. The ectoderm that extends outward and upward from the embryonic disc arches over it (embryonic disc) to form a dome-shaped roof.
81. The ectoderm forming the roof over the embryonic disc is the amnion.
82. The cavity within the amnion is the amniotic cavity.
83. A third layer of cells, the mesoderm, develops within the embryonic disc between the ectoderm and the endoderm.
84. The mesoderm spreads out, covering the ectoderm of the amnion and the endoderm of the yolk sac.
85. The placenta functions as an organ of exchange between the mother's blood stream and that of the embryo.
86. Food and oxygen pass from the mother's blood into the blood of the embryo, while waste move in the opposite direction.
87. The placenta is composed of two parts, embryonic and maternal.
88. As the outer cell layer (of the placenta) enlarges, finger-like projections, known as villi grow out from its outer surface into the uterine spaces formed by the disintegration of the tissue of the uterus.
89. Blood vessels that form in the embryo grow down into the villi. Through them the blood of the embryo flows into the villi and then back into the embryo.
90. The villi occupy spaces in the uterine wall into which the mother's blood vessels empty, and it is here that the exchange of food, oxygen and wastes occur. Other blood vessels drain the spaces. Thus, maternal blood is carried to the uterine spaces and away.
91. That part of the uterus that contains the blood spaces in which the villi lie is the maternal part of the placenta.
92. It will be remembered that early in development the blastula is a hollow sphere of cells. The inner cell mass is attached at one point and hangs into the cavity of the blastula.
93. A layer of cells, the endoderm, separates from the free surface of the inner cell mass and forms a hollow sphere called the yolk sac.
94. The ectoderm, or remainder of the inner cell mass hollows out to become the amnion.
95. The point where the two spheres (yolk sac and amnion) come together is the embryonic disc.

96. (Thus), the embryonic disc is composed of two layers of cells, the ectoderm and endoderm.
97. (The embryo develops from the embryonic disc) and the remainder of the tissues, including the amnion, yolk sac, and outer cell layers, become the membranes that function in aiding development.
98. The membranes that function in aiding development are discarded at birth.
99. During early development the embryonic disc raises upward relative to the amnion so that a circular groove appears around its edge. Actually the groove is caused by the downward growth of the amnion along the edge where it attaches to the embryonic disc. It (the amnion) grows downward and folds under.
100. As it (the amnion) continues folding under, the peripheral groove deepens and cuts under the edge of the embryonic disc. This infolding constricts the endoderm into two parts.
101. The upper part contained within the ectoderm of the embryonic disc is the gut, the forerunner of the digestive tract.
102. The lower part (of the endoderm) remains the yolk sac.
103. An outfolding of endoderm occurs in the floor of the embryonic gut just behind its attachment to the yolk sac. This saclike outfolding grows into a mass of tissue, the body stalk, which actually bedomes the umbilical cord.
104. The amnion enlarges as it grows. As the edges of the amnion fold under the embryonic disc, they form a tube that extends away from the lower surface of the embryonic disc. This tube is called the umbilical cord.
105. The umbilical cord contains the yolk sac and blood vessels.
106. The umbilical cord connects the developing embryo body to the villi, which develop into the placenta.
107. (Thus), all food, oxygen, and wastes that enter and leave the embryo do so through the umbilical cord.
108. All of the tissues, organs and systems that develop in the embryo and make up the adult body come from the three embryonic layers, the ectoderm, endoderm, and mesoderm.
109. The ectoderm develops into the nervous system and the outer layer of skin.
110. From the endoderm is developed the lining of the digestive tract and its glands, the liver and the pancreas.
111. The lungs also develop from the endoderm as an outfolding from the gut.
112. The mesoderm develpps into the muscles, bones, connective tissue, blood vessels, and other organs that make up the bulk of the body and lie between the outer layer of skin and the inner lining of the digestive tract.
113. After four weeks of development the embryo is only a little over one-eighth inch long.
114. After four weeks of development the embryo possesses some fish-like characteristics. It has gill slits and a tail.
115. The arms and legs begin to form as small buds on the sides.
116. At six weeks it (the embryo) is a half-inch in length, the arms and legs have grown and the head is quite large in relation to the rest of the body. The parts of the head are becoming differentiated. The gill slits and tail are still present.

117. By eight weeks the human form is attained though the length is only about one inch.
118. From this time (attainment of human form) on it (the embryo)is known as a fetus.
119. Furthur development (of the fetus) consists of growth and completion of the development of the parts already formed.
120. The heart starts beating at five or six weeks.
121. Birth occurs about nine months after conception.
122. During pregnancy the growth of the fetus is accomplished by an enlargement of the uterus.
123. (The uterus) becomes approximately fifty times larger (during pregnancy) than the original size.
124. By the ninth month the uterus extends to the lower end of the sternum.
125. The other organs within the abdominal cavity are compressed and displaced as a result of the growth of the uterus.
126. The fetus assumes a characteristic position within the amniotic cavity in which the elbows, knees and hips are flexed, the feet and arms are crossed, the back bent and the head rests on the chest and is turned to one side.
127. At birth the most common position is head downward, although the reverse position may be assumen with the buttocks near the vaginal opening.
128. The fetus also may lie crosswise.
129. When the fetus is crosswise or with the buttocks nearest the vaginal opening birth is more difficult.
130. Childbirth occurs approximately 280 days after the last menstrual period, or at the time of the tenth missed mensis.
131. Labor consists of a series of contractions of the involuntary muscles of the uterus.
132. The contractions of the involuntary muscles of the uterus cause the "pains" of child birth.
133. Contractions of the abdominal muscles assist in forcing the fetal membranes, containing the liquid and the child, against the dilating cervix.
134. The fetal membranes or "bag of waters" burst and the child is extruded.
135. Furthur uterine contractions after the birth of the child expel the placenta and fetal membranes.
136. (After birth) the umbilical cord is severed close to the childs abdomen.
137. Severing the umbilical cord separates the child from the placenta.
138. The stump of the cord becomes the naval.

UNIT 2 - Heredity

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 7, UNIT 1

1. To understand the mechanism of heredity.
2. To recognize the social and economic significance of the science of genetics.

PRINCIPLE I

Chromosome behavior and distribution during the maturation of the germ cells determines the number of different kinds of germ cells an organism can produce.

1. Heredity is the transmission of traits from parent to offspring.
2. In both sexual and asexual reproduction cells separate from the parent or parents to develop into the next generation.
3. The cells that separate from the parents and develop into the next generation represent the only protoplasmic link between parents and offspring.
4. It follows that whatever passes from parents to offspring to cause the development of parental traits in the offspring must be contained in the germ cells.
5. The controlling substance that passes from parents to offspring is the chromatin.

6. Chromatin contains chemicals known as genes which govern the development of the individual.
7. In asexual reproduction, such as mitotic minary fission, the single cell divides into two daughter cells. Before dividion takes place the chromatin is scattered in a granular form throughout the nucleus.
8. When division (binary fission) begins the chromatin arranges itself so that a number of threads are formed within the nucleus.
9. The particular number (of threads) that form is constant for any species of organism, but varies among different species.
10. Each thread duplicates itself to become a double strand of chromatin.
11. The genes are arranged in linear order on the chromatin thread, like beads on a string, therefore the duplication of the chromatin thread also duplicates the genes.
12. The double threads then shorten and thicken until short, double rods are formed.
13. These short rods are called chromosomes.
14. While the chromosomes are forming, the nuclear membrane disappears and a spindle forms in the center of the cell.
15. The double chromosomes line up with their long axes parallel to the equator of the spindle, so that one chromosome is on one side of the equator toward one pole and the other chromosome on the side of the equator toward the other pole.
16. The double chromosomes separate, one going to each poke of the spindle.
17. The cytoplasm constricts in the middle of the cell between the two groups of chromosomes, with the result that two cells are formed.
18. Both daughter cells have the same number and the same kind of chromosomes and the same kind of genes.
19. Since genes control the development of traits in offspring, it is apparant that in this kind of reproduction where the offspring get exactly the same kinds of genes as were present in the parents, the offspring become exactly like the parents.
20. In sexual reproduction genes from two parents are combined during fertilization to produce the new individual.
21. Thus, in sexual reproduction, the offspring inherit some of their traits from the father and some from the mother.
22. In order to understand how the offspring inherit some traits from the father and some form the mother one must follow the history of the genes during development of the germ cells within the parent.
23. The germ cells or gametes are produced in the testis of the male and in the ovaries of the female.
24. The development of these cells (gametes) is fundamentally the same in both sexes (male and female) so far as its effect on heredity is concerned.
25. The part of maturation that is particularly significant in heredity is reduction division.
26. The cells in the gonad (either ovary or testes) undergo a division during their development into mature germ cells that is similar to but not exactly like mitosis.

27. Thus (in reduction division) the chromatin granules form threads, which shorten and thicken into chromosomes as in mitosis, but in this case the threads do not duplicate.
28. (Instead of duplicating themselves as in mitosis) the threads (chromosomes) pair.
29. In a human cell prior to pairing there are forty-eight chromosomes, after pairing there are twenty-four pairs.
30. (In reduction division in humans) the twenty-four pairs of chromosomes line up on the equator of the spindle, the paired chromosomes separate, and each member of a pair goes to the opposite pole of the spindle.
31. Following separation of the paired chromosomes the cytoplasm constricts as in mitosis and two cells are formed.
32. Each of the new cells (resulting from reduction division) which contains one chromosome of each former pair, becomes a germ cell, either an egg or a sperm, depending on whether it is produced by the male or the female.
33. The primary result of the reduction division is to separate the paired chromosomes.
34. The paired chromosomes are homologus or alike; that is, they have genes for the same traits.
35. If we use the letters A, B, C and D to designate chromosomes an animal having eight chromosomes in a germ cell before maturation will have two A's, two B's, and so forth because each (kind of)chromosome has another like it. During reduction division the chromosomes will pair as follows AA, BB, CC, DD. When cell division (reduction division) occurs, two cells will be formed, each of which will contain A, B, C, D. This represents the chromosome content of a germ cell. The same kind of reduction occurs in the production of gametes by the other sex, so its germ cells also contain A, B, C, D. When fertilization occurs, the chromosomes of the two kinds of germ cells are united and the zygote contains AA, BB, CC, DD. This is the same number as in each of the parents, but half came from one parent and half from the other.
36. The illustration of the inheritance of a single pair of characters (a monohybrid cross) as given in the syllabus, pages 106-107.
37. The illustration of the inheritance of two pairs of characters (a dihybrid cross) as given in the syllabus, pages 107-108.

PRINCIPLE II

Genes determine the potentialities of organisms. The environment determines the extent to which these potentialities can be realized.

1. If a red snapdragon is crossed with a white snapdragon, the offspring are pink because neither gene of the pair determining color is dominant.

2. (In snapdragons individuals) heterozygous (for color) always show an intermediate condition between the parents when one pair of genes only is concerned.
3. (A type of inheritance similar to color in snapdragons) is illustrated in crosses between Negro and white races involving skin color.
4. There are genes for black skin and genes for white skin and none are dominant.
5. The F_1's of a black and white cross are all mulattoes of the same intermediate shade.
6. The F_2's of a black and white cross show a gradation of color from pure black to pure white.
7. There are two kinds of chromosomes in every cell of sexually reproducing organisms. They are the sex chromosomes called the X and Y chromosomes, and the autosomes.
8. The sex chromosomes control development of sex traits, while the autosomes control the development of other body (somatic) traits.
9. The X chromosomes contain most of the female determining genes.
10. The Y chromosomes contain few or no sex-determining genes.
11. The autosomes contain male-determining genes as well as the great majority of genes aggecting somatic characters.
12. Females have two X chromosomes plus autosomes.
13. Males have one X and one Y chromosome plus autosomes.
14. During development the presence of two X chromosomes in the zygote results in the development of a female because the genes for the development of the female sex are present in greater strength than the genes for development of the male sex in the autosomes.
15. If a zygote contains XY chromosomes the male genes in the autosomes control development and a male results.
16. The Y chromosome has no effect; rather it is the development of the extra X that makes possible the development of the male sex.
17. Occasionally an individual will appear among offspring that differs from any that have been produced before.
18. Sometimes the appearance of an offspring that differs from any that have been produced before is the result of the recombination of recessive genes and sometimes it is due to environmental causes producing a change in the chromosomes or genes.
19. Chromosomal or gene changes that result in the appearance of a new trait are called mutations.
20. Gene mutations are those in which a single gene is involved.
21. Chromosome changes include large sections of chromosomes and involve many genes.
22. An example of chromosome changes is deletion, where a piece of chromosome becomes lost.
23. The principles of heredity apply to man as well as to other organisms.

24. The study of human heredity is particularly difficult for several reasons. First, there are usually only three or four generations of humans produced within the lifetime of one investigator. Second, the number of human offspring is very small compared with the number of offspring produced by plants and animals. Third, individual and social resistance act as barriers which limit experimentation with human mating.
25. Despite the difficulties, much progress has been make (in human heredity) and a long list of inherited traits is known.
26. Some of this information (about human heredity) has been obtained through the study of family histories, which are interpreted on the basis of the laws of heredity originally discovered in other organisms.
27. Another method (of obtaining knowledge of human heredity) is through the use of statistical analysis.
28. This method (of statistical analysis in the study of human heredity) involves observations of the frequency with which a certain trait appears in a given population(the gene frequency)
29. Geneticist have established certain mathematical formulae by means of which these data (gene frequencies) can be interpreted to indicate the mode of inheritance for a particular trait. This hypothetical mode of inheritance is then furthur investigated by studies of the trait in closely related individuals.
30. (In previous discussions), it has been stated that the presence of certain genes is responsible for the development of certain traits in an individual.
31. The actual relationship between a gene and the trait which it determines, however, has been a matter of conjecture.
32. It has recently been shown by various workers in genetics that it is possible for a single gene to control a single biochemical reaction and that this control is probably due to a control of the production of enzymes.
33. (In other words) each gene may produce an enzyme or it may produce a substance which in turn produces an enzyme.
34. (These) enzymes regulate the thousands of chemical reactions which take place in an organism and it is conceivable that a change or cessation of one or more of these chemical reactions would result in variations in the appearance or behavior of an individual.
35. Albinism is an example of a characteristic in man which is a result of the failure of a certain chemical reaction to take place.
36. One of the amino acids is oxidized to form a substance called dopa. In normal man and women dopa is converted to a pigment called melanin which colors the eyes, skin, and hair. This change from dopa to melanin is attributed to a dominant gene.
37. The recessive gene evidently is unable to complete this chemical reaction (dopa to melanin) and, consequently, an individual who has two of these recessive genes will be an albino.
38. This person (an albino) will have very light skin, white hair, and pink eyes, because of an almost total lack of pigment in these structures.

39. The color of the eyes is due to granules of pigment deposited through the back part of the iris.
40. Blue color is due to granules which reflect blue light. Brown eye color is caused by the presence of brown pigment in front of the granules responsible for blue eye color.
41. Other eye colors (besides blue and brown), such as gray or green, are due to the varying amounts of brown pigment laid down on the granules reflecting the blue light.
42. In the case of individuals where no pigment is present, the eyes appear pink because of the reflection of the color of the blood in the blood vessels of the eye.
43. The exact mode of inheritance of eye color is not known, though it is thought that several genes are involved.
44. Brown is generally considered dominant over blue.
45. It should be appreciated that genes which determine the absence or presence of a certain characteristic are often influenced by genes which determine other characteristics.
46. Here is a situation (above) where the genes for albinism inhibit the potential development of eye color despite the fact that genes for eye color are present.
47. This example (of the inhibiting effect of albino genes) may give you an insight into the complexities of the interrelationships existing between the actions of the genes.
48. It is because of the complex interrelationships among genes that many of the things we would like to know about human inheritance have not been found out.
49. Skin color is determined by the pigment in the skin.
50. There is much pigment in the skin of Negroes and little in the skin of whites.
51. In the Negro white crosses the offspring are mulatto and intermediate in color.
52. When two mulattoes are crossed, the offspring are various degrees of pigmentation.
53. It is thought by some geneticist that many pairs of genes are responsible for the inheritance of skin color.
54. One explanation (for the inheritance of skin color) is that two pairs of genes are involved.
55. A black skin results from the genotype AABB and a white skin from the genetype aabb. A mulatto would have the genotype AaBb.
56. The skin of an individual having a genotype Aabb would be intermediate between mulatto and white and similarly a genotype or AABb would result in a skin color intermediate between mulatto and black.
57. If this hypothesis (for the inheritance of skin color) is accepted, it can also be inferred that the genes are passed from parent to offspring as they are in an ordinary dihybrid cross where there is a lack of dominance in both pairs of genes.
58. There are small color differences within the white race which may be caused by the influence of only a single pair of genes. The darker pigmentation apparently is dominant over the lighter.

59. Some baldness may result from disease, but much of it is a hereditary characteristic.
60. Apparently onepair of genes can express itself differently depending on the sex. In males the gene is dominant, while in females it is recessive.
61. This type of inheritance (as in baldness) is known as sex-limited or sex-influenced inheritance and explains why more men than women are bald.
62. In red-green color blindness the person cannot distinguish between red and green colors.
63. This abnormality (red-green color blindness) is inherited as a sex-linked recessive.
64. A sex-linked character is one in which the genes are on the X chromosomes.
65. The gene for color blindness is recessive to the normal gene; therefore two genes for color blindness- one on each X chromosome- must be present in the female to cause color blindness.
66. If only one gene is present (for color blindness) in the female, she is not color blind, but is a carrier, and can pass the gene on to one-half of her offspring.
67. The male , on the other hand, with one X and one Y chromosome, will be color blind if the defective gene is located on the X-chromosome.
68. The Y chromosome (of the male) carries no genes for this trait (color blindness).
69. Since only one gene is necessary to cause color blindness in males, more males are colorblind than females.
70. If a colorblind man marries a normal woman, all his sons and daughters will be normal, but one-half of his daughters will be carriers.
71. These (carrier daughters) may pass the gene to one-half of their sons, who will be color blind.
72. A color blind man will transmit this trait (colorblindness) to some of his grandsons through his daughters.
73. Total color blindness is also hereditary, as is the inability to distinguish between various pastel shades of color.
74. The mode of inheritance of these types of color blindness (total and pastel) has not been definitely established.
75. Surveys show that approximately 7 per cent of the white population is left handed.
76. Studies of closely related individuals indicate that there is a correlation between the handedness of parents and their offspring.
77. When both parents are right-handed, about 6 per cent of the children are left-handed.
78. When one parent is right-handed and the other left-handed about 16 per cent of the children are left handed.
79. When both parents are left-handed, about 50 per cent of the children are left-handed.
80. Since two right-handed parents may have left-handed children and two left-handed parents may have right-handed children, one hypothesis is that handedness is due to a single pair of genes with lack of dominance.

81. According to this hypothesis (that handedness is due to a single pair of genes with lack of complete dominance) those individuals who are homozygous for right-handedness will be right handed, those homozygous for left handedness will be left handed. Heterozygous individuals, however, may be ambidextrous, right or left-handed, depending upon environmental influences, which of course, are toward right-handedness
82. Handedness among homozygous individuals may occasionally be changed by environment, but such a change, according to some psychologist, may result in nervous disorders such as stuttering.
83. There are at least three blood groups in men, the ABO group, the MN group and the Rh group.
84. All three blood groups (ABO, MN and Rh) are inherited independently of each other.
85. One explanation of the inheritance of the A, B, O blood group is that three genes are involved.
86. Gene A causes the development of antigen A in the red blood corpuscle; gene B causes the antigen B to develop; gene O causes the development of no antigen.
87. These three genes (responsible for the ABO blood groups) are present in the population in general, but any one individual has at most only two ot the three.
88. Neither gene A nor gene B is dominant to the other but both are dominant to gene O.
89. It has been discovered that the A and B antigens are present not only in the red blood cells, but also in every cell of the body.
90. Experimental work in the field of plastic surgery indicates that better results are obtained in the grafting of tissues from one individual to another when these individuals are of the same ABO type. This may be due to the same principles involved in blood transfusions.
91. The A and B antigens are soluable in the body fluids.
92. The degree of solubility (of A and B antigens in the body fluids), however, varies with different individuals. In about 70 per cent of the population the presence of these antigens can be detected in the saliva.
93. (The individuals in which the antigens can be detected in the saliva) are known as secretors, the remainder non-secretors
94. The condition whereby antigens may be detected in the saliva is inherited as a simple dominant trait.
95. Under certain circumstances criminal investigators are able to determine the ABO type of secretors by analysis of saliva on recently discarded cigarette stubs.
96. In the inheritance of the MN group one gene (M) causes the development of the M antigen while another gene (N) causes the production of the N antigen.
97. Neither of the genes (for M and N antigen)is dominant.
98. The MN antigens are not known to produce any harmful effects as a result of blood transfusions regardless of the MN type of the donor or recipient.
99. A knowledge of the mode of inheritance of the ABO and MN blood groups is applied quite often in cases of disputed paternity.

100. Another of the inherited blood groups is the Rh complex.
101. One explanation of the inheritance of the Rh factor is the presence of three pairs of genes on a single pair of chromosomes.
102. The six genes (involved in the inheritance of Rh) when combined in all possible arrangements produce eight different Rh blood types.
103. Although these eight (Rh) types are due to different genotypes, seven of them are collectively known as Rh+, the eighth type, as Rh-.
104. For the sake of simplicity, however, Rh positive is said to be inherited as a dominant trait and Rh negative as a recessive trait.
105. According to this simplified explanation, an Rh+ individual would have a genotype or RR or Rr and an Rh- individual would have a genotype of rr.
106. About 85 per cent of the white population is Rh+ and 15 per cent is Rh-.
107. Knowledge of the inheritance of the Rh group is important because a mating between an Rh+ father and an Rh- mother will produce in at least one-half of the cases, offspring that are Rh+.
108. The presence of an Rh+ child within the body of an Rh- mother sometimes leads to tragic results.
109. If the Rh+ blood cells of the child diffuse into the blood stream of the mother, they cause in the mother's blood the production of antibodies.
110. If these antibodies (from the Rh- mother's blood stream) diffuse back into the infant's blood stream and come in contact with the infant's Rh antigen, the red blood cells of the infant may be destroyed and the child either dies or has severe anemia and jaundice at birth.
111. The first child born of such parents (Rh+ father and Rh- mother) usually escapes harm, but by the time the second or third child is developing there may be sufficient antibodies in the mother's blood to cause the symptoms described above (erythroblastosis) to occur in the infant if it happens to be Rh+.
112. This disease (Rh disease) known as erythroblastosis foetalis, has long been recognized, but the cause was not known before the discovery of the Rh antigens.
113. (As previously mentioned), the first child born to parents of this Rh combination (Rh+ father and Rh- mother) usually escapes harm and occasionally the second and third child may be unaffected.
114. There have also been cases in which no children (of Rh+ fathers and Rh- mothers) showed symptoms, however, surveys indicate that about one out of twenty-eight babies born to such parents show symptoms of this disease (Rh disease).
115. Of those (babies) showing these symptoms (of Rh disease) some recover without medical attention, others, more severely affected, may recover with medical treatment, and a few are stillborn or live for only a short time.

116. With increasing knowledge of the factors involved, physicians are constantly developing better techniques for the treatment of this disease (erythroblastosis).
117. The question whether mental ability is inherited has frequently been asked.
118. It is well recognized that the human population varies in intelligence from the idiot, who never reaches a mental age high enough to care for himself, to the genius, who presents the world with great accomplishments in literature, music, and science.
119. One thing is obvious, even if we assume that mental ability is inherited: environment has a definite role to play.
120. A potential genius, if completely isolated from society, would not develop his mental capacity to the point where it would be recognized as such.
121. (On the other hand), an individual who has a low mental capacity could never become a genius even if he were exposed to a society of the highest academic level.
122. For this reason (relationship between heredity and environment) it is almost impossible to attribute an individual's intelligence wholly to heredity or to environment; rather it is a product of both.
123. It is probable that heredity sets the limits of mental development, while environment acts within these limits.
124. Tests have been compiled by psychologist to measure intelligence.
125. These tests measure intelligence in terms of mental age.
126. By dividing the mental age of the individual by the chronological age and multiplying by 100, the I. Q., or intelligence quotient, is determined.

$$\text{I. Q.} = \frac{\text{Mental Age}}{\text{Chronological Age}} \times 100$$

127. The following arbitrary levels of intelligence have been established on the basis of intelligence quotients determined by these tests (intelligence tests)

I.Q.	Level
140 or over	genius
120-140	very superior
110-120	superior
90-110	normal
80-90	dullness
70-80	borderline
50-70	moron
25-50	imbecile
0-25	idiot

128. The persons considered mentally deficient or feeble-minded are classified as idiots, imbeciles, or morons.
129. Idiots are those individuals who have an I. Q. of 0 - 25.
130. The mental age (of idiots) is one to two years.
131. Idiots are absolutely helpless when it comes to feeding and caring for themselves.

132. One type (of idiot) is the microcephalic, or pinhead, in which the bones of the skull close very early in the life of the individual- earlier than in normally developing individuals.
133. This early closure of the skull(in microcephalic idiots) prevents the brain from growing and developing to normal size and mental capacity.
134. Another type of idiot is the cretin.
135. Cretinism is the result of insufficient thyroid hormone during early development.
136. One hypothesis as to the cause of idiocy is purely environmental, attributing the idiocy to faulty prenatal environment or birth injuries.
137. Another hypothesis as to the cause of idiocy points to heredity and requires the presence or absence of certain genes which, when expressed, produce the condition.
138. The third, and probably the least dogmatic hypothesis as to the cause of idiocy, includes both environment and heredity as contributing interacting factors.
139. An example of a type of feeble-mindedness which definitely is hereditary is phenylketonuria.
140. In normal individuals, phenylpyrivic acid, which is one of the products of metabolism, is oxidized by an enzyme.
141. In phenylpyruvic idiots, the enzyme (responsible for the oxidation of phenylpyruvic acid) is not present and phenylpyruvic acid is not oxidized and is excreted in the urine.
142. The excess of phenylpyruvic acid in the body damages the nervous system, thus causing idiocy.
143. Phenylketonuria is due to a recessive gene which results in the absence of the enzyme necessary for oxidation of phenylpyruvic acid.
144. Phenylketonuria is an example of a single gene's being responsible for the production of an enzyme, the presence or absence of which determines normality or feeble-mindedness.
145. Some feeble-mindedness, higher than idiocy, is also thought to be due to heredity.
146. Family histories indicate that this type of mental deficiency (feeble-mindedness higher than idiocy) occurs much more frequently in some families than in others.
147. The study of twins supports the hypothesis that heredity is the cause of certain kinds of mental slowness.
148. Studies of twins show that when one fraternal twin is feeble-minded, the other is feeble-minded in one-fourth of the cases; in identical twins, however, when one is feeble-minded, the other is feeble-minded in practically every case.
149. It is known that superior intelligence runs in families.
150. It is claimed by some that superior intelligence is due to an environment which encourages the development.
151. If environment is the sole cause(of superior intelligence) one would expect that all children reared in favorable surroundings would develpp into superior people. This, however, is not the case.

152. Dullards do appear in favorable environments, though not so frequently as in other families.
153. To the geneticist, the segregation of genes is the most reasonable explanation for the occasional appearance of dull children in bright families.
154. Studies made of children reared in orphanages where, presumable, the environment is fairly constant for all individuals, show that just as much variability exist among these orphans as in children raised in their own homes.
155. Another test (of the relationship of environment and heredity to intelligence) is the measurement and correlation of the intelligence of adopted children and their foster parents and comparison of the results with those derived from studies of true parents and their children.
156. It has been found that there is a closer correlation between true parent and true child than between foster parent and foster child.
157. Studies of identical twins show that they are more alike in intelligence than fraternal twins even when reared in different environments.
158. Insanity is a derangement of the normal mind.
159. A person of normal or superior intelligence may become insane.
160. There are some twenty types of insanity, several of which are considered hereditary.
161. Huntington's chorea is inherited as an autosomal dominant.
162. Because Huntington's chorea frequently appears late in adult life, its presence is frequently unsuspected until after the individual has married and reproduced.
163. Because Huntington's chorea does appear late in life after the normal reproductive period its control is difficult.
164. Huntington's chorea is a rare disease.
165. Hospital records show no more than 100 to 200 cases of Huntington's chorea per year in the United States.
166. The victims of Huntington's chorea exhibit irregular and spasmodic movements of the face and arms. Gradually other voluntary muscles are involved and the mental functions either slowly degenerate or the individual becomes violently insane.
167. There is no known cure for Huntington's chorea.
168. Schizophrenia (Dementia Praecox) is characterized by melancholia, emotionalism, and delusions of persecution.
169. Some geneticist claim that schizophrenia is hereditary and they use as a basis for their claim the fact that the frequency of the disease among relatives of affected persons is much greater than in the general population.
170. A study of twins shows that when one member of a pair of fraternal twins develops the disease, the other develops it in less than one-fourth of the cases (schizophrenia).
171. In identical twins when one member of a pair develops schizophrenia, both twins develop the disease in nearly every case.

172. The environmentalist say that there is greater frequency (of schizophrenia) among relatives of affected individuals because of common environment, common problems and common frustrations.
173. It seems reasonable to assume that mental defects are determined, in part, by heredity, since mental illnesses have their basis in the nervous system and the functioning of the endocrine glands.
174. Geneticist who have worked on the assumption that schizophrenia is inherited have postulated that it is transmitted as a recessive trait.
175. It is furthur postulated that individuals possessing genes for schizophrenia will not exhibit symptoms for it unless they are faced with certain types of problems and frustrations.
176. If individuals possessing the genes for schizophrenia should never be placed in an environment where certain types of problems and frustrations exist, it is believed they may not develop the disease.
177. Epileptics suffer convulsions with loss of consciousness.
178. Recent work indicates that epilepsy is due to a dominant gene with variable expressivity.
179. By means of the eledtroencephalograph (an instrument used to record the electrical pulsations of the brain) it has been found that all epileptics have an abnormal type of brain wave (cerebral disrhythmia) and that at least one of the parents will also exhibit this type of brain wave even though he may not be subject to the seizures.
180. It is assumed that the abnormal brain wave is the consistently expressed inherited condition (due to the genes responsible for epilepsy), and for some reason, possibly environmental influences, people displaying this abnormality may or may not exhibit epileptic convulsions.
181. Our knowledge of genetics has enabled us to improve the stocks of our domesticated animals and plants to a considerable extent.
182. There is little doubt from the standpoint of the common good of society that measures should be taken to control the spread of known hereditary defects throughout the population.
183. Biologist have long advocated the adopton of measures aimed at controling the spread of known hereditary defects throughout the population as part of an eugenics program.
184. Biologist have also pointed to the improvement of the human stock through selective breeding.
185. Whether the measures of negative or positive eugenics will be applied is dependent upon the attainment of a degree of social consciousness which,at present, seems Utopian.
186. Before any progress can be made toward the betterment of mankind through genetics, society must understand the facts placed at its disposal by scientist and must develop a willingness to use these fadts for the good of society.

187. Through a program of general education society can come to understand the facts placed at its disposal by science.

188. The development of a willingness on the part of society to use facts for its own good will have to wait upon an advance in our social evolution.

AREA 8 - INTERRELATIONSHIPS

UNIT 1 - The Organism and Its Environment

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 8, UNIT 1

1. To understand the nature of the environment of living things.
2. To understand that adjustment of organisms to an ever changing environment is essential if the organism or species is to survive.
3. To recognize that a knowledge of ecological principles increases one's understanding of human societies.

PRINCIPLE I

The animals and plants living in the same habitat constitute a community of interrelated and interdependent members. The plant life of the community is the primary determinant of the character of the community which because of its characteristics may be considered a superorganism.

1. No animal or plant lives a completely independent life.
2. All organisms are in constant interaction with their environment and continually respond to environmental factors in order to maintain themselves.

3. The responses of animals are often more immediate and noticeable than those of plants because of the higher degree of organization in animal forms.
4. The basic relation between organism and environment is the same for both plants and animals.
5. The environment of a given organism includes the sum total of the conditions or factors to which it is exposed.
6. The place or niche that an organism occupies in nature is called its habitat.
7. The term (habitat), however, includes only the physical factors in the environment of organisms and not the organisms themselves.
8. (In other words) the habitat is the physical framework that supports in one way or another the living organisms in a given community.
9. (For example) the habitat of an oyster population includes such physical factors as the type of botton, the chemical conditions of the sea water, the pressure, and light and temperature conditions prevailing in the area, but does not include the interactions between the oyster and its prey, parasites or predators.
10. Plants and animals are associated in natural units over the earth.
11. These (natural)units are called communities or, more specifically, biomes, and each contains many kinds of habitats.
12. To the biologist the biome is more than the sum of its parts.
13. In a certain sense the biome may be regarded as a kind of superorganism.
14. The biome concept is an operational concept in that it has proved useful in furthering our understanding of the interrelationships among living things.
15. The biome is not a static unit, but extremely dynamic.
16. The growth and development of the biome includes all of the changes bare or denuded areas pass through in arriving at a condition of relative stability called the climax stage.
17. The earth can be divided into eight biome types. These are (1) tundra and ice, (2) coniferous forest, (3) temperate forest, (4) grassland, (5) desert, (6) tropical forest, (7) temperate rain forest, (8) the ocean.
18. Each of the major natural units (biome types) produces characteristic vegetation.
19. The vegetation present (in a biome type or natural unit) is dependent upon climatic and other factors of the environment.
20. The animal life of the biome is dependent largely upon the plant life in the area.
21. Man, in turn, is dependent upon both plant and animal raw materials obtained from these natural life areas in order to live and build his industries and institutions.
22. The major vegetation areas on the earth's horizontal surface are also evident in the vertical plane, as on high mountains.
23. The habitat factors of climate and soil are important determinants of the distribution of plant and animal life.

24. The interaction of living organisms within the biome constitutes the biotic environment of the individual organism or the population.
25. All of the organisms living within the unit (biome) are striving to keep alive and reproduce their kind, the competition for food, shelter, space and mates results in a web of life exceedingly complex in its nature.

PRINCIPLE II

The feeding relationships between the organisms of the community constitute the center of activity within the community. Other basic pursuits by the organisms of the community are those involved in obtaining shelter and protection from the biotic and physical elements of the environment, mating, and caring for the young of the species.

1. One of the most important integrating factors in the biotic environment is the food chain.
2. The degree of interdependence of living organisms is evident in the food relationships of the community.
3. In a typical fresh-water pond the microscopic green plants or algae reproduce and grow in countless numbers.
4. The algae (in a fresh water pond) transform radiant energy into chemical energy of food by their photosynthetic activity and consequently serve as the basic source of food for the community.
5. Protozoans, microscopic crustaceans, and small insects feed upon the algae (in a fresh water pond), and these animals, in turn, are fed on by such larger animals as aquatic insects and small fish.
6. Large fish feed upon smaller fish and large insects (in a pond) and finally reptiles, birds, and mammals utilize the fish as food.
7. In a food chain such as that in a fresh-water pond, millions of algae are required to support thousands of microscopic animals, called key industry forms, which feed upon them.
8. The thousands of animals, which have transformed plant protoplasm into animal protoplasm, sustain hundreds of fish, which in turn support the relatively few fish-eating vertebrates.
9. A food pyramid is established for every food chain.
10. The food pyramid serves to present the quantitative aspect of the food web in a community.
11. Food pyramids are the result of two tendencies: (1) that smaller animals have a higher capacity to reproduce themselves than do the higher animals, (2) that the smaller animals usually are the prey for the larger animals.
12. Included as factors in the formation of food pyramids are such (factors) as the size of the food, the amount of food, the availability of food, and the capacity an animal has to utilize the food.
13. Organisms expend energy to obtain food and nourishment.

14. A very large animal occupying the apex of the (food) pyramid might be able to maintain itself on ameba protoplasm, but the amount of energy required to obtain sufficient numbers of ameba for this purpose would be altogether out of proportion to the energy yield of the food.
15. Because of the relationship between energy required to obtain food and the energy obtained from the food, animals usually feed upon the next size group in the food pyramid, thus obtaining the elements in the ameba protoplasm at third or fourth hand.
16. There are notable exceptions to this rule (that animals usually feed on the next size group in the food pyramid) such as the Whalebone whales and the Mississippi River paddlefish, which, despite their size feed on microscopic animal and plant life.
17. Man is the only organism which can feed on any size food.
18. Studies of fluctuations in animal populations, whether free living or parasitic, demonstrate that a change in one link of a given food chain will inevitably influence all the organisms involved in the chain.
19. It is well known that in Canada the arctic fox fluctuates with the lemmings, the numbers of red foxes fluctuate with mice and rabbits, the fisher varies with mice, rabbits and fish, and the lynx populations are correlated with the numbers of rabbits.
20. Any factor or set of factors which renders the environment unsuitable for the rodents will seriously influence the carnivores which prey upon them.
21. What is true for the free-living forms is true for the parasites they harbor. Food chains and parasitic life cycles are closely intertwined.

PRINCIPLE III

The world of nature is in a state of continual change. Organisms comprising a given community are continually altering the soil and water conditions of the habitat so that those organisms originally inhabiting the area must adapt themselves to the changes, migrate, or perish. Thus one community paves the way along the environmental path for another community in a dynamic progression called ecological succession.

1. The tendency to change is characteristic of life, whether at the cellular, individual organism, population or community level.
2. The changes which take place at the community level tend to put the plant life in better adjustment with the soil, water, light and biological conditions in the area.
3. Once the adjustment (between the plant life and other conditions in the area) is affected, a relatively stable condition known as the climax stage is reached.
4. The series of changes leading to the climax stage is called ecological succession.

5. The primary causes of ecological succession are (1) the reactions upon the habitat by the organisms living there, and (2) modifications of the habitat by such physical forces as silting, chemical changes in the soil caused by leaching of salts from the soil, drainage of swamps, fire, cultivation and many others.
6. (In all instances) the biological and physical forces at work cause a change in the plant life of the area, and changes in the plant life cause changes in the nature of the animal life. In this way the character of the community changes and one type of community paves the way along the environmental path for each succeeding community until the relatively stable climax community is reached.
7. A typical example of the interaction (leading to the climax community) is the transition of a given area from barren rock to the climax vegetation of the area.
8. The first organisms to invade a barren rock substrate are terrestrial algae, bacteria, lichens and mosses.
9. Through the continued action of climatic forces together with the biological action of terrestrial algae, bacteria, lichens and mosses, soil is formed from barren rock substrate.
10. When soil is formed in an area the environment is prepared for an invasion by various herbs and weeds.
11. Herbs and weeds are characterized by possessing light seeds which can very easily be transported by the wind.
12. Eventually, when sufficiently deep soil has been formed, shrubs and trees may invade the area, leading to dominant forms of vegetation which make it difficult for new species to gain a foothold.
13. Frequently the climax type of vegetation for a given area is not reached because it is arrested at some stage in the succession by such human activities as repeated burning or the constant use of an area for grazing purposes.
14. Arrested development (toward the climax stage) is temporary, however, for once the human influence is withdrawn, the natural process of change continues toward the climax type of vegetation.
15. Ecological succession may also have its beginning in a lake, pond or stream instead of barren rock.
16. When ecological succession begins in a lake, pond or stream the invasion of shore plants and the gradual deposition of silt reduce the area of open water and eventually a bog or swamp results.
17. The drying up of a bog or swamp and subsequent changes in the soil conditions create an environment suitable for land plants.
18. Over a period of time (beginning with a lake, pond or stream) a climax community with its characteristic animal life will develop.

19. Succession also occurs within a community.
20. An example of succession within a community is the succession in a culture jar of protozoa.
21. In a new culture of protozoa the clear culture medium becomes cloudy because of the rapid accumulation of bacteria. Changing environmental conditions in the culture jar then permit the development of various types of protozoa, eventually leading to a culture of the bell-shaped, stalked protozoa called Vorticella.
22. In the type of succession occuring within a culture of protozoa, the accumulation of metabolic wastes together with the exhaustion of food are important determining factors.
23. A knowledge of the natural trends in ecological succession is of importance to man in his efforts to conserve soil, improve grazing conditions for his cattle, increase the productivity of his forest lands, and conserve his wildlife.
24. Human efforts to conserve the irreplaceable natural resources without consideration of the natural trends in ecological succession are doomed to failure.

PRINCIPLE IV

The carbon cycle and the more complicated nitrogen cycle exemplify the complexity of the interrelationships among living things and their physical environment. In each instance there is a cyclic chain of events from the inorganic to the organic and back to the inorganic elements of the environment.

1. The physical environment of animals and plants consists of three media - soil, atmosphere and water.
2. Operating within these media (soil, atmosphere, water) are the physical factors of light, heat, pressure, gravity and chemical concentrations.
3. Soil is essential to life because it is the source of the chemical elements and compounds necessary for the formation and maintenance of protoplasm.
4. Living matter contains a minimum of ten essential elements.
5. The essential elements (in protoplasm) are carbon, hydrogen, oxygen, phosphorus, potassium, iodine, nitrogen, sulfur, calcium, iron and magnesium.
6. The essential elements can be remembered easily by using the memory device "C. Hopkins Cafe, mighty good".
7. Sodium and chlorine are essential to animal nutrition although not indispensible to plants.
8. Soil is a mixture of fragmented rocks and minerals, organic matter, water and air in varying proportions.
9. Soil develops under the influence of climate and living organisms.
10. The original rock of the earth is broken up in weathering by the action of the wind, rain, heat and freezing.

11. The extent of weathering in any area depends upon the climate.
12. Dead organisms contribute the organic matter of their bodies when they decompose.
13. Living organisms also contribute organic matter (to the soil) in the form of waste products.
14. Some living organisms, such as earthworms with live in the soil, improve it by burrowing through it, feeding on it, and mixing the organic matter and minerals.
15. Tons of soil per acre are moved and enriched each year by earthworms.
16. The production of good soil requires long periods of time. It is estimated that 300 to 1000 years are required to produce one inch of productive soil by natural processes.
17. Because it requires such long periods of time to produce soil the importance of soil conservation becomes obvious.
18. The chemical, physical, and biological factors operating within the soil exert their primary effects on the root systems of plants.
19. The texture of soil, its temperature, and its water, air and mineral content must be optimum if plants are to attain their maximum growth and vigor.
20. The oxygen content of air in the soil is especially significant because of its influence on the respiratory activity of plant roots.
21. Water-logged soil will eventurlly cause the death of plants because water fills the air spaces in the soil, thus depriving the plant of its oxygen supply.
22. Deficiencies in concentration of certain mineral salts in the soil reduce the vigor of plants.
23. The lack or insufficient abundance of any one of them (certain mineral substances) can limit the growth and development of the plant.
24. A biological principle based upon (one phase) of the relationship of organisms to environmental factors is called the "Law of the Minimum". It states that the factor present in minimum concentration in the envoronment of an organism may limit the growth and distribution of that organism.
25. An example of the "Law of the Minimum" is that there may be a superabundance of water and optimum conditions of light and dissolved mineral salts, but the photosynthetic activity of any given plant may fall below the energy requirements of the plant if the concentration of carbon dioxide is too low. Should this persist over a period of time the plant will die.
26. The atmosphere is (one of) the basic media in which organisms live and from which they obtain their requirements.
27. The atmosphere is a gaseous envelop that surrounds the earth.
28. The atmosphere consist mainly of nitrogen, oxygen and carbon dioxide.
29. Nitrogen makes up 79 percent of the atmosphere by volume and is an essential element in living organisms.
30. The amino acids cannot be synthesized without nitrogen.
31. Proteins cannot be make without amino acids.

32. Because amino acids cannot be synthesized without nitrogen and proteins cannot be made without amino acids, the life of all organisms is dependent on the nitrogen of the atmosphere.
33. Despite the abundance of nitrogen in the air, green plants which manufacture the amino acids cannot obtain the nitrogen directly from this overhead supply.
34. Green plants must get nitrogen from the nitrogen compounds in the soil in the form of soluble salts and ammonia.
35. Nitrogen is constantly being lost from the soil to the atmosphere and is being constantly returned from the atmosphere to the soil.
36. The interchange of nitrogen between the atmosphere and the soil is cyclic in nature.
37. The cyclic interchange of nitrogen between the atmosphere and the soil is one of the most fendamental interrelationships between living matter and the inanimate environment.
38. Certain bacteria known as nitrogen-fixing bacteria can utilize atmospheric nitrogen to manufacture nitrates (NO_3).
39. Nitrogen-fixing bacteria may be living either in the nodules of the roots of leguminous plants, such as peas, clover, alfalfa and beans, or as free organisms in the soil.
40. The nitrates produced by nitrogen-fixing bacteria are used by plants in the synthesis of amino acids and plant proteins.
41. Animals eat (the) plants or saprophytic plants attack them and digest the proteins to amino acids, which are then resynthesized into the proteins of the devouring organisms.
42. In animals some proteins are used to produce carbohydrates, with the result that nitrogen is released and excreted as urea.
43. Urea and eventually the dead animal body are decomposed by putrefactive bacteria which change the nitrogen compounds to ammonia (NH_3).
44. Ammonia is returned to the soil (through the action of putrefactive bacteria) and is acted upon by a group of bacteria which change ammonia into nitrites (NO_2).
45. A third group of bacteria, the nitrate bacteria, change the nitrites into nitrates (NO_3).
46. Basically there are four processes involved in the nitrogen cycle: (1) the process of decomposition involving the organisms of decay, (2) the process of nitrification in which ammonium compounds are changed into nitrite and nitrate compounds, (3) the process of denitrification in which certain kinds of bacteria operating under certain soil conditions change nitrogen compounds of the soil into free atmospheric nitrogen, and (4) the nitrogen-fixing process involving the nitrogen-fixing bacteria which either live in a symbiotic relationship with leguminous plants or are free-living and convert atmospheric nitrogen into the usable nitrate form.
47. The element corbon is also constantly being withdrawn from the environment to become a part of the organic makeup of living things.

48. The source of the carbon used by living things is the carbon dioxide of the atmosphere and water.
49. The atmospheric supply of carobn dioxide is replenished through the respiratory activities of animals and plants, especially bacteria; through the combustion of animal and plant residues such as wood, coal, petroleum, gas and the dead remains of organisms; and through volcanic eruption which bring into the atmosphere carbon dioxide trapped in the earth's crust in the geologic past.
50. Carbon dioxide diffuses into green plants and is used in the manufacture of simple sugars.
51. The simple sugars (manufactured by the plant) may be oxidized immediately by the plant for energy, in which case the carbon dioxide is released again to the atmosphere, or used again in photosynthesis.
52. The simple sugars (manufactured by the plant) may become a part of complex carbohydrate molecules to be used as a part of the plant structure.
53. The simple sugars (manufactured by the plant) may be synthesized into proteins or fats.
54. If the carbon becomes a part of the plant as complex carbohydrate, protein or fat, it remains in the plant until it is digested and used by the plant or until the plant is eaten by an animal or dies.
55. If the plant is consumed by an animal, it is digested and the carbon may become a part of the animal body as animal carbohydrate, fat or protein or it may be used for energy and carbon dioxide may be given off as a by-product.
56. If the plant dies, bacteria and other organisms digest and decompose the plant compounds and eventually release the carbon as carbon dioxide.
57. The carbon in animals is also released to the atmosphere as carbon dioxide when the animal dies and decomposes.
58. Decomposition of organic compounds by bacteria and other fungi is known as either fermentation, putrefaction or decay.
59. By one of the three processes, fermentation, putrefaction, or decay, the carbon becomes a part of the microorganisms before it is released to the atmosphere as carbon dioxide.
60. Fermentation is the breakdown of sugars by bacteria and yeast with the production of alcohols and acids.
61. The souring of milk is an example of fermentation. Milk contains sugars which are changed through bacterial action to lactic acid.
62. The sour taste of dill pickles is also the result of fermentation.
63. Certain of the products of fermentation are carbon dioxide and water.
64. Putrefaction refers to the decomposition of protein molecules by microorganisms.
65. Protein molecules (may be broken down by microorganisms) into simpler compounds to produce amino acids and finally carbon dioxide, ammonia, hydrogen sulfide, nitrates, and other simple compounds.

66. Some of the intermediate products of putrefaction have unpleasant odors.
67. The microorganisms that cause putrefaction are anaerobes.
68. Anaerobes do not require free oxygen for respiration, but obtain their oxygen from the compounds they decompose.
69. Decay is similar to putrefaction in that protein compounds are decomposed.
70. Decay differs from putrefaction in that no unpleasant odors are produced.
71. The process of decay is carried on by aerobic microorganisms that must have free atmospheric oxygen for respiration.
72. Oxygen, like nitrogen and carbon, is constantly being passed back and forth between organisms and the atmosphere.
73. Both plants and animals remove oxygen from the atmosphere and use it in respiration.
74. The green plants return oxygen to the atmosphere through the photosynthetic process.
75. Though oxygen is almost universally available, it is much more abundant in the atmosphere than in water.
76. Many fresh water lakes are deficient in oxygen at the lower levels during the summer months.
77. Pollution frequently causes a depletion of dissolved oxygen in lakes and streams.
78. Atmospheric oxygen decreases in concentration with increase in altitude.
79. Breathing air at high altitudes results in oxygen starvation or anoxia.
80. Whether in a pond or at altitude, low oxygen concentrations are frequently a limiting factor to the life activities of organisms.
81. Water covers about 72 percent of the earth's surface.
82. If the water on the earth's surface were uniformly distributed it would form an ocean approximately two miles deep over the entire face of the earth.
83. Water evaporates from oceans, lakes and streams, land surfaces and living things and is transferred as water vapor to all parts of the world.
84. The water vapor in the atmosphere ultimately precipitates as rain, fog, dew, snow, or hail and provides regions far removed from the oceans with water.
85. The cycle of water from earth's surface to atmosphere and back is called the hydrologic cycle.
86. The hydrologic cycle has undoubtedly continued with little change throughout the geologic past until the present time.
87. It is estimated that about 6,500 cubic miles of water run off the land annually by way of streams.
88. Annually, the run off water carries with it some five trillion tons of dissolved and suspended matter, all derived from the soil and the earth's crust.
89. The increasing saltiness of the sea is an evidence of the effectiveness of the erosion process.

90. Man's present and future welfare demands an effective control of the destructive action of water.
91. As a basic environmental medium, water has many outstanding characteristics. It serves as a solvent, food, circulating medium, temperature regulator, and catalytic, hydrolytic, and ionizing agent.
92. Water is an essential constituent of protoplasm and constitutes between 40 and 90 percent of its substance.
93. Unless animals and plants can adapt themselves to the water conditions of their surroundings, they must either migrate to more congenial conditions or perish.
94. The water content of an organism frequently determines its ability to withstand unfavorable environmental conditions.
95. An organism's water requirements are often partially met by the organism's ability to extract a supply of water through the metabolism of organic foods.
96. In most instances (however) living things depend upon free water to supply their needs.
97. The activation of the elements borrowed from the earth's crust and atmosphere and organized into living things is affected by the energy from the sun.
98. Organisms derive their energy from their surroundings and also give it up to their surroundings.
99. The available radiant energy varies greatly on different parts of the earth and also exhibits annual and daily cyclic fluctuations.
100. Solar radiation penetrates the earth's atmosphere quite readily, but water absorbs certain of the wave lengths.
101. These facts (concerning energy) are of significance with relation to the distribution and activities of animals and plants.
102. Light is essential to the process of photosynthesis and consequently is basic to the food supply of all living things.
103. The photosynthetic process carried on by chlorophyll bearing plants transforms the radiant energy of the sun into chemical energy, thus bridging the energy gap between the physical and biological worlds.
104. As an environmental factor, light must be considered in terms of its quality and intensity.
105. The quality of light refers to its wave length.
106. Color of light is a function of its wave length.
107. Light intensity refers to the quantitative aspects of light.
108. The environmental effects of light quality and light intensity are well exemplified by the requirements of the photosynthetic process.
109. Chlorophyll is most rapidly decomposed in the orange-red region of the visable spectrum.
110. It is also true that more light is absorbed by chlorophyll in the orange-red region of the visable spectrum than in any other.
111. The optimum quality of light for photosynthesis (consequently) is light of the orange-red color.

112. If the light intensity is too great, light of these wave lengths (orange-red) becomes a limiting factor in photosynthesis.
113. Plants need a definite number of energy units of light for their growth and maturation.
114. Generally, a plant functions more efficiently when the light is distributed over a longer period of time at a lower intensity than when the opposite conditions prevail.
115. Animals, almost without exception, can live independently of light.
116. Some animals such as the cave dwellers, deep-sea fishes, and intestinal parasites normally live in environments lacking light.
117. Light does influence the activities and behavior of the majority of animals.
118. The colors of many animals change in response to the incident of light.
119. The color changes in animals in response to the incident of light are responses of the pigment-containing cells in the animal's integument and are often adaptive in nature.
120. In some fishes, as in some birds and mammals, the sexual cycle appears to be determined largely by the intensity of light.
121. The behavior responses of animals and plants to light are called phototropisms.
122. Earthworms generally move away from the source of light.
123. Moths and many other insects move toward a given light source.
124. Plant stems are definitely positive in their reaction to light.
125. Plant roots are negatively phototropic.
126. One of the most spectacular responses to light made by any living organism is the phototropic response of a fungus which lives in cow or horse dung and which can shoot its spores toward a spot of light with remarkable accuracy.
127. Animals and plants can live within only a relatively narrow range of temperature.
128. Animals and plants are extremely sensitive to sudden changes in temperature and are frequently killed at temperatures only a few degrees above those at which they are accustomed to live.
129. The death of organisms because of heat is best explained at present by the fact that the proteins of the living cells become coagulated in the same way that egg albumin coagulates when heated.
130. The water content of organisms seems to be an important factor (in resistance to heat), susceptibility to heat increases as water content increases.
131. Animals and plants also may be killed by cold.

132. Water content is an important factor (in resistance to cold) susceptibility to cold increases as water content increases.
133. It is generally agreed that the formation of ice crystals in the tissues causes death.
134. The rate at which biological reactions occur depends very definitely upon the surrounding temperature.
135. According to a physical law, the velocity of chemical reactions increases two or three times with each rise of 10°C. in temperature. Metabolic processes conform to this law in a general way.
136. (A more exact generalization is that) metabolic reactions are controlled by the slowest reaction in a metabolic system and that these systems have critical temperatures.
137. Enzymes are active within a marrow temperature range.
138. Cold blooded animals do not have temperature-regulator mechanisms and consequently their metabolic processes are more subject to temperature fluctuations than those of warm blooded animals.
139. Temperature affects the distribution of plants and animals on the earth.
140. Temperature influences the mechanical and chemical changes which occur in soil and thus it influences the nature of the plant cover of the region.
141. The distribution of herbivorous animals is correlated with the distribution of plants and the distribution of carnivorous and omnivorous animals is associated with the distribution of their prey.
142. All living things are subject to mechanical pressure in the environment.
143. Aquatic forms must withstand the pressure of the water which lies above them.
144. Terrestrial forms are adapted to the atmospheric pressure.
145. In water, a change in depth of 34 feet is equivalent to a change in pressureof one atmosphere (14.7 pounds per square inch).
146. On land, the atmospheric pressure decreases with an increase in altitude.
147. At an altitude of 2000 feet above sea level, the atmospheric pressure is a little less than one atmosphere, and at 18,000 feet approximately one-halt of one atmosphere.
148. When Stephens and Anderson made their stratospheric balloon flight to an altitude of 72,595 feet in 1935 the atmospheric pressure on the outside of their pressurized gondola was approximately four-hundredths of one atmosphere.
149. At 63,000 feet the atmospheric pressure is so low that human blood would begin to boil spontaneously.
150. The oxygen pressure at altitude decreases proportionately to the decrease in total atmospheric pressure.
151. Deep sea fishes live normally under pressures exceeding eight hundred atmospheres. Man requires the environment within a bathosphere in order to study deep sea forms at relatively moderate depths.

152. The hydrostatic pressure acting upon deep-sea fishes is so great that when such forms are brought to the surface the air in their swim bladders expands to such an extent that it is everted from the body and the fish is said to explode.
153. Divers working in caissons under pressures exceeding one atmosphere must return to the surface slowly so that their bodies can become adapted to the decreasing pressure.
154. Unless (divers working under pressure in caissons return to the surface slowly) a condition known as "caissons disease" can develop and may prove to be fatal.
155. Aviators flying at high altitudes often complain of the "bends" and suffer symptons similar to caisson disease.
156. The symptons (of caisson disease and bends) are caused by the release of nitrogen in the form of bubbles from the body tissues due to the decreased atmospheric pressure.
157. As in the case of other physical factors of the environment, living things in general are adapted to a relatively narrow range of pressures.
158. All living things respond to the force of gravity.
159. (Gravity) influences the structural characteristics of organisms as well as their behavior and physiological adjustment to the environment.
160. A notable example of the way in which the factor of gravity affects animal structure is the femur of higher animals.
161. The engineering design of the human femur admirably adapts this part of the skeleton to meet the stresses produced by the force of gravity.
162. Another example of the influence of this factor is evident in the adaptations which occur in the skeleton of birds.
163. (In birds) reduction in weight without loss of strength results in an increase in the power of flight.
164. As far as terrestrial forms are concerned, the factor of gravity definitely limits the maximum size that an animal can attain.
165. The behavoral and physiological adjustments of organisms to the factor of gravity are quite evident in living things.
166. Acting in conjunction with plant hormones, the factor of gravity causes the roots of plants to grow downward and the stems of plants to grow upward.
167. Such responses (as those shown by roots and stems) resulting in movements of organisms are called tropisms.
168. In animals specialized organs are often present which keep the animal aware of its position in relation the earth. These specialized organs are called statocyst.
169. The semicircular canals of the human ear represent the highest degree of development of the type of organs which keep animals aware of their position in relation to the earth.

170. It has been suggested that the movements of one-celled animals and many movements of plants are responses to stumuli set up by starch grains or other inclusions in cells as these granules fall through the viscous protoplasm attracted by the force of gravity. In such instances the cell acts like a statocyst.
171. Organisms must be able to adjust themselves to their chemical environment.
172. The chemical environment supplies the organism or tissue with essential chemical foods.
173. The chemical environment produces conditions of osmotic pressure and acidity or alkalinity (hydrogen-ion concentration) which must be optimum if the living matter is to function normally or at all.
174. Red blood corpuscles of a frog, when placed in mammalian physiological salt solution, will loose water and shrink.
175. Plants, if overfertilized, will die as a consequence of of the failure of their roots to adjust to the increased salt concentration of the soil water adjacent to the plant.
176. The adaptations of organisms and tissues to chemicals can also be extremely specific.
177. Potassium ions have a definite influence on the heart beat of animals.
178. Magnesium is absolutely indispensible to the formation of the chlorophyll molecule.
179. The degree of acidity or alkalinity of the chemical environment is of great importance.
180. Adjustment of the hydrogen-ion concentration beyond an optimum range is a common method of inhibiting bacterial growth.
181. In human reproduction the degree of acidity of the female reproductive tract is a common cause of sterility because the male reproductive elements are adapted to a relatively narrow range of hydrogen-ion concentration, and if the female tract is too acid the spermatozoa are killed.
182. When living tissues or organisms cannot adjust themselves to their chemical environment they die. This is the basis of chemotherapy in the field of medical science.
183. Antibiotic substances such as penicillin or streptomycin create an unfavorable chemical environment for certain types of bacteria and inhibit the growth of the bacteria, thus enabling protective mechanisms of the body to exert their influence.
184. Metallic compounds such as mecuric chloride and iodine cause the death of the bacteria in a short time.
185. If the chemical concentrations are not too unfavorable, organisms can adapt themselves to changes in their chemical environment.
186. Plants of the desert or seashore adapt themselves to increasing concentrations of salts in their environment.
187. Bacteria can adapt themselves to sulfonamide concentrations to the extent that they become resistant to the chemical.
188. Human beings living at high altitudes, such as the plateaus of Tibet and Peru, are adapted to the low oxygen concentrations prevailing at those altitudes.

189. The adjustment of living things to their chemical environment illustrates strikingly that adaptability is a fundamental characteristic of living matter

PRINCIPLE V

Social groupings among individuals of the same species and associations between individuals of different species are adaptive responses which often increase the chances of survival for the organisms involved.

1. In general animals live together. Birds form flocks while fishes form schools. Mosquitoes swarm and wolves travel in packs and hunt the herds of deer. Bees, wasps and ants build their own homes, where each individual has a specific function to perform.
2. Associations of animals vary in their degree of organization.
3. Some associations of animals are completely lacking in any degree of integration and, in fact, are associated only through the chance operation of natural laws.
4. An example of accidental association is organisms cast into long drift lines along the sandy beaches of lakes. In such drift lines one can find many organisms including insects, small bivalves, aquatic snails, and even fish.
5. Associations of animals may be brought about because the animals all react the same way to the same kinds of environmental stimuli.
6. The collection of insects about a light on a summer evening is an example of animals reacting in the same way to the same kind of environmental stimulus.
7. Associations or aggregations of animals are caused by forces or factors that are more social in nature.
8. Such aggregations as bird flocks, schools of fish, "dancing midges", and herds of deer are caused by reactions to each other.
9. Instead of responding to an impersonal external force (animals which associate because of reactions to each other) collect as a result of positive reaction to the presence of others like themselves.
10. One aspect of aggregations (with a social basis) may be sexual and result in the collecting together of two or more individuals during the breeding season.
11. Sex, however, is not the only factor (involved in aggregations of a social nature) because many animals collect together in nonbreeding seasons or continue their association long after reproduction is accomplished.
12. In some(animal) forms the association is distinctly a social phenomenon carried to a high degree of specialization.
13. For example, (of an association which is distinctly a social phenomenon carried to a high degree of specialization) hives of bees with the reproductive queen, the males or drones and the sterile females or workers constitute a permanent association that is organized so that the group is an entity in itself. Certain individuals may die but the group persist.

14. Ants and termites also represent social organization in a complex form.
15. Human beings live together in an intricate and complex interdependence. The human from birth to death is a part of a group. His distinctly human characteristics are the result of group living, and the group goes on after the individual is dead.
16. Group or social living is a common biological phenomenon.
17. Group or social living varies from loose, temporary, and accidental associations to highly integrated and permanent interrelationships.
18. (Apparently), living together offers some advantages over the condition of living alone.
19. The advantages of cooperative group effort in human society are obvious.
20. Many examples are available demonstrating that the combined, cooperative action of many people can accomplish task that are impossible for a single individual.
21. The advantage gained by the less organized and unconscious associations (such as fish in a school or birds in a flock) is survival.
22. An example that illustrates the survival value of aggregations of animals is as follows: A large group of fish can tolerate an amount of poison in the water that would kill a very few. The reason is that each one of the group absorbs a small protion of the poison and reduces the total amount so that on one fish is seriously affected. If only a few fish were present, the amount absorbed by each one would be enough to kill it.
23. Another example of survival value of aggregations is the collection of certain birds in close groups during cold weather. Collectively they can withstand the low temperature, while individually they would perish.
24. Social groups have certain characteristics in common.
25. The characteristics which social groups have in common are social characteristics and are derived from the interaction between the members of the group.
26. The social characteristics that groups have in common involve (1) the holding of territory, (2) domination-subordination, and (3) leadership-followship.
27. The different types of interactions in the group may occur in fairly pure form, or they may grade into each other, even in schools of fish, to give complicated organizational pattern
28. The concept of territory refers to an animal's recognition and proprietorship of a certain area. It includes homing or the defense of a certain area, or both.
29. Homing reactions occur when an animal returns to a specific area after it has left it.
30. The (return) distance covered (in the homing reaction) may be only a few feet as in certain mollusks, or it may be hundreds of miles, as in homing pigeons and the golden plover.

31. The defense of a given area is characteristic of territoriality.
32. Birds defend their selected territory against invaders, as do many fishes, lizards and mammals, including man.
33. Organisms that show a reaction to territory react negatively to invaders of the same species. They prevent, by actual combat, or threat of combat, any individual of the same kind from entering the selected area.
34. An exception to this(defense of territory against entrance by organisms of the same kind) is made to a mate or mates.
35. Organisms (that show territoriality characteristics) react positively to the (selected) territory, seeking it and living in it.
36. Social hierarchies develop in groups of animals based on the second characteristic of group living, dominance-subordination.
37. An example of dominance-subordination is the peck order in chickens. A newly collected flock of chickens will, in a relatively short space of time, develop a social organization based on the domination of certain individuals over others. The social order is established and maintained by the giving and receiving of pecks, or by reactions to threats of pecking. From this the term peck order has come to refer to established social hierarchy in chickens.
38. When two chickens meet for the first time either there is a fight or one gives way without fighting. The successful bird in the initial encounter retains the right to peck the other bird at any subsequent encounter. This process continues throughout the flock, each chicken engaging in battle or threat of battle until all fall into a serial hierarchy with one having the right to peck all other chickens and not be pecked in return; with a second being pecked only by number one while it pecks all other hens in the flock; with a third submitting to numbers one and two but dominating all the remaining birds, and so on, down to the last bird in the flock which receives the pecks of all and gives none in return.
39. Other animals that show a domination-subordination type of social organization include fishes, lizards and mammals.
40. Certain human social organizations are suspiciously similar to peck order.
41. W. C. Allee has summarized the qualities that make for high social status in groups of vertebrates as follows: (1) the stronger individual usually wins in pair contacts, (2) mature animals usually dominate those less mature, (3) larger animals usually have a higher social rank than their smaller associates, (4) the location of the first meeting is often important, since many animals fight best in or near their home territory, (5) an animal surrounded by members of its own group often wins over a stranger, (6) animals with young tend to fight more fiercely than at other times, (7) males usually dominate females, (8) the amount of male hormone present often determines the social dominance of either sex, (9) the female consort of a dominant male tends to be accorded his social status so long as she remains near him.

42. Hereditary differences are important in relation to domination-subordination.
43. Inbred strains of mice tend to differ both in aggresiveness and in fighting ability.
44. Defeat which results in lowered social status is often accompanied by easily recognized changes in behavior.
45. A defeated fish may drop its challenging posture of tense body and erect fins; the fish seems to hang limply in the water; it backs away slowly and then turns and flees. Many animals, among them hens, mice and boys, not infrequently emit characteristic cries when beaten. The head furnishings of defeated hens sometimes blanch, while those of the victor remain flushed. Defeated mice rear up in characteristic postures. Other signs of low social rank include the avoidance of encounters with superiors; defeated hens move about quietly, often with head held low, or hide in out-of-the-way places or in protected niches.
46. Leadership, another characteristic arising out of group living, consists in giving guidance and directing others along a certain course or pattern of behavior.
47. A leader may be able to attract others to follow him, but sometimes force is necessary to control the followers or even to secure them.
48. The position of leadership is held by the animal that initiates, stabilizes, or integrates behavior of the group.
49. Leadership may be held by either male or female, who may be young, mature or old.
50. Leadership may be held by one individual or a group of individuals.
51. The leader may lead in the physical sense of going before when the group changes its location or activity. However, this is not always true.
52. The animal moving in advance may not be the real originator of the movement.
53. In some flocks of birds the bird in advance in flight is simply following along in front of the flock. Any change in direction originates within the body of the flock.
54. Leadership may or may not be associated with social status.
55. In flocks of hens leadership often rest in the mid-social ranks rather than with the number-one hen in the peck order.
56. In ants individual-to-individual dominance is unknown, yet leadership exist.
57. Among groups of mammals the socially dominant animal is often the leader.
58. Among the red deer of Scotland the males exert dominance, but the real leadership is held by a female.
59. In rhesus monkeys there is a complete linkage of dominance and leadership. The strongly dominant and aggressive individual is also the leader.

60. In a community relationships exist between species which result in (1) the toleration of one species by the other, (2) the exploitation of one species by the other, and (3) the unconscious cooperation of two species which results in mutual benefit being derived from the association.
61. The term symbiosis is used by the biologist to include all types of (such) partnerships (which exist in a community).
62. The toleration of one species by another is called commensalism.
63. The exploitation of one species by another is called parasitism.
64. The unconscious cooperation between species is called mutualism.
65. Among the most interesting of the commensal relationships are those involving species of insects and flowering plants.
66. The collection of nectar and pollen by honey bees to supply food for the bee colony is an example of a commensal relationship. In the pursuit of nectar and pollen the honey bees make possible cross-fertilization in the plants.
67. The commensal relationship may be casual, (as in the case of the honey bee and the flowering plant) or it may be obligatory as in the case of the Yucca moth and the Yucca plant.
68. The only insect capable of pollinating the Yucca flower is the Yucca moth.
69. The female moth, after collecting pollen from several stamens, drills a hole through the ovary wall of the Yucca flower and lays her eggs among the ovules of the flower. Development of the ovules into seeds is insured by inserting the pollen grains into the canal of the pistil.
70. Only a few eggs are laid in any one flower thus insuring an adequate food supply for the larvae without endangering the propagation of the plant upon whose existence the survival of the Yucca moths depends.
71. Mutualism is found between species of animals, species of plants or between animals and plants.
72. A mutually beneficial relationship existing between an animal and a plant is seen in the relationship between the green alga Chlorella and the fresh-water coelenterate hydra.
73. The green alga lives within the body walls of the hydra and utilizes the carbon dioxide released by the animal to manufacture sugar by photosynthesis. The hydra, on the other hand, uses the oxygen liberated in photosynthesis in its own respiratory activity.
74. Other examples of mutually beneficial relationships are those existing between certain fungi and algae resulting in the composite plants called lichens; the relationship between the root-inhabiting nitrogen-fixing bacteria and leguminous plants; and the relationship between certain termites and their intestinal protozoa.
75. Termites cannot live without the presence of the protozoa (in their digestive tract) for the protozoa digest the wood (cellulose) eaten by the termites.

76. Parasites are organisms, either plant or animal, that live on or within another organism and at the expense of the other organism.
77. The benefits derived by the parasite may include food, shelter, dispersal, and a means of completing the life history.
78. The host is an organism that harbors a parasite.
79. If the parasite is in an immature stage of growth, the host is usually known as an intermediate host.
80. If the parasite is adult, the host that harbors it is known as the final host.
81. The habitat of the parasite is the host.
82. The habitat provided by the host is comprable to the water and land habitats of free-living forms, and parasites become adapted to it just as free-living organisms become adapted to their (habitats).
83. The parasitic habitat is essentially of two types. One is ectoparasitic, in which the parasite lives on the outside of the host. The second is endoparasitic, in which the parasite lives within the host.
84. Examples of ectoparasitic organisms are lice, fleas, and ticks on man.
85. Examples of endoparasitic organisms are protozoan blood parasites that cause malaria, tapeworms that live in the intestine, and bacteria that live in the respiratory tract.
86. Most parasites can live only in a specific host or hosts.
87. Parasites become adjusted to a certain host environment and can tolerate no other. This condition is known as host specificity.
88. (Furthurmore) parasites usually are restricted to living in or on only certain parts of the host. This is tissue specificity.
89. Tissue specificity is exemplified by the viruses which cause rabies and poliomyelitis and affect the nervous system only.
90. Other viruses, such as those that cause chickenpox and smallpox, attack the skin.
91. The parasite is not the only part of the host-parasite relationship that shows specificity.
92. The host also is specific in its tolerance of parasites. It accepts some and rejects others.
93. A host that tolerates the presence of a parasite is said to be susceptible.
94. A host that does not tolerate a parasite is said to be immune.
95. Animals and plants that are parasitic have evolved from free-living ancestors.
96. Parasitism probably began as a result of a chance encounter of two organisms in which one served as a vehicle for the transportation of the other. This relationship probably persisted for sometime, during which the future parasite came to depend upon the host for food and perhaps other necessities, and as the degree of dependence grew the degree of parasitism grew.

97. During the evolutionary adaptation from a free-living to a parasitic mode of life, the parasite changes, and the degree of change usually is correlated with the length of time the organism has been parasitic.
98. Parasites that have been parasitic for a short time, in general, show few changes and those that have been parasitic for a long time show great changes.
99. The changes that a parasite undergoes are usually in the direction of greater dependence upon the host.
100. The variations in the parasites may be simplifications of structure or they may be complications.
101. Complex life histories have developed in many parasitic species.
102. Complex life histories in parasites is associated with differences between young and adults.
103. When the offspring are like the parents, as in the case of bacteria, both can live in the same environment and the complex life histories do not develop. However, when the offspring have one form and the adults have another, they need different environments in which to live and develop.
104. (Thus) immature or larval parasites live in intermediate host, of which there may be one, two or three. The adult lives in the final host. To complete development of the parasite or to complete its life history, it must pass from host to host.
105. The human pork tapeworm is an example of a parasite having a relatively simple life history. The adult tapeworm lives and reproduces within the human intestine, the fertilized eggs pass out of the intestine with the human excreta. Most of them die, but sone are eaten by pigs. Within the pigs they undergo certain growth changes and migrate until they invade the pig's muscles. If man eats the pig's muscle tissue in the form of insufficiently cooked pork, the young tapeworm gains entrance into the human digestive tract, where it develops into an adult.
106. The total effect of parasitism on the host depends upon a number of factors, including the virulency of the parasite, the number of parasites, the resistance of the host, and whether the parasite-host association is temporary or permanent and of long duration or of recent origin.
107. Virulence is the capacity of a parasite to produce abnormal conditions in a host by reproducing rapidly and producing highly toxic substances.
108. Parasites differ in their virulence.
109. Parasites that are highly virulent cause the severe diseases, while those of less virulence cause mild illnesses only.
110. The number of parasites that invade a host has a decided effect on the severity of the host's reaction.
111. A few parasites can usually be tolerated by the host, but if the numbers increase the host's resistance is usually overcome and the damage may be great.

112. The resistance of the host to the specific parasite determines whether the parasite will become established.
113. Resistance of the host to a specific parasite is great in some cases and very little in others.
114. Temporary associations of parasite and host, such as mosquito and man, seldom do much damage, while more or less permanent associations such as tuberculosis-causing bacteria, hookworms and tapeworms can cause great damage.
115. When the parasite host relationship is of long duration and the parasite and host have lived together for countless generations, a mutual tolerance sometimes develops.
116. Under conditions of mutual tolerance between parasite and host, the host may not be injured sufficiently to cause death, but he (host) may suffer from a slight and continued impairment of health known as a chronic disease.
117. If the parasite-host relation is of recent origin in the evolutionary sense, severe reactions may occur. The host is unable to inhibit the action of the parasite sufficiently to protect itself from harm, and as a result severe disease and perhaps death of the host ensues.

AREA 8 - INTERRELATIONSHIPS

UNIT 2 - Populations and Conservation

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas of the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 8, UNIT 2

1. To understand the relationship between a species' capacity to reproduce its kind and the factors of the environment which resist increase in population size.
2. To recognize the fact that human populations are subject to the same biological forces as are the populations of other organisms.
3. To understand the significance of the conservation of natural resources to human welfare.

PRINCIPLE I

The population size of a species is a result of the interaction between the theoretical capacity of that species to reproduce its kind (its biotic potemtial) and the environmental resistance confronting the organisms comprising the species.

1. The physical and biological factors in the environment can be thought of as constituting a resistance to the increase in numbers of living things.

2. Unless the individual living organism is adopted or can consciously adjust itself to unfavorable environmental conditions, it cannot survive.
3. This principle (that unless the individual living organism is adapted or can consciously adjust itself to unfavorable environmental conditions, it cannot survive) applies with equal effectiveness to populations of individuals.
4. Since all living things possess a tremendous capacity to reproduce their kind, the size of animal or plant populations fluctuates with the degree of environmental resistance exerted.
5. This basic concept of interrelationships in the natural world can be expressed very simply by the equation:

$$\text{Population} = \frac{\text{Reproductive Capacity}}{\text{Environmental Resistance}}$$

6. The idea of an organism's theoretical capacity to reproduce can be gained from the following example. It has been estimated that a single bacterium 1/20,000 of an inch long and 1/30,000 of an inch thick, if allowed to reproduce to the limit of its capacity without the restraining influence of its environment, could, in one day's time, fill a pipe one inch in diameter reaching from New York to San Francisco.
7. Within twenty-four hous this reproductive spree (of a single bacterium) would result in four sextillion bacteria.
8. We need not, however, limit our example to bacteria. It has been estimated for humans that if one husband and wife had six childred and each pair of children had six children, the entire world could be populated in nineteen generations. The fourth generation would produce 162 individuals whild the nineteenth would consist of 2,324,522,934 individuals.
9. Biblogist hypothesize that the failure or success of the human race will depend upon the wisdom man shows in controlling his reproduction quantitatively and qualitatively.
10. In this respect (ability to apply control measures to his reproduction both qualitatively and quantitatively) man differs from other living things, for he (man) can apply creative intelligence to a problem which other living things must leave to the action of non-conscious natural forces.
11. A population can be compared to a living organism in several respects.
12. Like an organism, a population has a life history, it grows in a typical fashion, undergoes changes that may lead to a division of labor among its members, ages and dies.
13. Like an organism it is an integrated unit. It meets the forces of the envoronment as a whole rather than as a loose assemblage of parts.
14. (A population) has an heredity.
15. The structure and composition (of a population) change with increasing age even though at any one time it seems very stable.

16. The basic similarity (between organisms and populations) is especially evident when a population growth curve is compared to the growth curve of an individual.
17. Under ideal environmental conditions the growth of a population follows the same pattern of development as does the growth of an individual.
18. Growth is slow at first, gradually increasing in rate until a maximum is reached. Almost imperceptibly this rapid rate of growth begins to slow down and after a time the rate decreases more and more rapidly until at a later date there is no appreciable increase in the size of the population.
19. When the growth of a population is plotted with either weight or numbers against time, a typical S curve is secured like that for the growth of an individual.
20. A population is defined as a group of living individuals set in a frame that is limited and defined in respect to time and space.
21. If more than one species is included in the group, the group is spoken of as being a mixed population.
22. Animal and plant communities are usually mixed populations.
23. In his efforts to understand the population aspects of group biology, the biologist is concerned basically with three factors. These factors are (1) the birth rate, (2) the death rate, and (3) the dispersion within the population.
24. The birth rate, or population-increase factor, takes into consideration the theoretical reproductive capacity and the realized reproductive performance of a species.
25. The distinction between them (theoretical reproductive capacity and the realized reproductive performance) is clear.
26. (For example), a population might have a theoretical reproductive capacity of 20,000 offspring per year but a realized peproductive performance of only 3000 individuals for the same period of time.
27. Statistics on human populations show that the range of reproductive performance extends between an average maximum of approximately 50 births per 1000 population per year to an average minimum of approximately 15 birth per 1000 annually.
28. Countries populated by members of the caucasoid race tend to have a lower birth rate than countries populated by non-caucasoids.
29. Studies also reveal that in humans the rate and success of reproductive performance in a population are determined by the age of the reproducing members.
30. (For example), mothers 19 years of age and under are the most fertile and fertility decreases with increasing age.
31. The death rate, or population-decrease factor, interest the biologist from the standpoint of why organisms die and why they die at a certain age.
32. It is a population principle that different phases of the life history of a population have diffefent and characteristic death rates.

33. If the cause of death (of a population) can be ascribed to the environment, it follows that a more complete knowledge of the environment can lead to reductions in the death rate, if this is desirable.
34. There is a tendency for the industrialized caucasoid countries of the world to have lower death rates, just as they have lower birth rates.
35. (Conversely), a country with a high death rate also has a high birth rate.
36. Although the human population may be declining in certain areas on earth, in general the human population is increasing in size at a relatively rapid rate.
37. Some biologist point out that the human race is actually enjoying a "breeding storm" notwithstanding wars, famines and disease.
38. In 1630 approximately 400,000,000 inhabited the earth. By 1830 this number had doubled. By 1900 the number ahd increased to 1,600,000,000 and the total at present is over 2,000,000,000 with an annual increase of 20,000,000 or roughly one per cent.
39. It is predicted that by 1999 there will be 3,300,000,000 people on earth.
40. The dispersion factor is concerned with the emigrations and immigrations which occur within a population.
41. If either (emigration or immigration) is excessive a condition of depopulation or overpopulation can take place within an area.
42. One of the most significant elements in the biological environment of living things is population density.
43. (Population density) is defined as the number of organisms per unit space they occupy.
44. (Population density) has been shown to affect the growth form of a population.
45. Increased crowding of organisms in a population reduces the growth rate and can even bring about a decline in the population.
46. If there is competition for food the fecundity of the females in the population decreases with an increase in population.
47. When the total environment is unsaturated, increased emigration caused by crowding leads to survival in the population because the organisms moving out find environmental niches still unexplored.
48. When the total population is static, however, emigrations from one place to another lead to death.
49. (Finally), the age composition of a population reveals the "youngness" or "oldness" of the population in terms of its life history.
50. A growing and vigorous population contains a great preponderance of young organisms.
51. A stationary population has an intermediate number of young as compared to old individuals.
52. A declining population is characterized by a preponderance of old organisms.
53. The social, economic, and political implications of these facts for human populations are manifold.

PRINCIPLE II

The conservation of natural resources is a logical consequence of man's understanding of the interrelationships among living things and between the living and nonliving parts of the environment.

1. An understanding of ecological relationshops reveals the intricacy of the factors in the soil-water-plant-animal complex.
2. It should be obvious that the welfare of human life on earth is directly dependent upon an understanding of these factors.
3. The study of food chains and the phases of ecological succession reveals the fact that a disruption of any one of the links in a given sequence can seriously affect the entire complex.
4. Man, (therefore), in his agricultrual and industrial pursuits must consider the biological and ecological principles which underlie his activities.
5. He (man) should remember that he cannot conquer nature.
6. At best he (man) can merely cooperate with nature on the terms and under the conditions she sets forth.
7. He (man) should constantly be aware of the social, economic and political implications of man-initiated disruptions of the ecological pattern.
8. (Since) the human community is completely dependent upon the earth's crust and its resources, a prime objective of human activity should be the wise use of these resources.
9. Outstanding geographers point out that any nation, if it is to support its population and maintain a high standard of living among its people, requires five classes of resources. First, it must have an abundance of fertile soil; second, an adequate supply of minerals; a sufficient and dependable supply of fuel and power; fourth, a sufficiency of timber; a relatively high proportion of its people must be of hereditarily high biological quality.
10. Of the resources listed fertile soil stands formost.
11. The food problems of the world with its ever-increasing population can be solved only in terms of the basic medium for food production, the soil.
12. Soil conservation (thus) becomes a matter of international concern, since the unchecked depletion of the soil resources through erosion and the consequent decrease in food supply are ever present invitations for social unrest and political upheaval.
13. Peace with hunger cannot be peace for long.
14. Closely related to soil conservation is the conservation of forest, grasslands, water resources and wildlife. All are a part of the soil-water-plant-animal complex.
15. The wise use of our forest, grasslands, and the land under cultivation leads to better control of the water and wind forces causing erosion.
16. Where forest, grasslands, and hedgerows exist, one will find environmental conditions suitable for wildlife.
17. Where wildlife abounds man has an unexcelled recreational outlet.

18. Conservation through ecological engineering is of importance to human welfare, whether in terms of his food and nutritional needs or in terms of his mental and emotional well-being.
19. With regard to mineral, fuel, and power resources, it should be recognized by all that America has become great because of her original store of geographic goods and not necessarily because of her social and political institutions.
20. Her natural resources of coal, iron, copper, and other basic minerals together with her resources of oil, timber, and ground water were the greatest on earth and upon these resources was constructed the greatest industrial civilization known to man.
21. As a noted economist states it, "The greatness of America has been the greatness of our continent- its sweep, its varied resources, its abundant vitality. We have what other nations go to war to obtain. And if we are determined to defend it from attack, we should be equally determined to defend it from our own abuse."
22. To promote successfully the conservation of our natural resources, whether soil, mineral, fuel, timber, or human, requires the development within each of us of an ecological conscience.
23. In the words of the late Aldo Leopold, " The practice of conservation must spring from a conviction of what is ethically and esthetically right, as well as what is economically expedient. A thing is right only when it tends to preserve the integrity, stability and beauty of the community and the community includes the soil, water, fauna and flora, as well as people.

AREA 9 - EVOLUTION

It is the purpose of this investigation to discover the relative importance of the facts included in the Lecture Syllabus for Biological Science. Each fact is to be evaluated in terms of the contribution which you believe it makes toward the understanding of a fundamental principle of biology. Please interpret the word "understanding" within the limits you believe to be imposed by the objectives of general education and the specific objectives of the area in which the principle occurs. The principles were taken from the Study Guide for Biological Science. You will find the principles from each area in the study guide followed by facts taken from corresponding areas in the syllabus. Will you rate each fact according to the following key ?

Mark space 1 if you believe that knowledge of the fact is <u>essential</u> to an understanding of the principle.

Mark space 2 if you believe that knowledge of the fact is <u>quite important</u> to an understanding of the principle.

Mark space 3 if you believe that knowledge of the fact is of <u>average importance</u> to an understanding of the principle.

Mark space 4 if you believe that knowledge of the fact is <u>relatively unimportant</u> to an understanding of the principle.

Mark space 5 if you believe that knowledge of the fact is <u>unrelated</u> to an understanding of the principle.

THE SPECIFIC OBJECTIVES OF AREA 9

1. To understand the development of the concept of organic evolution from the historical viewpoint.
2. To understand the history of the development of living things in the course of geologic time.
3. To recognize and appreciate the validity of the various sources of evidence supporting the fact of organic evolution.
4. To understand the Theory of Natural Selection.
5. To study the evolution of man.

PRINCIPLE I

Every kind of animal and plant living today has descended, with modifications, from organisms which have lived in the geologic past.

1. Biological evolution is a principle which states that the kinds of animals and plants living today have descended from different forms that lived in the past.

2. The essential point (concerning biological evolution) is that species are not static but have changed in the past, are changing now, and will continue to change in the future.

3. Biological evolution is concerned with explaining the changes that have occured in living forms from the first primitive living substance to modern organisms.

4. Biological evolution does not attempt to explain how life originated.

5. No one knows when or how the first forms of life appeared on earth, but there are several interesting theories.

6. The Special Creation Theory states that all living things were created within a short space of time immediately after the earth was made. All things were created at this time, and there has been no change in any of the living things since this time.

7. According to the Spontaneous Generation Theory it was once generally believed that, given suitable environmental conditions, non-living matter could form into complete, complex living things such as insects, frogs, and fish.

8. According to Van Helmont, a sixteenth century Dutch scientist, the combination of soiled linen and cheese would produce mice. The Nile river mud plus the heat of the sun supposedly was able to produce both mice and rats.

9. The Physico-chemical Evolution Theory assumes that at one time during the history of the world conditions were such that very simple forms of life arose through the combination of non-living matter.

10. The physico-chemical theory is somewhat similar to that of spontaneous generation. The difference is that according to spontaneous generation the production of living things from nonliving occurs constantly while according to the physico-chemical evolution theory it occured only at some remote time in the earth's history and has not happened since. Also spontaneous generation supposes that complex organisms arise from non-living matter, while the physico-chemical theory assumes that only very simple forms of life arose in this fashion and that all modern, complex forms have evolved from the primitive forms.

11. (These) preserved forms, the fossils, have told man most of what he knows concerning the evolutionary history of life.

12. The earth is constructed of a central core and a crust that lies outside the core. The crust is a shell of rock that varies in thickness. In places it is covered with water forming oceans. In other places the rock is exposed, forming the continents.

13. The rock of the continents is exposed to the action of wind, rain, temperature changes, and plants and animals, which result in a gradual disintegration or "weathering" of the rock.
14. The loose material (thus) formed (by weathering action on rock) covers the earth as the soil.
15. Some (of this) soil is washed away by rain and streams and eventually deposited as sediment in lakes and oceans, where it settles to the bottom to form layers of mud or sand. As time passes more layers are added on top of the earlier-formed ones and eventually all of them become rock because of chemical changes and the compressing effect of weight.
16. Rock (formed by the deposition of water borne deposits is called sedimentary rock because of the materials out of which it is made and also is called stratified rock because it is formed in layers.
17. Weathering, when continued over millions of years, gradually wears away the exposed rocks and the continents become flattened.
18. As the continents wear away the edges of the oceans become filled with sediments and the water of the ocean gradually overflows the land.
19. The continents as a whole also rise and sink slowly over long intervals of time, and when they sink the water of the ocean inundates parts of the continent.
20. (Because of the changing relationship between land and water) great arms of the ocean cover vast areas of the continents.
21. (Hudson Bay is an example of an arm of the sea having moved in over a vast area of continent).
22. Into (these) shallow continental seas more sediment is carried and more sedimentary rock is formed. Eventually the continents rise again. The oceans recede from the continents and the sedimentary rock becomes dry land.
23. Usually during (these) periods of uprising continents, the earth's surface buckles in places and mountains are formed.
24. Following the rise of the continents and the formation of mountains weathering again begins its leveling action through rock disintegration and sedimentation.
25. This cycle of rising and sinking continents has occured many times in the past history of the earth and during each cycle new layers of sedimentary rock are formed.
26. The layers of sedimentary rock laid down at the beginning of a cycle are always underneath those laid down later and also the layers of an earlier cycle are always beneath the layers of a later cycle.
27. Occasional exceptions to this rule (law of superposition) occur when, during mountain formation, the buckling of the earth results in a folding of the rock layers.
28. During the time when sedimentary rock is being formed, animals and plants are occasionally buried within the sediment. Some of these forms are preserved.
29. This (preservation) is particularly true of the hard skeletal parts of organisms, though sometimes even the softer body parts or their form are preserved.

30. (These) preserved animal and plant remains are called fossils.
31. With the lifting of the continents the rocks containing the fossils become exposed to weathering and as the rocks wear away, some of these fossils are exposed so that man can find them and study them.
32. By means of a study of the sequence in time in which the rock layers have been formed plus a study of the fossils contained in the rocks, is has been possible to trace the history of living things on earth.
33. By various means it has been possible to determine the approximate age of the rocks, with the result that a time scale has been made of the history of the earth's surface and of the history of life on the earth. This is known as the Geologic Time Scale.
34. Copy of Geologic Time Scale as given on page 217 of Syllabus for Biological Science.
35. What ever the cause or the manner of the origin of life it is generally agreed that the first forms of life were comparatively simple.
36. It has been suggested that these first living things were protein in nature and that they had the ability to use inorganic sources of energy.
37. There are certain bacteria living today that do not need plant food (produced by the action of chlorophyll) as a source of energy, but can obtain the energy that require by causing certain chemical reactions in inorganic matter.
38. The first living organisms were probably of this sort (similar to the bacteria which do not depend upon plant food) and later evolved into forms that utilized the sun as a source of energy.
39. The development of chlorophyll or a chlorophyll-like substance probably occured very early.
40. These forms (containing chlorophyll or a chlorophyll-like substance) were then able to capture the energy of the sun and to store this energy in the form of food.
41. No one knows at what stage the substance of these early living things became protoplasm as we know it today, nor can we say when this protoplasm became cellular.
42. The early stages of evolution are lost in antiquity, but it seems reasonable to assume that they occured very early in world history.
43. (It is also reasonable to assume) that after the appearance of simple cellular plant-like forms, life divided into two streams. One of these streams produced the modern plants while the other resulted in the modern animals.
44. There are forms living today that are neither plant nor animal in the strict sense.
45. (Euglena is an example of an organism that is neither plant nor animal in the strict sense). It has animal traits such as a gullet and a food vacuole and also the characteristic plant trait, chlorophyll.
46. The first animals were the invertebrates and of these the single-celled Protozoa appeared first.
47. The sequence of development of the remaining invertebrate types is in doubt, but on the basis of structural complexity it was probably as follows. After the single-celled Protozoa came the colonial Protozoa.

48. Colonial Protozoa are made up of aggregations of cells all of the same type (showing no differentiation).
49. The colonial stage was probably followed by a differentiation of certain of the cells (making up the colony) to bring about dividion of labor.
50. (Differentiation means that) within a cluster of cells making up the colony some would be specialized for food getting, others for reproduction and still others for other functions.
51. The next step (following differentiation) was the arrangement of these specialized cells into layers.
52. The sponges represent the stage in evolution in which specialized cells are arranged into layers, being made up of loosely integrated cells arranged in an outer and an inner layer.
53. The inner layer (in animals with two cell-layers) functions mainly in food getting while the outer layer is primarily protective, but also contains sensitive cells that can respond to environmental stimuli.
54. The Coelenterates represent the next probable evolutionary advance (above the sponges).
55. (In Coelenterates) the cells within the two cell layers become more closely integrated so that they may be called tissues.
56. (In Coelenterates) the outer layer is protective and sensitive, while the inner layer is concerned with digestion.
57. A third cell layer appears next between the original two to increase the complexity of the organisms. The modern flatworms are representatives of this evolutionary step.
58. Flatworm embryos contain an external cell layer, the ectoderm, an internal cell layer, the entoderm, and a layer in between known as mesoderm.
59. The ectoderm (in flatworm embryos) develops into an outer layer which is still primarily protective in function and also retains its ability to receive stimuli from the external environment.
60. The inner ectoderm (in flatworm embryos) becomes the lining of the digestive tract and is digestive in function.
61. (In flatworms) the mesoderm in the middle develops into muscle and other internal body organs that make up the bulk of the organism.
62. The next evolutionary advance (over the flatworms) was the development of segmentation, as in modern annelid worms.
63. Segmentation is where the parts of the body are repeated in a serial pattern from anterior to posterior.
64. The arthropods such as the crab, crayfish, insects, and spiders probably evolved from the early primitive annelids, for they retain the segmentation of the annelids to a marked degree.
65. (The arthropods added many new features (to those of the annelids) including an external skeleton of chitin and jointed appendages.
66. The mollusks, such as the oyster and the clam, became specialized in the development of an outer protective shell.
67. The echinoderms evolved with a five-rayed body pattern and a special type of locomotion by means of tube feet.

68. One should not conclude from a discussion of the sequence of evolution that it occured in strictly serial fashion, beginning with the protozoa. Such is not the case.
69. The exact sequence of evolution is unknown.
70. It is generally agreed that evolution has not proceeded in a straight line, but rather that it has branched like a tree.
71. Following the analogy of the tree, the earliest forms of life would represent the base of the trunk. The trunk immediately splits into two main stems, one stem becoming the first animal forms and the other stem the primitive plant forms. The base of the animal stem represents the primitive Protozoa from which a branch extends laterally to represent the development of the modern Protozoa. Another branch represents the modern spenges. The main stem continues upward as the primitive coelenterates and from here several branches diverge. One branch leads to the flatworms and roundworms, another to the annelids, another to the annelids, and another branches to form the echinoderms and the chordates which evolve into the vertebrates. The annelid branch separates into two smaller branches, one becoming the arthropods and the other the mollusks.
72. The vertebrates evolved from the invertebrates.
73. The vertebrates appeared early in the history of life on earth.
74. The vertebrates appeared about 550,000,000 years ago.
75. The vertebrates appeared during the Paleozoic Era.
76. In general (vertebrate) evolution was directed toward a type of animal having greater locomotory powers than the invertebrates possessed.
77. The invertebrates were sluggish, slow-moving or sessile animals, while the vertebrates became fast moving and agile.
78. It is probable that the first vertebrates appeared in fast-flowing fresh water streams where swimming powers were essential to prevent being swept into the seas.
79. The adaptations that developed in the vertebrates include an internal supporting axis, the vertebral column, segmented body muscles that permitted a lateral bending of the body to attain fowward propulsion and fins to give leverage for the muscular action.
80. The ostracoderms are the most primitive vertebrates known.
81. The ostracoderms lived about 450,000,000 years ago.
82. The ostracoderms lived during the Paleozoic era on the botton of fresh water streams.
83. The ostracoderms had fish-like bodies and tails that ranged from six inches to one foot in length, and they were covered with thick bony scales. The mouth was a transverse slit and jaws were absent.
84. In many ways the ostracoderms resembled the modern cyclostomes, which are the most primitive of modern fish.
85. The ostracoderms or their relatives gave rise to the sharks which represent the next step in vertebrate evolution.
86. The modifications (of primitive ostracoderms appearing in sharks) include the development of jaws with teeth, the loss of the heavy armor and the development of fins.

87. The jaws (in sharks) probably developed from the first pair of gill arches.
88. (The teeth in sharks) probably developed from the scales that covered the surface of the body near the mouth.
89. Gill arches are cartilaginous or bony supports for the gills and lie just behind the mouth on each side.
90. (In sharks the first pair of gill arches) one on each side, moved forward, became hinged in the middle and took on the new function of opening and closing the mouth.
91. (In sharks) the scales lying near the edge of the mouth moved in to rest upon the jaws and become teeth.
92. The transition from gill arch to jaw bone is evident in the development of embryos and the similarity of scales to teeth can be seen on modern sharks.
93. The sharks also developed paired fins.
94. The acquisition of jaws, teeth, and paired fins enabled the sharks to leave the bottom of the streams and swim freely in the water. The fins made control of body movements possible and the jaws and teeth were useful in catching prey.
95. These modifications made greater freedom of movement possible and the sharks migrated into the oceans where they are found today.
96. The next advance (above the sharks) in the evolution of the vertebrates was the appearance of the bony fish.
97. (These) fish developed a skeleton of bone while the forms that evolved into modern cyclostomes and sharks retained the cartilage.
98. The fish that developed their skeletons of bone are important because they not only produced the myriads of modern fish and salt water fish, but also gave rise to the land living vertebrates including man.
99. The bones of these early (fish) forms made up the internal framework of the body and also covered the tops and sides of the skull.
100. The pattern of skull bones laid down in these (early) fish can be traced with modifications into almost every later vertebrate type.
101. Even the parts of the human skull can be compared with the individual bones of these early fish skulls.
102. An innovation just as important to vertebrate evolution as the bony skeleton appeared (in the primitive bony fish). This was the development of paired lungs.
103. It is probable that lungs developed during a time when seasonal climatic changes were extreme, resulting in a periodic drying up of streams and ponds.
104. (During a time of extreme seasonal climatic changes resulting in the drying up os ponds and streams) a fish with lungs would have an advantage over those without lungs in being able to come to the surface and gulp air, when pools became stagnant, foul, and deficient in oxygen.
105. The early bony fish with lungs branched into three groups, the ray-finned fish, the lung fish, and the lobe-finned fish.
106. The ray-finned fish evolved into the modern fish.

107. The lungs of the ancestors (of the modern fish) became modified into an air sac or bladder that moved to the dorsal side of the body cavity.
108. (The air sac or bladder in modern fish) is used to change the specific gravity of the body enabling the fish to change its elevation in the water with ease.
109. The lung fish of today include three forms. One type lives in Australia, the second in Africa and the third in South America.
110. (Modern lung fish) live in ponds and streams that dry up periodically and when this happens the fish burrow into the mud of the botton. There they remain until water returns to the pond.
111. The lobe-finned fish are very similar to lung-fish. The only significant difference is that the lung fish remained stationary in the evolutionary sense while the lobe-finned fish evolved into land living vertebrates.
112. The characteristics of the lobe-finned fish that make possible the transition from water to land include the lungs, an open connection between the external nostrils and the throat, and fins that were rounded and strong, containing both bone and muscle.
113. The fundtion of the lungs in an air breathing animal is apparant.
114. The internal connection of the nostrils to the throat (in the primitive lobe-finned fish) permitted breathing through the nostrils.
115. The bone-supported fins (of the primitive lobe-finned fish) gave sufficient support to permit locomotion across dry land.
116. (The structure of the skeletal support of the fins of the lobe-finned fish is as follows) One bone connects with the shoulder skeleton. Extending from the end of this bone within the fin are two bones lying side by side. From the ends of these bones a series of small bones branch to support the free end of the fin.
117. The single bone that connects with the pectoral girdle is comparable to the humerous of land animals including man.
118. The paired bones (below the humerous in lobe-finned fish) are similar in position to the hand and finger bones.
119. The paired bones (below the humerous in lobe-finned fish) is comparable to the radius and ulna (of land animals).
120. The lobe-finned fish lived during a time when seasonal changes were great, and it is believed that some of them were forced to become adapted to living on land or die.
121. (Some of the lobe-finned fish) became adapted and evolved into amphibians.
122. The amphibians which evolved from the lobe-finned fish ranged in size from about two feet in length to individuals equal in size to modern crocodiles. They had long, slim fish-like bodies with long tails. Paired limbs supported these bodies by means of an internal bone structure similar to that found in the human skeleton.
123. In amphibians lungs replaced the ancestral gills.
124. (In amphibians) air was forced into the lungs by swallowing.

125. The ear made its first appearance in amphibians.
126. One of the ancestral gill slits persisted as a tubular opening from the throat to the side of the head. This tubular opening known as the eustachian tube, was closed over at the outer surface by a membrane, the ear drum.
127. Just beneath the membrane a bony remnant of one of the gill arches served as a connecting link between the ear drum and the internal ear.
128. Vibrations of the ear drum were caused by sound waves and these vibrations caused movements in the ear bone, which in turn moved parts of the inner ear thus setting up nerve impulses which were carried to the brain.
129. While the success of amphibians in making the transition from water to land was a tremendous evolutionary step it was not quite complete. The amphibia started the parade to land, but they never quite succeeded in leaving the water completely, for when it came time to reproduce they had to return to water.
130. Modern amphibia, among them the frogs and toads, are still doing this (returning to water during breeding activity) while many of the salamanders live permanently in water.
131. Reproduction of any vertebrate animal must necessarily occur in water. Eggs and sperms need water to unite. The embryo needs water in which to develop.
132. The problem was to evolve a mechanism for creating this aquatic environment (necessary for vertebrate reproduction) on land so that reproduction and development could take place.
133. Some amphibia lay eggs in moist burrows, some use rain-filled hollows in trees, and one modern toad deposits its eggs in little pits on its back.
134. None of the (amphibian) schemes (for obtaining an aquatic environment for fertilization) was very successful and the amphibia, which started the procession to land, fell backward in the evolutionary race.
135. It remained for the reptiles to solve the problem of reproducing on land.
136. The reptiles evolved from the amphibia.
137. In reptiles the land egg developed and they were freed forever from the necessity of visiting ponds and streams for reproduction.
138. The egg that developed in the reptiles consists of a water filled sac, the amnion, that surrounds the developing embryo, a yolk sac containing food suspended from the embryo, and another sac that serves as a respiratory organ. All of this is surrounded by a tough, porous protective shell.
139. The(land) egg contained all of the environmental conditions normally found in ponds and streams and could be laid anywhere on land.
140. Internal copulation developed (in reptiles) as a necessary reproductive function to bring the sperms and eggs together in a moist medium.
141. The reptiles made use of the freedom provided by this new reproductive mechanism and evolved into many different types which entered practically all of the available land habitats.

142. Some reptiles developed wings and flew while others turned back into the water.
143. The reptilian body as a whole became adapted to land living.
144. A thick, tough, horny body covering prevented excessive water evaporation. The heart became more efficient and the brain more highly developed, and many other internal organs advanced beyond those of the amphibians.
145. The oldest known birds were scarcely more than feathered reptiles.
146. The birds evolved from the reptiles.
147. The skeletons (of primitive birds) was typically reptilian, with a long tail and teeth attached to the jaws. Each wing had three fingers extending from it and these bore claws.
148. The only reason for identifying these skeletons as birds is the presence of a faint impression of feathers.
149. It is still questionable how flight evolved.
150. One theory (as to how flight evolved) states that these early birds lived in trees and learned to glide from branch to branch.
151. Another theory(as to how flight evolved) states that the ancestoral birds ran along the ground and with wings outstreached soared into the air.
152. The major structural changes that occured during the evolution of birds are practically all adaptations to aid in flight.
153. Feathers serve to streamline the body and to act in the wings and tail as resistant surfaces to push against the air.
154. The feathers (of birds) are probably modified reptilian scales.
155. The brain (of the birds) enlarged, but without an increase in intelligence.
156. The parts of the brain that enlarged were concerned primarily with sight, balance and the muscular coordination needed for flight.
157. The sternum (of birds) increased in size to afford greater area for wing muscle attachment and the bones hollowed out, making the body lighter.
158. The eyes developed into efficient organs for sight. The teeth were lost and a beak developed.
159. The creatures (birds) also became warm blooded and correlated with this was the development of an efficient circulatory system that brought a good supply of oxygen to the tissues.
160. As a part of the circulatory system (of birds) a four chambered heart developed.
161. The four chambered heart effectively separated the oxygenated blood from the nonoxygenated blood and so increased the efficiency of oxygen distribution.
162. The reptiles had scarcely began their long evolutionary history on earth when the mammals first appeared.
163. The first mammals were modifications of a primitive group of flesh eating reptiles.
164. The first mammals were small and probably were no bigger than modern mice and rats.

165. (The early mammalian) teeth were sharp and adapted for flesh eating, but it is believed that they fed mostly on insects and worms.
166. The brains (of the early mammals) were better than those of the reptiles, but not particularly well developed in comparison with modern mammals.
167. Some of the characteristics that developed in mammals include a modification of the reptilian mode of reproduction, warm blood, a better developed brain, and a change in the position of the limbs. Mammals retain their young within the body of the mother until they are quite well developed. They also have special glands, the mammary glands, which secrete milk for the nourishment of the young. They are warm blooded and have a gour chambered heart so that the production of energy is higher than in reptiles. The brain is large, resulting in a high degree of intelligence, and the limbs are directly under the body with the knees directed forward and the elbows back. This position of the limbs supports the body and enables the development of rapid locomotion. The teeth of mammals are quite specialized, and the ear drums are sunk below the surface of the head. Hair is a characteristic body covering.
168. There are three major groups of mammals: the monotremes, the marsupials and the placentals.
169. The monotremes are found only in Australia and Tasmania.
170. The monotremes are the most primitive of all mammals.
171. (The monotremes) still have many reptilian characteristics, including the habit of laying eggs which hatch in a nest.
172. The marsupials have a pouch on their abdomens in which they carry their young.
173. The young (of marsupials) are born prematurely and finish their development hanging onto a nipple within the pouch (on the mothers abdomen).
174. The kangaroo is the most generally known marsupial, though there are many others, including the opossum in the United States.
175. Practically all (of the marsupials), however, are confined to Australia and adjacent areas.
176. The placental mammals retain their young within the body of the mother longer than the monotremes and marsupials.
177. (In placental mammals) nourishment for the embryo is provided by the placenta.
178. (In placental mammals) this longer period of development before birth presumably gave these mammals an advantage for they have flourished and evolved into many successful animal types, including man.
179. The insectivores are small, primitive, insect eating placentals such as the mole and shrew.
180. The carnivores are the flesh eaters and include the seals, walruses, bears, cats, dogs, weasels, raccoons and others.
181. The herbivores are the hoofed animals.
182. Some (herbivores), such as the pig, cattle and deer, have two hoofs on each foot, while others, such as the horse have but one hoof per foot.

183. Bats are flying mammals.
184. (In bats), a flap of skin extends between the elongated finger bones and from the arm to the body to form the wings.
185. Whales are the largest of mammals.
186. Whales are entirely aquatic spending their entire life from birth to death in the water. The body has become streamlined and the fore limbs have become flippers. The hind legs are gone. A fish-like tail aids in swimming.
187. The primates are the group of mammals to which man belongs.
188. All of the primates are tree dwellers except a few forms like the baboon and man, who normally live on the ground.
189. The structural characteristics of primates are adapted for a life in trees.
190. (The structural characteristics) of primates include flexible limbs that permit climbing and swinging through the trees. Both the hand and the foot are grasping organs. The thumb and big toe are opposable to the other fingers. Most primates have a tail that is used in some as a grasping organ, though in the man-like apes and man the external tail is missing. The teeth are reduced in number as compared with those found in other mammals.
191. The eyes of primates are well developed
192. Stereoscopic vision, which permits the formation of a single image from the two eyes, appears (in the primates).
193. (Stereoscopic vision) gives greater depth of field and greater perspective.
194. In the monkeys, apes and man a special area, the central pit, is present on the retina that enables these animals to see greater detail.
195. (In the primates) the sense of smell is degenerate.
196. (The primate) brain is highly developed, resulting in a high degree of intelligence.
197. There are three main groups of primates: the lemurs, tarsius and the anthropoids.
198. The lemurs are small primitive primates.
199. The lemurs live in Asia and Africa.
200. Tarsius is (also) a (small primate).
201. Tarsius lives in East India.
202. Tarsius is intermediate in development between the lemurs and the anthropoids.
203. The anthropoids include the monkeys, the manlike apes, and man.
204. The monkeys are separated into two groups. One, the New World monkeys, lives in South America, the other group, the Old World monkeys, in Asia and Africa.
205. Monkeys are noted for their curiosity.
206. This (curiosity of monkeys) is due to a high degree of intellectual development that supposedly is the result of the combined effect of the well developed brain, the ability to sit up, the opposable thumb, and keen eyesight.
207. A well developed cerebrum is essential for intelligence.
208. The ability to sit up supposedly has contributed to the development of intelligence by freeing the hands for use in handling objects.

209. The opposable thumb enables the monkey to handle objects.
210. The keen eyesight (of monkeys) enables him to see more things to be curious about.
211. Man also has all of these characteristics (which the monkey has), and it is believed that man's intelligence is the result of the futher development of the same kinds of traits that are found in monkeys.
212. The manlike apes include the gibbon, orangutan, chimpanzee and gorilla.
213. (The manlike apes) are the closest of all the primates to man in physical development.
214. The skeleton (of the manlike apes) is very similar to man's.
215. The chest (of the manlike apes) is broad rather than narrow as it is in the monkeys and other mammals.
216. (In the manlike apes) the arms are larger and the legs are shorter than in man and the big toe is opposable, but the hand is very similar to the human (hand).
217. These animals (manlike apes) have an erect posture when swinging through the trees, whereas on the ground they usually progress on all fours.
218. Man differs from the apes in many ways, but the differences are all differences of proportion of basically similar parts.
219. The major differences (between man and the apes) are related to methods of locomotion and to the growth of the brain.
220. Man is erect and walks on the ground. This erect posture has resulted in a curved backbone that brings the trunk and head directly over the hips and thus centers the weight over the legs.
221. The foot (of man) is madified by a shortening of the toes and the expansion of the heel bone as a prop in back. The big toe is no longer opposable but it in line with the other toes. Man's foot is adapted for walking and is no longer a grasping organ.
222. The hand (of man) differs less from the ape's hand. It is still primitive and very useful as a grasping organ. The thumb remains opposable.
223. Man's face is shorter than the apes; the nose is more prominent and a chin projects from the lower jaw.
224. The teeth (of man) are smaller and weaker than the ape's.
225. The (human) brain is much larger, being two or three times greater than in apes, and man is more intelligent.
226. All primates including man evolved from a common ancestor.
227. (The common ancestor of all primates) was one of the most primitive of mammals, the aboreal insectivore.
228. Each of the modern types of primates evolved along a separate path resulting in lemurs, tarsius, monkeys, apes and man.
229. (Thus), man it should be understood, did not evolve from modern monkeys or apes, but both (man and modern apes) evolved along separate paths from a common ancestor.
230. The earliest man probably originated during the Pliocene period of the Cenozoic era and evolved into modern man during the Pleistocene period.

231. The Pleistocene period was approximately one million years long and was characterized by periods of glaciation.
232. (During the Pleistocene period) there were probably four successive ice sheets, with long periods of temperate to warm climates between the periods of glaciation.
233. The warmer periods (of the Pleistocene) were from ten to hundreds of thousands of years in length.
234. The most positive evidence of man's evolution consists of a number of human fossils.
235. (The human fossils) include the Piltdown man, (Eoanthropus dawsoni), the Heidelberg man (Homo heidelbergensis), the Java man (Pithecanthropus erectus), the Peking man (Sinanthropus pekinensis), the Neanderthal man (Homo neanderthalensis) and the Cro-Magnon man (Homo sapiens)
236. This list (above) does not include all of the human fossils but does include the best known ones.
237. There is no final agreement as to the exact sequence in which these early men appeared.
238. It is not certain that each of the fossil men represents a step in a single evolutionary path.
239. It is possible that early in human evolution there was a divergence so that two or more lines of human evolution may have occured.
240. The age of the rocks in which the fossils were found indicate that the Piltdown and the Heidelberg man lived during the early Pleistocene period.
241. The Java and Peking men were probably contemporaneous during the middle Pleistocene.
242. The Neanderthal and Cro-Magnon men lived during the late Pleistocene, with the Cro-Magnon man appearing somewhat later than the Neanderthal type.
243. The Piltdown man was found in Piltdown, Sussex, England in 1912.
244. The (Piltdown) fossil dates from the first interglacial stage in early Pleistocene and consists of pieces of skull, most of a lower jaw, nasal bones, a canine tooth and two cheek teeth.
245. A few crude tools were found associated with the bones (of Piltdown man).
246. The skull of Piltdown man is modern in type except for the bones, which are twice as thick as modern man.
247. The brain capacity (of Piltdown man) is 1300 ml.
248. The brain capacity of modern man ranges from 1200 to 1500 ml.
249. The jaw (of Piltdown man)is apelike and has a retreating chin.
250. The canine tooth (of Piltdown man) is also apelike while the cheek teeth are a type that coubd be found in either an ape or in a primitive man.
251. The Heidelberg man is represented by a lower jaw with attached teeth.
252. (The Heidelberg jaw) was found near Heidelberg, Germany.
253. (Heidelberg jaw) was recovered from rock of early Pleistocene formation.
254. (Heidelberg jaw) is apelike in that it is large in size and heavy in build and has no chin.

255. The teeth and dental arch (of Heidelberg jaw) are human in character.
256. (Heidelberg jaw) shows some similarities to the Java man and to the more recent Neanderthal man.
257. The Java man dates from the middle Pleistocene about 500,000 years ago.
258. The first find (of Java man) made in the East Indies included a skull cap, three teeth, and a femur.
259. Java man had some features that were human in character and some that were apelike.
260. The human characteristics of Java man are as follows: The brain capacity of the skull (940 ml.) is intermediate between apes (600 ml.) and modern humans (1200 to 1500 ml.). The median sagittal crest is absent. This is a prominent ridge of bone that extends from fromt to back along the middle of the skull in some apes. The femur has a straight shaft, and the position of the articular surfaces indicates that the muscle attachments were for an erect posture. The teeth are more human than apelike.
261. The apelike characteristics (of Java man) include heavy brow ridges. Also the forehead slopes back from the brow ridges which makes the vault of the skull low. The canine tooth of the lower jaw fits into a space between the teeth of the upper jaw. The wisdom teeth are not reduced. There is no chin, and the hole through which the spinal cord enters the cranium is visible from behing. This is not true of modern skulls.
262. The Peking man was found in a limestone cavern near Peking, China.
263. (At the Peking find) the remains of three dozen individuals of both sexes and both young and adults were discovered.
264. There are some differences between the Peking man and Java man, but they are not any greater than the differences among modern races of men.
265. The Peking man was a tool user because crude stone tools were found associated with the bones.
266. Likewise remnants of fires were found, indicating that the Peking man had learned its use.
267. Many brain cases had been opened from the botton, evidently by man himself. This is interpreted to mean that the Peking man was a cannibal.
268. The Neanderthal man was the first human fossil discovered.
269. The first discovery was made in the Neanderthal Valley near the Ruhr district in western Germany in 1856.
270. Since (the original discovery) many skeletons have been found in the following locations: Western Europe, Gibralter, North Africa, Italy, Croatia, Palestine, and Russia.
271. (The many locations in which Neanderthal finds have been made) indicates that the Neanderthal man had spread all over Europe.
272. (Neanderthal man) had heavy brow ridges, a receding forehead and a low vault to the brain case. There is no chin on the massive jaw.
273. The brain capacity (of Neanderthal man) was 1550 ml. which is as large as or larger than the cranial capacity of modern races, but it was due to increased capacity at the back of the skull rather than in the fore part as in modern man.

274. (Neanderthal) males were about 5 feet 4 inches tall and females about 4 feet 8 inches tall. The posture was stooped and the knees slightly bent.
275. Neanderthal man used flint tools.
276. Cro-Magnon man was first found in the Cro-Magnon vacinity of France.
277. (Cro-Magnon man)is believed to represent a race of man that replaced the Neanderthal type in Europe.
278. (Cro-Magnon man) was essentially modern. The head was large with no brow ridges, a high forehead, a prominent and narrow nose, and a well developed chin.
279. The cranial capacity (of Cro-Magnon man) was 1700 to 1800 ml.
280. The Cro-Magnon males were 6 feet or more in height.
281. The Cro-Magnon people disappeared at the end of the Pleistocene period and were replaced by modern man.
282. There is evidence that some of the people living in North Africa, Canary Islands, Iceland, North Germany, and Norway may be descendents of the Cro-Magnon man.
283. Modern man evolved during the late Pleistocene and became sub-divided into several racial types or sub-species.
284. The major races are the Negroids, the Mongoloids and the Causasoids.
285. (While) most human beings fit into one or the other of these categories (Negroid, Mongoloid or Caucasoid), there are many intermediate types and it is probable that at present there is no such thing as a pure race.
286. Man has always been nomadic, with the result that no human group has remained isolated long enough to prevent interbreeding with other races.
287. The Negroid race includes the dark-skinned people who have curly hair and long heads.
288. The Mongoloids are the yellow and the red-skinned people of the world. They have broad heads and straight hair.
289. Indians, Chinese, Japanese, Malays and Eskimos are Mongoloids.
290. The Caucasoid race or Caucasians are usually white-skinned, though they also have some pigment in their skin. Their head shape may be long or broad and their hair form is generally wavy.
291. Early in the history of life the stream of evolution divided into two branches, the animals and plants
292. The separation of living things into two kinds occured while life was still in its simple cellular stage.
293. The first plants were probably single cells that differed from their animal relatives by having chlorophyll.
294. The early plants lived in water.
295. Many of the descendants of the early plants, the thallophytes, still remain (living in water).
296. Some of the thallophytes (descendants of the early plants) have developed into large, complex, many-celled structures, though many are still single-celled.
297. During the time (Devonian) when the lobe-finned fish were climbing out on land to evolve into the amphibians, plants were also moving out of water.
298. (In fact), it is very probable that the plants preceded the animals on land, for the animals could not have remained there had there been no food available.

299. Some of the most prominent and successful of these early land forms were the seed ferns.
300. (Early seed ferns) grew to the size of modern trees, some of them having stems three feet in diameter.
301. (Early seed ferns) differed from modern ferns not only in size but also in producing seeds. Modern ferns do not produce seeds.
302. The seed ferns and their relatives, such as the tree-like horsetails and club mosses, flourished in wet, swampy ground. Many of them were preserved after death and changed through compression within the earth to form coal.
303. The gymnosperms, represented today by the evergreen, evolved after the ferns.
304. (The early gymnosperms) had straplike leaves rather than the needle-shaped leaves present in modern forms (of gymnosperms).
305. The true flowering plants appeared later, about the middle of the Mesozoic.
306. (The true flowering plants) were very successful land plants and spread over the entire earth.
307. Today they (flowering plants) are the dominant land plants, though representatives of other forms still exist.
308. The most direct evidence that all living things have developed by evolution is the evidence of fossils.
309. Fossils are the remains of animals and plants that lived during the past ages.
310. (Fossils) may be foot prints, animal burrows, leaf prints or any sort of indications of past life.
311. It is possible to determine the approximate time when fossil forms lived and also to determine the sequence of their appearance on earth.
312. From the study of sequence (of fossils) it becomes readily apparant that the simpler forms of life appeared first and that more complex forms followed, to be followed in turn by organisms still more complex.
313. The order of appearance of animal forms is first the simpler invertebrates, then the more complex invertebrates.
314. The complex invertebrates were followed by the primitive vertebrates, the ostracoderms.
315. (Following the appearnce of the ostracoderms) the fish then evolved and the amphibians came later, to be followed by the reptiles, birds and mammals.
316. Many of the forms that lived in the past are no longer present. It is true that representatives of all great animal groups can be found on the earth today, but countless forms related to each of the forms how living have ceased to exist.
317. Each major group evolved in its turn and produced a myriad of forms which spread over the earth into every available habitat. Then each group declined, leaving a few hardy members to continue the struggle for existence, but never again to fluorish and to dominate the earth.
318. As each group declined in numbers and types, a new group would appear. It (the new group) would produce millions of individuals and many new forms and then it, too, would eventually decline.

319. (Finally), the mammals appeared and today man, as a representative of this group of animals, dominates the living scene
320. All other evidence(besides that based on the fossil record) that supports the principle of evolution is based on one fundamental assumption. It is that similarity of organisms indicates relationship and that the degree of closeness of similarity runs essentially parallel to the closeness of kinship.
321. The validity of this assumption (that similarity of organisms indicates relationship) is apparant when it is considered in relation to human kinship. It is well known that some identical twins are so alike that their friends and even their families have difficulty in distinguishing between them. This likeness is due to their common heredity. Identical twins have the same kinds of genes because they develop from the same fertilized egg. Thus both likeness and relationship are as close as they can possibly be in any two living organisms.

The next most closely related humans are offspring, not identical twins, of the same parents. These are known as siblings. They are less alike than identical twins and also their relationship is not quite so close because they develop from different zygotes. They receive many of the same kinds of genes but also many different kinds of genes.

Cousins represent a human relationship that is still farthur removed from the identical twins. Their relationship is not so close as between either identical twins or siblings because their common ancestors are grandparents. They have fewer like genes in common, and they also have fewer characteristics in common.

Individuals of the same race have many characteristics in common, hence must have a common heredity from a common ancestor, but the ancestor lived many generations ago and the similarities are fewer than those found in cousins and siblings
322. On the basis of the assumption that similarity of structure indicates relationship due to inheritance from a common ancestor the entire system of classification is a genealogy of living forms.
323. All individuals belonging to a species are alike, and being related, they all have a common ancestor.
324. (Likewise), all species that are alike are related.
325. This relationship (between species) is indicated in the system of classification by placing similar species in one genus. Hence, the animals or plants belonging to a genus are related. Genera that are alike are grouped into families and like families into orders. Like orders are grouped into classes and classes into phyla. Finally all animal phyla are grouped on the basis of similarities into the animal kingdom and all plants into the plant kingdom.
326. Even the plants and animals have some characteristics in common, such as cells and protoplasm, so that they too show relationships.
327. The logical conclusion (based on the genealogy of living forms) is that all living things are related.

328. Some (living forms) are more distantly related than others, but the evidence of a common ancestor is to be seen even in the most dissimilar of forms.
329. If this relationship (among living organisms) is accepted it follows that evolution must have occured; for if no change had taken place all living things would be alike.
330. Evidence from the study of comparative anatony supports the theory that animals are basically alike and hence related even though they differ in superficial appearance.
331. In some organisms the similarities are obscured by modifications of organs as a result of adaptations to the environment.
332. (An example in which similarities are obscured as a result of adaptation can be seen in) the skeletal structure of the arm of man, the foreleg of a horse, the flipper of a whale, the wing of a bat and the wing of a bird. All are fundamentally the same but in each form the bones have become modified in relation to the particular function that each performs.
333. Structures that have a basic similarity but which have developed special functional adaptations are said to be homologus.
334. The study of embryology also contributes evidence of the fundamental similarity of animals.
335. During the embryonic development of animals similarities appear that would never be suspected on the basis of a comparison of adults.
336. Animals that differ only slightly as adults such as the dog and wolf or man and ape are so similar during the early stages of development that it is impossible to tell them apart. They look exactly alike. During the later stages of development the differences that are visable in the adult begin to appear.
337. Animals that are widely different as adults are more easily distinguished as embryos, but some similarities remain in the early stages.
338. For example (of similarities in the embryo) all animals begin development as a single cell, the zygote. All animals above the Protozoa go through a period of cell division which ends in the formation of a two layered gastrula. All animals from the flatworms up go through another common stage, which is the formation of the third layer of cells, the mesoderm.
339. Another very striking example of related but different organisms going through similar embryonic stages is that of the development of gill slits in the embryos of all vertebrates. In fish the gill slits appear in the embryo and remain in the adult as functional structures, but in amphibia, reptiles, birds and mammals they appear for a short time only during development and then disappear before birth.
340. The appearance of (these) gill slits in embryos indicates a genic complex causing their development. The only possible explanation of the presence of these genes in all vertebrate embryos is common ancestory.
341. On the basis of similarities found among all animals during embryonic development a theory has been proposed which states that during embryonic development every animal goes through developmental states that correspond to evolutionary stages which the ancestors of the animal have passed through. This is the Theory of Recapitulation.

342. An example to illustrate the theory of Recapitulation follows: The human embryo starts as a single cell, the zygote. This zygote supposedly represents the single cell stage of evolution that occured at the very beginning of life on earth. The next embryonic stage is cell division of the zygote into a "hollow ball of cells" stage called the blastula, which supposedly corresponds to the time in evolution when colonial Protozoa represented the highest development of life. In the following divisions of the zygote the embryo becomes a two-layered blastula, which corresponds to the two-layered animal stage represented in modern forms by the coelenterates. The next major embryonic step is the formation of mesoderm which presumably followed the evolutionary development of three-layered forms. The flatworms of today represent this evolutionary step. The appearance of gill slits in human embryos represents the fish stage of human evolution.
343. (Thus), it is possible to relate most of the stages of embryonic development with a corresponding stage in evolution and also with a modern animal type that apparantly stopped its evolutionary developmeht at one or another of the evolutionary steps.
344. The validity of this theory (of Recapitulation) is questioned, particularly in relation to its extension to include all embryonic stages and structures in an evolutionary sequence.
345. Obviously no animal can go through its entire evolutionary history in the short time it takes for embryonic development.
346. Many stages (in embryonic development) are telescoped and many more are left out entirely.
347. (Furthermore), many embryos have developed special structures that have no evolutionary significance beyond the aid they give the embryo in survival.
348. (Consequently), it is impossible to read the entire evolutionary history of an animal in its embryonic development.
349. (Nevertheless), it is probable that the embryo does repeat a few of the evolutionary stages of its ancestors, and in so far as it is possible to recognize these, the Theory of Recapitulation is valid.
350. All animals including man have certain vestigial anatomical structures that have no apparant use.
351. The appendix in man is such a(vestigial anatomical)structure.
352. The degenerate muscles by means of which a certain few human beings can wiggle their ears is another(example of a vestigial structure).
353. The coccyx or tail bones of the human skeleton represents another example of vestigial structures.
354. By comparing (the) structure (of vestigial organs) with similar organs in related forms it becomes apparant that they are vestiges or remnants of fully developed useful organs.
355. (For example), the human coccyx is a remnant that represents the tail vertebrae of other primates.
356. The development of the coccyx in any individual is due to genes which come from its ancestors.

357. (Presumably, therefore) man's ancestors had genes causing the development of a tail which in modern forms have been reduced in their effect so that a remnant only develops.
358. No other explanation (except a genetic one) is logical on the basis of out knowledge of inheritance.

PRINCIPLE II

The evolution of living things is, in the broadest sense, progressive and not regressive in nature.

1. Evolution seems to be progressive.
2. Within the total picture, the evolution of individual forms tells the same story. For example, the horse began as a small, five-toed creature that evolved in a more or less direct line into a large, single-toed animal.
3. The loss of toes (in the horse) was not sudden but gradual. During the millions of years that elapsed while the horse was evolving, some of the toes became gradually reduced in size and were lost, while one on each foot increased in size.
4. Other fossil animals and plants show this same progressive change (that the horse shows) by steps from one condition to another.
5. One explanation of this progressive evolution is orthogenesis, which claims that there is some unknown force within the organism that guides its evolution.
6. Another explanation of progressive evolution is natural selection.
7. The Theory of Natural Selection was proposed by Darwin.
8. According to the Theory of Natural Selection all organisms are engaged in a struggle for existence.
9. Each generation produces many more offspring than can possibly survive primarily because of limited food supply.
10. The offspring vary in their ability to compete for the available food and consequently during this competition some perish.
11. The offspring that perish in the struggle for existence are the less fit, those that survive are the most fit.
12. (Thus) Natural Selection results in the survival of the fittest.
13. The survivors (at any given time) then overproduce another generation and the competition and selection goes on.

PRINCIPLE III

Germinal variation is essential to the continuance of evolution.

1. In order that evolution can occur, it is necessary that different kinds of organisms be produced.
2. One source of new organisms is sexual reproduction.
3. Each generation of offspring of sexual parents differs in some respects from the preceding generation.
4. (Offspring of sexual parents differs from the preceding generation) due to the uniting of half of the genes from each parent in fertilization with the result that an organism somewhat different from the parents is produced..
5. It is known that according to the laws of heredity the degree of variation in organisms is limited.

6. (The) source of new organisms is limited because the number of different genes that can combine is limited.
7. Something besides sexual recombination of genes is necessary before evolution can continue indefinitely.
8. Some change in heredity must have occured to produce the millions of different living things that have inhabited or still inhabit the earth.
9. The additional necessary factor (additional to sexual recombination if evolution is to continue) is mutation.
10. This change in heredity is the essence of evolution.
11. There are different kinds of mutations, all of which involve a change in the mechanism of heredity, but the most fundamental is gene mutation.
12. Gene mutation is a change in a gene that results in the development of a new inherited trait.
13. It is believed at the present time that (gene mutation) is the source of all variations that result in evolution.
14. Years ago a Frenchman named Lamarch suggested that changes in the mechanism of heredity were brought about by the use or disuse of organs or parts of the body.
15. This (theory of Lamarck's) is known as the Theory of the Inheritance of Acquired Characters.
16. According to this theory (of Lamarck) the loss of toes that occured during the evolution of the horse resulted from the lack of use of such toes.
17. How the use of an organ apparently resulted in its change can be illustrated by the long neck of the giraffe. It was supposed that the giraffe got its long neck by stretching upward in search of food in tall trees.
18. This theory (of Lamarck) was very attractive because it explained so simply how animals and plants became adapted to their environments.
19. (According to Lamarck's explanation) many cave dwelling animals are blind because they did not use their eyes in the dark caverns.
20. Likewise (according to Lamarck), the whale became streamlined and developed flippers and a fish-like tail by living in the water where such body traits are useful.
21. As attractive as (the Theory of the Inheritance of Acquired Characters) is, it is probably not true, because we do not inherit characteristics of the body that are developed as a result of the direct effect of the environment.
22. We inherit but one thing and that is a complex of genes that is contained in the germ cells.
23. Changes in the body such as the enlargement of muscle through exercise or the skill and coordination that results from long practice do not affect the genes in the germ cells.
24. One can listen for a lifetime to good music and can practice day after day on a musical instrument and one's offspring will be no more musical than the genes will allow.
25. Changes within the genes contained in the germ cells can be caused by a number of different things.
26. In one kind of plant it was found that aging of the seed would induce mutations.

27. In the fruit fly high temperatures will cause mutations.
28. Most important of all environmental factors (in relationship to mutations) is irradiation by x-rays.
29. Earth radiation and cosmic rays also cause genes to change.
30. After the discovery that irradiation caused gene mutation, it was thought that the naturally occuring rays that come from the earth and from space would be sufficient to account for all of the mutations that occur spontaneously in animals and plants.
31. (But) it was found that many more mutations occur than could be accounted for on the basis of the amount of irradiation present.
32. Something else (other than naturally occuring rays), still unknown, causes the bulk of the mutations.
33. Nobody knows what the unknown factor is that causes the bulk of mutations.
34. Natural selection results in the survival of the fittest (of the mutants).
35. If one thinks of survival in terms of genes, it becomes obvious that the genes possessed by the survivors are the ones that are passed on the the next generation.
36. The genes of the individuals that perish are lost and no not contribute to the evolution of the population.
37. Add to this (concept of the survival of genes), the factors of isolation and mutation and it becomes evident how two or more different kinds of organisms can descend from a single common ancestor.

PRINCIPLE IV

The interaction of organisms with their environment results in a natural selection of certain organisms. The ultimate consequence of this selection is the origin of new species.

1. According to the Theory of Natural Selection all organisms are engaged in a struggle for existence.
2. Each generation produces many more offspring than can possibly survive primarily because of limited food supply.
3. The offspring vary in their ability to compete for the available food and consequently during this competition some perish.
4. The offspring that perish in the struggle for existence are the less fit, those that survive are the more fit.
5. (Thus) Natural Selection results in the survival of the fittest.
6. The survivors (at any given time) then overproduce another generation and the competition and selection goes on.
7. If one thinks of survival in terms of genes, it becomes obvious that the genes possessed by the survivors are the ones that are passed on to the next generation.
8. The genes of the individuals that perish are lost and do not contribute to the evolution of the population.
9. Add to this (concept of survival of genes) the factors of isolation and mutation and it becomes evident that two or more different kinds of organisms can descend from a single common ancestor.

10. Isolation means the separation of individuals of the same kind from each other so they cannot mate.
11. Isolation may result from migration where one group wanders off into new territory.
12. Isolation may result from physical changes in individuals within a single area so that such individuals cannot mate.
13. An example (of physical change of individuals within a single area preventing mating) is the change that occured in the copulatory organs of a type of fruit fly that prevented other flies from mating with it.
14. Social custom such as race prejudice that discourages interracial mating in human societies may result in a kind of isolation.
15. What ever the cause of isolation if two groups of organisms of the same kind are separated from each other they will evolve separately.
16. (When two groups of organisms of the same kind are separated) new mutations will occur in each group.
17. New genes (arising in separated groups) will be confined to the group in which they arose because there is no mating with other groups.
18. The result (in isolated groups) will be independent mutation and selection in each group and hence independent evolution.
19. If the environment of two isolated groups is the same the evolution may be parallel, but if it differs it is likely that the two lines of evolution will be different.