CONSIDERATIONS IN SELECTING, DEVELOPING, AND
VALIDATING LABORATORY EXPERIENCE UNITS IN
GENERAL BIOLOGY FOR PROSPECTIVE
ELEMENTARY SCHOOL TEACHERS

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CONSIDERATIONS IN SELECTING, DEVELOPING, AND
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GENERAL BIOLOGY FOR PROSPECTIVE
ELEMENTARY SCHOOL TEACHERS

DISSERTATION

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By

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CHAPTER I

INTRODUCTION

Purpose

The primary purpose of this study was to develop the considerations and techniques for the selection, development, and validation of laboratory experience units in general biology for prospective elementary school teachers. The completed laboratory experience units developed in this study may serve as resources of activities for college instructors who teach general biology to undergraduate majors in elementary education. For purposes of this study, the laboratory experience units were centered about those principles of general biology which an elementary school teacher should understand in order to teach about plants and animals.

Statement of the Problem

The problem of this study was to develop techniques for the selection, development, and validation of laboratory experience units in general biology, a procedure that could be used by college instructors of general biology to develop laboratory experiences for elementary education majors.
Definition of the Problem

The problem of this study was defined in two ways as follows: (1) Definition of Terms, and (2) Limitations of this Study.

1. Definition of Terms

Elementary education majors. -- Students enrolled in a curriculum designed to prepare them to teach in the elementary schools, grades one through six.

Laboratory experience. -- This term is given broad meaning to include one or more activities during a period set aside for student activities which may be used to assist students to gain meanings which collectively should help to effect an understanding of a principle of general biology. Some of the activities may include performing experiments and demonstrations, taking field trips, seeing films, observing biological phenomena, listening to recordings, or making a study of living things in the classroom.

Principle of biology. -- The definition of a principle of biology developed by Martin was used:

1. It must be a comprehensive generalization which resumes the widest possible range of facts within a domain of facts with which it is directly concerned. The facts resumed in the description must denote:
   a. Objects and/or events and the relations between them.
   b. Properties.

2. It must be scientifically true. To satisfy this criterion:
It must be verifiable, i.e., it must be stated so that it suggests directly or indirectly a definite operation of observation or experiment whereby its truth can be tested or verified.

b. It must be consistent with the body of scientific knowledge, and except for a few limiting or singular exceptions, with all the data (facts) relevant to it.¹

Content area of biology.— This term was used to refer to that portion of the study about plants and animals which was concerned with a group of related meanings, for example, Survival of Plants and Animals. All meanings pertaining to the aspect of survival of living things were grouped together, and constituted a content area of study about plants and animals.

Considerations.— This term was used to refer to those component parts of a process which were instrumental in guiding and effecting the selection, development, and validation of laboratory experiences.

Laboratory experience unit.— For the purposes of this study, an experience unit was considered to consist of two or more activities in general biology which centered about a principle of biology for the purpose of developing those meanings which should help students to understand some aspect

of a major principle of general biology. In some instances, a principle of biology resumed such a wide range of facts that it would be possible to develop more than one laboratory experience unit for that principle.

2. Limitations of This Study

The limitations of this study were as follows:

1. The laboratory experience units which were developed in this dissertation centered about those principles of general biology which are considered important for an elementary school teacher to understand, as ascertained from the opinions of a select group of elementary school teachers.

2. The college instructors who were asked to serve as judges for evaluating experience units in general biology were all from state teachers colleges and/or state colleges with programs for the preparation of elementary school teachers, and are members of the American Association of Colleges for Teacher Education.2

3. The criteria which were selected and developed as guides for the development of laboratory experience units were compiled from a survey of articles in selected educational journals and discussions in science books and manuals dealing with activities in biology for college students.

For purposes of illustration of the process of selection, development, and validation of laboratory units, only eight principles of general biology were selected as bases for developing units. These principles were rated by a select group of elementary school teachers as the most important principles of the 106 principles in the list, for teachers to understand in order to teach about plants and animals.

Significance of the Problem

One important aspect of instruction in biological science at most teacher training institutions is the provision of laboratory experiences. The noticeable trend is toward a goal of understanding the meaning of science rather than merely knowing about science. Educators in the field of biology are stressing the teaching of biological principles, or understandings about plants and animals.

In order for teachers to be effective in their role as leaders in elementary science education, they need a high quality of professional preparation. Powers pointed out that:


The program of liberal education must be supplemented with such additional education as will enable the teacher to meet specialized demands of professional service. In other words, the program of teacher education should be judged from the standpoint of its adequacy for professional education.

Science preparation should include the biological sciences as well as the physical sciences, including the kind of subject matter that is broad in scope and content, one that explores many areas within the large fields of natural science. Wells indicated that many specialized courses fail to meet the preparation of prospective elementary school teachers when he said:

Young folks who are going to teach in the elementary school or the secondary school are handicapped by the university conception of undergraduate science courses as vestibules leading directly into specialization in science on graduate levels. Accordingly, there is no broad offering in science as general education, no challenge to keep abreast with current scientific developments. Even the freshman courses are projected as pre-requisites in separate special fields. Those who do not specialize are far more numerous than those who do, but their broader, general orientation to science is not facilitated. In view of the recognized role of science in modern life and in general education today, and in view of the broader content needs of teachers, there should be

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concerted pressure for some arrangement whereby people who want to be generally intelligent about science in life and people who are going to teach science to children are not hamstrung by being carried from one vestibule of specialization in science and dropped there.7

Elementary school teachers experience difficulty in trying to orient or adapt this subject matter to the elementary school level. Baker states that courses for elementary school teachers should be professionalized to a greater degree than they have heretofore, and that much of the subject matter content and experiences related to this content should be such that the beginning elementary school teacher may find this material of some use.8 The Forty-Sixth Yearbook of the National Society for the Study of Education defines "professionalization" as "... a judicious selection of subject matter with respect to the use to be made of it and, second, a harmonious blending of subject matter and methods of instruction so that the student, while learning subject matter and methods of instruction, will see how it can be taught in the elementary school." 9


8A. Leroy Baker, "The Development of Science Content Courses for the Training of Elementary School Teachers," Science Education, XXV (February, 1941), p. 98.

9Forty-Sixth Yearbook, op. cit., p. 127.
If we are to professionalize the science content of the science courses for elementary school teachers, many of the principles considered essential for inclusion in a biology course should be realized and regarded as an important acquisition by a prospective elementary school teacher. Mere amassing of facts and general knowledge within a subject matter area may not necessarily be an assurance of an understanding of the many principles included within the subject matter area. Haupt pointed out that understandings of scientific principles should be the basic acquisition of a pre-service teacher in a broad course in science, so that teachers will have the understandings or means with which to help individuals to interpret their immediate environment.¹⁰

The methods which elementary school teachers are likely to employ in their teaching are often inspired by the way they themselves received instruction in science. Greenlee has this to say:

The way in which a teacher is taught is equally important as what is taught. We are not being fair to the prospective teacher when we provide him with no opportunities to participate in learning situations in which he has a possibility of attaining the same attitudes which we expect him to want in children. Traditional subject-matter organization does not contribute

sufficiently to these goals. For example, if we expect that a teacher will use a problem-solving approach in his teaching we must provide situations in which he will learn in the same manner. 11

Merrill supported the statements of Greenlee by saying that laboratory procedures should be employed which will (a) provide for an acquisition of principles of science and the many facts of science, and (b) are of the type which may be applied in some form to the instruction in the elementary schools. 12

If we are to prepare elementary school teachers to teach about living things, certain acquisitions of understandings of principles of general biology should be assured. To effect this, there is a need for ascertaining which principles of general biology an elementary school teacher should understand in order to teach about plants and animals. This analysis should provide college instructors with a list of principles of biology which should be included in a course which is to be designed for prospective elementary school teachers.


One of the media of instruction in effecting understandings concerning living things is the laboratory experience. In selecting and developing experiences for prospective elementary school teachers, problems arise as to how this may be accomplished, and which activities should be selected and/or developed. A source of some activities should also prove most helpful to instructors in teaching general biology.

**Outcomes of This Study**

1. A technique for selecting, developing, and validating laboratory experience units for prospective elementary school teachers.

2. A validated list of principles of general biology which elementary school teachers should understand in order to teach about plants and animals, based upon judgments of a select group of fifty-six elementary school teachers.

3. A list of criteria for the development of laboratory experience units in general biology for elementary education majors.

4. A number of activities centered about selected principles of general biology, and validated by a jury of instructors of courses in biological science in terms of the criteria selected for the development of the experience units. Each unit was assigned for the development of meanings which were likely to contribute to an understanding.
Procedure

Major Steps

The procedure for this study consisted of the following six major steps:

1. Formulating a list of principles of general biology.
2. Determining the comparative value of a list of principles of biology for the elementary school teacher, as judged by a jury of elementary school teachers and administration.
3. Formulating a list of criteria for the selection and development of laboratory experience units in general biology for prospective elementary school teachers.
4. Developing laboratory experience units in biology in terms of the criteria selected for this study.
5. Developing a rating scale for the evaluation of the laboratory experience units in biology.
6. Validation of eight laboratory experience units by a jury of college biology teachers.

Brief Summary of Procedures

In order to acquaint the reader quickly with the procedures utilized in this study, a brief summary of the procedures is presented. A more detailed statement of the procedures is included in the subsequent chapters which deal with aspects of the major steps outlined on this page.
1. **Principles of biology.**—A list of principles of general biology was compiled from reports of previous studies, and from a survey of elementary science textbooks and college biology textbooks. The tentative list of principles was checked by five college instructors for technical accuracy and completeness of coverage of principles of general biology.

2. **A jury to rate principles of general biology.**—The following bases were used to select elementary school teachers to membership in the jury:

   a. A strong interest in elementary science education as evidenced by having published articles in educational journals.
   
   b. The elementary school teacher was recommended by a leader in elementary science education.

   Each member of the jury was instructed to rate the importance of the list of principles of general biology in terms of a rating scale.

3. **Criteria for selecting and developing laboratory experience units.**—Eight criteria served as guides in developing experience units. The criteria were established after a survey of journals concerned with science education, books and manuals dealing with laboratory activities, and books emphasizing methods of science instruction.
4. Laboratory experience units in general biology.---
To illustrate the technique of selecting, developing, and validating laboratory experience units, eight principles of general biology with the highest rating were selected for development. Each unit of experiences consisted of two or more individual activities which collectively should help the student to understand either the entire principle of biology, or some aspect of a broad principle. Each unit was developed in terms of the eight criteria selected for this study.

5. Evaluation of the experience units in general biology.--- A four-point rating scale was developed by which the units were evaluated by a jury of college biology instructors. Eight judges evaluated the experience units according to the same criteria by which the units were developed.
CHAPTER II

PREVIOUS STUDIES AND RELATED LITERATURE

Introduction

It is the purpose of this part of the dissertation to review the professional literature that was of some value to this study. A review of the literature provided either a background for the understanding of some aspects of the problem of this study, or had a direct bearing upon and implications for this dissertation. Only those research studies were included which pertained to laboratory experiences, principles of biology, subject matter areas of general biology courses, and problems related to the understanding of plants and animals. The related studies are listed in chronological order as frequently as possible.

Related Studies

Baker conducted a study during the summer of 1938 to determine the content of college science courses. A questionnaire was sent to instructors of science in thirty senior colleges in Texas and to instructors of science in thirty junior colleges in Texas. Copies of the questionnaire were also sent to each of the seventeen senior colleges in the United States which Baker considered to
be the leaders in the field of science. Twenty-nine replies were received from the different institutions as follows: eleven senior colleges, nine junior colleges, and nine senior colleges from states other than Texas. The results indicated that:

1. Science instruction, including biological science, is a way of living, and that the organization of the course content is in terms of general principles.

2. Only four of the colleges indicated that they did not offer laboratory instruction, whereas fourteen colleges indicated that laboratory instruction ranged from two to four hours per week.

3. A definite trend was indicated toward the use of the laboratory as a problem-solving shop.¹

Baker states that "There should be some relationship between the science course and the elementary school teacher as exists between a professional course in law and the lawyer."²

Winokur in 1941 developed a biological science unit for purposes of orientation of students in the natural

¹A. Leroy Baker, "The Development of Science Content Courses for the Training of Elementary School Teachers," *Science Education*, XXV (February, 1941), pp. 97-98.

²Ibid., p. 61.
sciences. Winokur considered that textbooks of general biology are good sources of principles of biological science, and used these sources to establish the following five major principles of biology:

I. Life exists in the forms of living things.

II. All living things are similar in that they all perform the basic biological activities.

III. There is a great variation in the structural integration and organization of living things.

IV. The many different kinds of plants and animals on the earth today have evolved from other living plants and animals.

V. The physical and chemical properties and relationships of plants and animals constitute the knowledge of Man.\(^3\)

Winokur established the following categories of subject matter areas:

<table>
<thead>
<tr>
<th>Life and Death</th>
<th>Biotic Environment</th>
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<tr>
<td>Protoplasm and Cell</td>
<td>Health and Disease</td>
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<tr>
<td>Feeding</td>
<td>Reproduction</td>
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<tr>
<td>Digestion</td>
<td>Embryology</td>
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<tr>
<td>Circulation</td>
<td>Origin of Life</td>
</tr>
<tr>
<td>Respiration</td>
<td>Classification</td>
</tr>
<tr>
<td>Growth</td>
<td>Heredity</td>
</tr>
<tr>
<td>Waste</td>
<td>Evolution</td>
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</tbody>
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\(^3\)M. Winokur, "A Biological Science Unit for Orientation in Natural Science," *Science Education*, XXV (February, 1941), pp. 61-63.
Martin conducted a study in 1945 to determine the principles of biology of importance for general education. It was decided for the purposes of his study that lists of "needs" of individuals could be compiled from a study of various kinds of scientific materials in magazines and newspapers. These sources were very likely to include the many problems encountered in everyday living of individuals. Martin made an analysis of newspapers and certain magazines to determine the principles indicated in these sources. The assumption of his study was that a knowledge of certain biological principles is necessary for the individuals to understand the science content of the literature in newspapers and magazines. The article in each issue of the literature was given a reading, and statements were selected that met the following criteria:

1. If a literal and/or direct statement of the principle is made in the article.
2. If, though it does not state the principle directly, any statement from the article can be restated in such a way as to do so; or if the statement can be combined justifiably with an accompanying statement from the course, into an acceptable statement of the principle.
3. If, in the opinion of the investigator, a knowledge of the principle is necessary for clear understanding and appreciation of the true biological significance of the content of the article. This criterion is satisfied:

\[\text{Ibid.}, \ p. \ 64\]
a. If the content of an article relates unquestionably to a biological principle by furnishing a clear illustration of it;
b. If it includes a term, or terms, which are unquestionably related to a principle, and which require an understanding of the principle for an understanding of the term;
c. If it discusses or describes processes, interactions, or relationships which are unquestionably related to a principle.

As a result of Martin's analysis of sources of principles of biology, 300 major principles and 236 minor principles of biology were compiled. Each of the principles was checked for technical accuracy by science people. There were 2,573 statements assigned to Martin's principles of biology. A frequency of statements per principle was used to determine which principles received the highest rank.

As a result of an evaluation of 300 principles from the standpoint of their suitability as "objectives" for general education in the biological sciences, twenty principles received a very high rank and are listed as follows:

A List of Principles in the Decreasing Order of Importance

1. Infection by microorganisms is possible under the following conditions: (1) The infecting organism must enter the host in sufficient numbers; (2) It must enter by an appropriate avenue; (3) The host must be receptive.

2. All communicable diseases are caused by microorganisms.

3. The antitoxins produced by the body of an organism are specific.

4. The food requirements of every living thing are: fuels capable of yielding, when oxidized, the supply of energy without which life cannot continue; materials for growth and for replacement for the slight wearing away of the living tissues involved in any activity; minerals, the necessary constituents of cell structure, of cell products, and of the bathing fluid of cells.

5. Most cases of fermentation, souring, and putrefaction are brought about by living organisms.

6. Reproduction is a fundamental biological process that provides for the continuance of life on earth by providing new individuals.

7. A parasitic organism harms its host in various ways and to various degrees, by actively attacking the tissues, by shedding poisons (toxins) which are distributed throughout the body of the host, by competing with the host for food, or even by making reproduction of the host impossible.

8. Food, oxygen, certain optimal conditions of temperature, moisture, and light are essential to the life of most living things.

9. Circulation is carried on in all living organisms. With increase in size and complexity of the body of an organism there goes a corresponding elaboration of transportation (circulatory) system.

10. The biological functions of color are to conceal, disguise, or to advertise.

11. Protective adaptations aid survival.

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

12.5 The protoplasm of a cell carries on continuously all the general processes of any living
body; the processes concerned in the growth and repair of upbuilding of protoplasm (anabolism) and the processes concerned with the breaking down of protoplasm and elimination of wastes from the cell (catabolism). The sum of all these chemical and physical processes is metabolism.

14. Enzymes, vitamins, and hormones are chemical regulators (stimulators and suppressors) of the reactions that occur in living organisms.

15. The surface of the earth and the atmosphere surrounding the earth are undergoing constant changes; therefore in order to survive, organisms must migrate, hibernate, aestivate, build artificial shelters or otherwise become adapted to these changes.

16. All gradations of association occur in intimate associations between organisms, from those which are mutually beneficial to the individuals concerned (symbiosis) to those in which one member secures all the advantage at the expense of the other (parasitism).

17. All plants and animals are engaged in a constant struggle for energy.

18. Cells are organized into tissues, tissues into organs, and organs into systems, the better to carry on the functions of complex organism.

19. Digestion accomplished two things; it makes food soluble in water, thus enabling the nutrients to pass through membranes and thereby reach and enter cells; it reduces complex nutrients (fats, proteins, and carbohydrates) to simple building materials which in turn can be rebuilt into whatever living material or structural feature is necessary at the place of use.

20. A balance in nature is maintained through interrelations of plants and animals with each other and with their physical environment.

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6Martin, op. cit., p. 155.
In order to establish one hundred principles for general biology, Martin used the aggregate rank of the 300 principles of biology on three measures as follows:

1. The total frequency of appearance of each major principle in the textbooks and lists of research studies.
2. The total frequency of assignments of statements from the magazine and newspaper articles to each major principle and its related minor principles.
3. The totals of values assigned to each major principle by the evaluators.7

Martin suggests that although the major list consists of many principles, too many to be included in an introductory course in biology, that the topmost principles in the list of one hundred principles be considered the essential ones for general education. The instructor should include as many of the topmost principles in an introductory course in biology as there is time for their development.8

Bullington conducted a survey of 720 colleges, 118 of which were teachers colleges, to determine the types of courses used in the various science fields. It was indicated that there were four general categories of courses in biological science as follows:

1. A general biology course of two semesters' duration, 35 colleges reporting.

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7Martin, op. cit., p. 162.
8Martin, op. cit., p. 162.
2. A single subject course in biology designed for non-majors, 28 colleges reporting.

3. Biological science of one-semester duration, paired with a companion physical science course for a total of six semester hours, 17 colleges reporting.

4. A survey course, including material from the physical and biological sciences, 17 colleges reporting. 9

Bullington stated that further development of survey courses is contemplated less and less, and that the more common type of course in biology is one that extends through one year of study. Twenty-two out of thirty-three teachers colleges reported that their two-semester courses in biology are usually coupled with another six-hour course in physical science. 10

From another study by Bullington, the following are considered to be the most common teaching practices and materials in courses in biological science:

Field trips
Motion pictures
Slides and/or filmstrips
Charts, maps, models
Demonstrations


10 Ibid., p. 241.
Individual student project
Group student project
Term paper (long)
Short papers
Required student notebook
Text of syllabus reading
Supplementary reading
Student demonstrations
Book reports

Van Deventer pointed out in his study of trends and problems in general education science courses that a broader concept of the meaning of "laboratory experience" is needed. He indicated that any experience which helps to solve broad or real problems and helps to realize understandings of principles of science may well be termed a laboratory experience. This may include such activities as listening to recordings, making surveys, and several of the activities or practices indicated in Bullington's list of the most common teaching practices and materials used in teaching biological science.

Van Deventer indicated that many of the courses being structured in colleges in the field of science are of the block and gap type wherein completeness of coverage in the many areas is sacrificed for depth of development.


13 Ibid., p. 189.
Todd reported a course in natural science that was used and subsequently modified at Colgate University. This course in natural science is a one-year course, one semester of which is biological science. The course of study was designed as a terminal course, rather than as a course for more advanced studies in biology. The seven problems considered each semester in biology are as follows:

1. Does Blood Circulate?
2. Why Do We Breathe More Rapidly When Exercising?
3. Why Does the Body Contain Useless Parts?
4. How Is Skin Color Inherited?
5. What Is Life?
6. Can Life Arise from Non-Living Substances?
7. How Is the Earth's Food Supply Continually Renewed?  

Surveys of student opinions conducted by Todd indicated that those problems centering around the human body were voted most important.  

Reynolds reported data dealing with the trends and present status of generalized science in state teachers colleges in 1950. The conclusions that were reached were based on a study of 118 teachers colleges during 1938, and 79 state teachers colleges in 1948. The conclusions reached by Todd were as follows:

1. In 1938, generalized science was a required subject in 78 per cent of the colleges.

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15 Ibid., p. 76.
whereas 85 per cent of the colleges reported this requirement in 1948.

2. Whenever biological science was included in the survey program, two courses were usually offered; one course in biology, the other in physical science.

3. Changes in science requirements were noted in the curricula of elementary education majors; 11 per cent of the state teachers colleges required biological science in 1930, whereas 20 per cent of the colleges required biological science in 1948.15

McFadden reported in his study of trends in the teaching of biology that major concepts in history were receiving much attention in science courses. The main theme is the development of concepts about several topics in biology.17

Cronkhite conducted a study of the science teaching in the state teachers colleges of the Northwest in 1951. He indicated that the prevalent feature that is characteristic of the changes which took place during the change of two-year normal schools to four-year teachers colleges was the


increase in the number of courses in the science curricula. General education courses in science increased in number, whereas courses dealing with teaching methods did not increase in number, nor have they ever constituted a prominent part of the curriculum in the past. Specially designed content courses for teachers, which were a vital part of the preparation of elementary school teachers in the past, appear to be on their way out. Cronkhite pointed out that science courses which were developed to meet very specific needs of teachers in content material did not prosper. Science courses were found to be of the following three types: (1) subject matter courses which comprised 82 per cent of the total; (2) general education courses, 13 per cent; (3) methods and special content materials course, 5 per cent of the total.18

Bullington made an extensive study of the subject matter content of general education science courses in 1952 by examining 150 college-level science courses. The following types and number of courses were examined:

A. Courses in biological science, 52 courses of study examined.
B. Physical science, 51 courses of study.

C. General type courses which included both physical and biological science, 17 courses of study.

D. Single-subject courses designed for general education, 28 courses of study.

Student interests, student needs, and analyses of course objectives were found to be the principal criteria for determining the content of general education courses. The most common change that was noted in the development of many courses of study was the reduction in the number of topics, and a thorough development of a few areas in natural science.\(^1^9\)

On the basis of his study of college-level general education courses of study in science fields, Bullington grouped the different courses in biological science as follows:

1. A survey of the plant and animal kingdom; one-half Botany, one-half Zoology [these are courses to prepare the student for further work in biology and to provide for the general student].

2. Courses organized around basic principles or processes [respiration, reproduction, photosynthesis, and minor attention to morphology and taxonomy].

3. Man centered [these courses are concerned with the biological processes in man, and

deal with plants and animals only insofar as they apply to man's general welfare in some way).

4. Courses organized around main topics: Organism and the Environment (studies are made of the dynamic activities of the organisms in the environment emphasizing their relationship and interdependence).

5. Courses based on a few selected problems (some of these problems deal with the origin of life, reproduction, evolution, and others).20

Bullington reported that the following topics received major emphases in courses of study in biology, and listed the topics in order of frequency as follows:

1. Principles of Genetics
2. Evolution
3. Protoplasm and the Cell
4. Reproduction in Man
5. Foods and Digestion
6. Blood and Circulation
7. Nervous System and the Senses
8. Excretion
9. Metabolism
10. Endocrine System
11. Health, Diseases and Immunity
12. Mitosis and Meiosis
13. Photosynthesis and Respiration in Plants
14. Reproduction in Plants
15. General Ecology21

The following topics received moderate emphasis in courses in biological science that were designed as general education courses, but not listed in order of frequency:

Tissues and Organs
Anatomy of the Frog

20 Ibid., p. 289.
21 Ibid., p. 290.
In response to questionnaires requesting information about the teaching of biology for purposes of general education, twenty-five teachers, most of whom were members of the National Association for Research in Science Teaching during 1952, complied with Washton's request. Washton found that the majority of these educators indicated the following:

1. Teach biological principles pertaining to behavior, reproduction, heredity, and evolution in order that students may be provided with the necessary knowledge, skills, and attitudes to
   a. attain an emotionally stable personality and make a worthy social adjustment;
   b. be better fit for successful family and marital relationship.

2. To teach principles pertaining to heredity and evolution in order that students
a. understand the social, economic and spiritual forces at work in society and develop a sense of social responsibility;
b. participate more effectively in solving problems of contemporary society;
c. recognize the interdependence of the different peoples of the world.

3. To teach principles pertaining to nutrition in order that students
a. understand the place of the consumer in society and learn to become intelligent consumers of goods, services and time;
b. participate more effectively in solving problems of contemporary society.

4. All of the principles of biology should be emphasized to students in terms of the following objectives of general education:
a. gain a better understanding of the meaning of and purpose of life and a truer sense of value;
b. maintain and improve their health and share in the responsibility for protecting the health of the community;
c. utilize a scientific approach in solving problems dealing with society and human welfare.\(^2\)

Washton recommended that the following areas of biology should be studied in the sequence as listed, and that principles pertaining to these areas should also be studied in this order:

A. Protoplasm and the Cell
B. Energy and Life
C. Ecology, Plant-Animal Relationships

---

Consolidating the lists of principles of biology suggested by Downing in 1932, Winokur in 1941, and Martin in 1945, Washton developed a set of forty-two principles for a general education course in general biology. Principles were actually developed for the purpose of constructing an outline for a course of study, or a syllabus. Each principle listed by Washton was compared with those principles listed by other authors to assure their inclusion in the new list.

Wilson conducted a survey of the general education science courses in Southern Association of Junior and

---

24 Ibid., p. 238.


Senior Colleges during 1952. For the purposes of his study, Wilson defined a general education science course as "... one that has as its major purpose the development of attitudes toward an understanding of science which are important in the education of citizens regardless of their future vocations." Seventy-six per cent of the teachers colleges were known to have integrated courses. Wilson pointed out that integrated courses are courses that cut across various subject matter fields. No one text has been found to be popular among teachers colleges. Wilson lists the following textbooks in biology, in order of frequency of adoption, during 1952: General Biology, by Mavor; Man and His Biological World, by Jean et al.; Life Science, by Laubenfels; Biology the Human Approach, by Villee; and The World of Life, by Pauli. At least one half of the courses in biology included in the curriculum in colleges in the Southern Association were one year courses in biology with six semester hours of credit. The integrated courses in biology were not accepted generally toward a major in science. Most of the courses were of the survey type, and included studies of problems. Teachers colleges rated the social implications of science much higher than did other types of senior or junior colleges.

colleges. The general subject matter content of courses in biological science in the colleges of the Southern Association were estimated to be as follows: Human Biology, 35 per cent; Zoology, 35 per cent; Botany, 20 per cent; and miscellaneous topics, 10 per cent.\(^{30}\)

Lawson outlined the main areas of content in the biological science part of the Natural Science Program at Michigan State College. Emphasis was upon a few areas of study rather than upon all fields of biology, as is frequently attempted in a survey course. Areas of content were selected in terms of the following criteria: (a) The area should illustrate a method of science, (b) The area should be one in the history of the development of science and should exemplify a fruitful generalization, (c) The area should be teachable and of interest to students, (d) The area should have some bearing and implication for the life of the students. An attempt was made in this course to use the Harvard Case History Approach by structuring the historical accounts of the development of discoveries. The areas of study included: I. Meanings of Hypotheses; and II. Reproduction and Heredity. Reproduction was considered as an opportunity to relate objects and

\(^{30}ibid., pp. 294-295.\)
Interpolate observations. Heredity was studied from the standpoint of introducing the conceptual scheme as being a form of generalization.\textsuperscript{31}

Van Deventer in his study of laboratory teaching in college basic science courses pointed out that much of the initial purpose of laboratory work was lost in a maze of cookbook-type of laboratory manuals. Van Deventer listed three possible approaches to laboratory teaching: "(1) The repetition of classical experiments from the history of science; (2) The case study method; (3) The problem approach."\textsuperscript{32} It was pointed out that the problem-solving approach should be the one which should predominate in laboratory work since the problems concern the everyday living of the individual. Although it is true that many of the problems are imposed upon a student, still, these problems were found to predominate in the thinking of students and were likely to appear.\textsuperscript{33}

Andrews and Breukelman made a study of the biology requirements of 152 midwestern colleges and universities. It was found that in teachers colleges, non-major and science

\textsuperscript{31}Chester A. Lawson, "General Education in the Natural Sciences," \textit{The Science Teacher}, XX (March, 1952), pp. 56-69.

\textsuperscript{32}W. C. Van Deventer, "Laboratory Teaching in College Basic Science Courses," \textit{Science Education}, XXXVII (April, 1953), pp. 159-162.

\textsuperscript{33}Ibid., p. 163.
major students were more likely to be put into the same required biology course than in any other group of colleges. Plants were emphasized less than animals, and biology courses of less than six hours were more common. Regarding the number of colleges requiring biology in the basic curriculum, data indicated the following: 52 out of 152 colleges, or 34 per cent of the colleges in this study required biology; in teachers colleges, 24 out of 58, or 41 per cent of the colleges required biology.34

Shawver reported the development of a science program in teacher education at Madison College during 1954, and projected plans for including a professionalized course in biological science. The success with the program to date warrants the inclusion of a course of the type that represents their physical science. It was recommended that the science preparation of teachers should include eight semester hours in the physical sciences and four hours in biology, or a total requirement of twelve semester hours in science.35

The study of Winler is of interest in that he indicated the areas of study included in the biological


science course at the Iowa State Teachers College during the college year of 1954. Biology at this teachers college is studied from the standpoint of considering issues that are important for personal-social needs. The issues included in the content areas of biological science were as follows: "Conservation, Regional Planning, Sex Education, Man's Origin and Development, Quality of Population, Racial Inequality."36

Merrill conducted a dissertation study in 1952 to develop a course of study in science for the education of elementary education majors at Radford College in Virginia. Several aspects of science teaching were investigated, including laboratory work. Merrill stated that laboratory work should be conducted in such a way that will make it possible for students to gain knowledge and understandings, and at the same time provide an instructional procedure for students to witness and employ that can be applied to the teaching of science in the elementary school.37

Merrill stated:

The content (here Merrill is referring to the content of science courses, physical as well


as biological science I should be selected from the various compartments of science without regard to lines of division. Principles, facts, and generalizations should be associated with every day activities. . . . In other words, science for elementary [school] teachers should be a combination of appropriate subject matter and methods of teaching which will develop effective teachers, who are secure in their knowledge of children and science and the methods of using it.38

One of the forms of laboratory experience is the field trip. Merrill lists several specific suggestions which should contribute to successful trips. The following points should be covered in the outline of the trip:

a. Statement of the objectives of the trip.
b. The time and place for departure, and the time to get back.
c. Directions for getting to the selected spot.
d. Things to be done and seen.
e. Precautions to be followed.
f. Type of reports desired and the date for the reports.
g. References to be looked up.39

Merrill reported that conservation is one of the topics that is frequently reported as part of the areas of study in biology courses. Merrill suggested the following activities to help the student to learn more about conservation practices:

a. Visit sections of the campus and park as well as farms to see and compare wise and unwise land use.

38 Ibid., p. 31.
39 Ibid., p. 40.
b. Try various methods of control on a small section of eroded land (herein are opportunities to use plants in conserving land).

c. Talk with farm agents and farmer about the most desirable crops for the type of soil in the locality and the ways of cultivation that are best suited to the soil (herein are possibilities of surveys as laboratory experiences).

d. Study the relationships between the land coverage in forests and fields and drainage and the relationship between drainage and erosion (field studies).

e. Get information from the national and state agencies on erosion and conservation.

f. Cooperate with such agencies as 4-H clubs in their conservation program.

Merrill analyzed eight series of textbooks of elementary science to determine the subject matter content that is generally reported. The subject matter was centered about the following topics and is not listed in order of importance.

1. The common types of plants and animals.
2. Special studies of mammals, birds, insects, reptiles, and spiders.
3. Special studies of trees and common plants.
4. The structure and function of leaves, and flowers.
5. Garden plants and foods.
6. Animals and plants used for food, shelter and clothing.
7. Seasonal changes in plants and animals.
8. Plants and animals of the past.
9. Man—his structure and functions.
10. The balance of nature.
11. Plant and animal breeding.

12. Plant and animal pests and their control.
13. Personal and community health.

Summary

1. With few exceptions, most of the colleges surveyed in the research studies that were reported in this chapter offer some laboratory experience as part of the instruction in biological science.

2. Courses in biological science appear to be organized in terms of general principles, and center around a few topics instead of many topics in the field of biology. A breadth of coverage of many areas in biological science is sacrificed for depth of development of a few topics.

3. Courses dealing with general education in the biological sciences increased in number at teachers colleges, whereas those organized as courses in methods of teaching elementary school science did not prosper.

4. Individual student activities, demonstrations, and field trips were listed among the most common practices utilized in instruction in biological science.

5. Research workers attempted to ascertain the principles of biology as objectives of general education, but no effort was taken to determine how essential such objectives were from the standpoint of the elementary school.

Ibid., pp. 54-55.
teachers. Since the elementary school teacher is actually involved in the teaching-learning situation, it would be reasonable to expect that judgments of these teachers concerning the kinds of understandings a teacher should have, would be most enlightening.

6. Research reveals that there should exist some relationship between the elementary course in biological science and the prospective elementary school teacher. Some colleges experienced success with courses in science which were professionalized to improve teacher education in science. It was stated in the literature by several people that experiences in science should be so organized as to make it possible for students to experience the use of such methods as might prove helpful to future elementary school teachers.
CHAPTER III

FORMULATING A LIST OF PRINCIPLES
OF GENERAL BIOLOGY

A Tentative List of Principles
of General Biology

A tentative list of principles of general biology was compiled utilizing sources such as educational periodicals, elementary science textbooks, and college textbooks of biology. A tentative list of 104 principles of general biology, prior to evaluation by college instructors, is included in Appendix A.

Principles of Biology as Reported in Periodicals

The list of twenty principles of biology as the "objectives" of general biology enumerated by Martin and listed in Chapter II, the list of principles of biology for general education as established by Martin¹, and Washton's² list of forty-two principles of biology for general education were found to be excellent sources of principles of biology.


Survey of Textbooks in College Biology

To assure coverage of those principles of biology which are most frequently listed in college textbooks, twenty-one textbooks listed in Table I were examined.

TABLE I

FREQUENCY OF ADOPTION OF TEXTBOOKS IN BIOLOGY FOR COURSES IN BIOLOGICAL SCIENCE WHICH ARE REQUIRED OF ELEMENTARY EDUCATION MAJORS AT FIFTY STATE TEACHERS COLLEGES AND STATE COLLEGES FOR THE YEAR 1955-1956

<table>
<thead>
<tr>
<th>Title of the Textbook</th>
<th>Author(s)</th>
<th>Frequency of Adoption</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Biology</td>
<td>Strausbaugh-Weimer</td>
<td>6</td>
</tr>
<tr>
<td>Biology: Its Human Implication</td>
<td>Hardin, G.</td>
<td>4</td>
</tr>
<tr>
<td>Principles of Biology</td>
<td>Whaley, et al</td>
<td>4</td>
</tr>
<tr>
<td>General Biology</td>
<td>Kenoyer, et al</td>
<td>4</td>
</tr>
<tr>
<td>The Biotic World and Man</td>
<td>Milne-Milne</td>
<td>3</td>
</tr>
<tr>
<td>Biology</td>
<td>Vilee</td>
<td>3</td>
</tr>
<tr>
<td>Principles of Modern Biology</td>
<td>Maraland-Douglas</td>
<td>2</td>
</tr>
<tr>
<td>General Biology</td>
<td>Mayor</td>
<td>2</td>
</tr>
<tr>
<td>Introductory Biology</td>
<td>Stauffer</td>
<td>2</td>
</tr>
<tr>
<td>Man and the Biological World</td>
<td>Rogers, et al</td>
<td>2</td>
</tr>
<tr>
<td>Brief Biology</td>
<td>Mavor</td>
<td>1</td>
</tr>
<tr>
<td>Biology: The Science of Life</td>
<td>McDougall-Heggner</td>
<td>1</td>
</tr>
<tr>
<td>Man and His Biological World</td>
<td>Harrah, et al</td>
<td>1</td>
</tr>
<tr>
<td>Elements of General Biology</td>
<td>Barrows</td>
<td>1</td>
</tr>
<tr>
<td>New Introduction to Biology</td>
<td>Kinsey</td>
<td>1</td>
</tr>
<tr>
<td>A Textbook of General Biology</td>
<td>White</td>
<td>1</td>
</tr>
<tr>
<td>Biology</td>
<td>Stanford</td>
<td>1</td>
</tr>
<tr>
<td>This Biotic World</td>
<td>Milne-Milne</td>
<td>1</td>
</tr>
<tr>
<td>A Survey in Biological Science</td>
<td>Young, et al</td>
<td>1</td>
</tr>
<tr>
<td>General Biology</td>
<td>Beaver</td>
<td>1</td>
</tr>
<tr>
<td>Human Biology</td>
<td>Baisell</td>
<td>1</td>
</tr>
<tr>
<td>Fieldbook of Natural History</td>
<td>Palmer</td>
<td>1</td>
</tr>
<tr>
<td>Science for the Elementary Teacher</td>
<td>Craig</td>
<td>1</td>
</tr>
<tr>
<td>Teaching Science in the Elementary School</td>
<td>Burnett</td>
<td>1</td>
</tr>
</tbody>
</table>
A survey was made to determine which textbooks in biology were most frequently adopted in courses in biology which are required of prospective elementary school teachers. Fifty colleges submitted courses of study of the required courses in biological science, and included at the same time the names of the textbooks that were used in these courses. Four colleges reported that they did not use a textbook, and in two instances books dealing with the methods of teaching science were used in place of an actual textbook in college biology.

In addition to the twenty-one textbooks listed in Table I, two other books were examined: (1) The World of Life, by Paul; and (2) Life Science, by Thomas Hall and Florence Moog.

In summary, the following may be said about the adoption of textbooks in courses in biological science which are required of elementary education majors:

1. There was no textbook in this survey that was used by a majority of instructors. The maximum frequency of adoption of any one text in biology was six.

2. Fifty respondents indicated that they were using twenty-four different textbooks in their courses in biology for teachers.

Colleges submitting data for this study. In addition to the names of textbooks, the courses of study in biology
helped to clarify some of the trends with respect to the subject matter content and methods of instruction in courses in the biological sciences. In some instances, the courses of study contained lists of principles which were developed by the instructor of the course, hence serving as additional sources of principles of general biology.

The following is a list of names and locations of the colleges that submitted their courses of study in biological science, including the name of the textbook that was used in a particular course in biology during the academic year 1955-1956:

- Alabama (Troy) State Teachers College
- Arizona (Tempe) Arizona State College
- Arkansas (Arkadelphia) Henderson State Teachers College
- Arkansas (Conway) Arkansas State Teachers College
- California (Long Beach) Long Beach State College
- Colorado (Alamosa) Adams State College
- Colorado (Greely) Colorado State College of Education
- Illinois (Charleston) Eastern Illinois State College
- Illinois (DeKalb) Northern Illinois State Teachers College
- Indiana (Muncie) Ball State Teachers College
- Kansas (Hays) Fort Hays Kansas State College
- Kansas (Pittsburg) Kansas State Teachers College
<table>
<thead>
<tr>
<th>State</th>
<th>City</th>
<th>Institution Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kentucky</td>
<td>Murray</td>
<td>Murray State College</td>
</tr>
<tr>
<td>Kentucky</td>
<td>Richmond</td>
<td>Eastern Kentucky State College</td>
</tr>
<tr>
<td>Louisiana</td>
<td>Natchitoches</td>
<td>Northwestern State College</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Boston</td>
<td>State Teachers College at Boston</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>Framingham</td>
<td>State Teachers College</td>
</tr>
<tr>
<td>Michigan</td>
<td>Kalamazoo</td>
<td>Western Michigan College of Education</td>
</tr>
<tr>
<td>Michigan</td>
<td>Marquette</td>
<td>Northern Michigan College of Education</td>
</tr>
<tr>
<td>Michigan</td>
<td>Mount Pleasant</td>
<td>Central Michigan College of Education</td>
</tr>
<tr>
<td>Minnesota</td>
<td>St. Cloud</td>
<td>State Teachers College</td>
</tr>
<tr>
<td>Missouri</td>
<td>Maryville</td>
<td>Northwest Missouri State College</td>
</tr>
<tr>
<td>Missouri</td>
<td>Springfield</td>
<td>Southwest Missouri State College</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Chadron</td>
<td>Nebraska State Teachers College</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Peru</td>
<td>Nebraska State Teachers College</td>
</tr>
<tr>
<td>Nebraska</td>
<td>Wayne</td>
<td>Nebraska State Teachers College</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>Plymouth</td>
<td>Plymouth Teachers College</td>
</tr>
<tr>
<td>New Jersey</td>
<td>Jersey City</td>
<td>State Teachers College</td>
</tr>
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<td>New Jersey</td>
<td>Newark</td>
<td>State Teachers College</td>
</tr>
<tr>
<td>New Jersey</td>
<td>Trenton</td>
<td>State Teachers College</td>
</tr>
<tr>
<td>New York</td>
<td>Brockport</td>
<td>State University Teachers College</td>
</tr>
<tr>
<td>New York</td>
<td>New Paltz</td>
<td>State University Teachers College</td>
</tr>
<tr>
<td>North Carolina</td>
<td>Cullowhee</td>
<td>Western Carolina Teachers College</td>
</tr>
<tr>
<td>North Dakota</td>
<td>Minot</td>
<td>State Teachers College</td>
</tr>
<tr>
<td>State</td>
<td>College</td>
<td></td>
</tr>
<tr>
<td>-----------------------</td>
<td>----------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Oklahoma (Tablequah)</td>
<td>Northeastern State College</td>
<td></td>
</tr>
<tr>
<td>Oregon (Ashland)</td>
<td>Southern Oregon College of Education</td>
<td></td>
</tr>
<tr>
<td>Pennsylvania (Bloomsburg)</td>
<td>State Teachers College</td>
<td></td>
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<tr>
<td>Pennsylvania (East Stroudsburg)</td>
<td>State Teachers College</td>
<td></td>
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<tr>
<td>Pennsylvania (Indiana)</td>
<td>State Teachers College</td>
<td></td>
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<tr>
<td>Pennsylvania (Millersville)</td>
<td>State Teachers College</td>
<td></td>
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<tr>
<td>Pennsylvania (West Chester)</td>
<td>State Teachers College</td>
<td></td>
</tr>
<tr>
<td>South Dakota (Madison)</td>
<td>General Beadle State Teachers College</td>
<td></td>
</tr>
<tr>
<td>South Dakota (Springfield)</td>
<td>Southern State Teachers College</td>
<td></td>
</tr>
<tr>
<td>Texas (Denton)</td>
<td>North Texas State College</td>
<td></td>
</tr>
<tr>
<td>Texas (San Marcos)</td>
<td>Southwest Texas State Teachers College</td>
<td></td>
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<tr>
<td>Wisconsin (Eau Claire)</td>
<td>Wisconsin State College</td>
<td></td>
</tr>
<tr>
<td>Wisconsin (Oshkosh)</td>
<td>State Teachers College</td>
<td></td>
</tr>
</tbody>
</table>

**Survey of Textbooks in Elementary Science**

Six series of science textbooks for grades one through six were examined. Any principles of general biology which were not included in the tentative list of principles, but were found in or inferred from the elementary science textbooks, were added to the tentative list, or were absorbed to become part of a broad principle of general biology. The following elementary science textbook series were examined:


All of the science series surveyed in this study with the exception of the series entitled The Wonderworld of Science by Knox and others, are the science series textbooks that are currently adopted for grades one through six by the State of Texas.3

Checking the List of Principles of Biology for Technical Accuracy and Completeness of Coverage

In order to be certain that the list of principles of general biology was technically accurate and covered the

3Texas Education Agency, Current-Adoption Textbooks, 1954-1955, Bulletin 567 prepared by the Division of Textbooks, H. A. Glass, Director, Austin, Texas, p. 12.
field of general biology, it was necessary to submit the
list of principles of biology to a jury of college in-
structors. Subsequent to the evaluation of the principles
by a jury, the list was modified according to the recom-
mendations of the jury.

The Jury

The membership of the jury for the evaluation of a
tentative list of principles of biology consisted of five
college instructors who teach courses in biological science
which are required of prospective elementary school teachers.
The jury was instructed to comment on the technical accuracy
of the principles, and to submit any principles which were
omitted from the tentative list. The following is a list
of names and addresses of the jury that helped to define a
list of principles that was considered for the purposes of
this study to be technically accurate and covered the field
of general biology:

W. T. Garrett
Chairman, Department of Biology
Northwest Missouri State College
Maryville, Missouri

Catherine Bergen
Chairman, Science Department
State Teachers College
Jersey City 5, New Jersey

Robert E. Gordon
Head, Department of Science
State Teachers College
West Chester, Pennsylvania
Classification of Principles of Biology into Subject Matter Content Areas

After the tentative list of principles was completed, and prior to submitting this list to college instructors for evaluation, the principles were categorized into specific content areas, as suggested by the principles themselves. The number of principles for each of the ten areas in general biology is summarized in Table II.

### TABLE II

**THE TEN CONTENT AREAS OF GENERAL BIOLOGY SUGGESTED BY THE NATURE OF THE LIST OF 106 PRINCIPLES, AND THE NUMBER OF PRINCIPLES OF BIOLOGY CLASSIFIED INTO EACH AREA**

<table>
<thead>
<tr>
<th>Content Area of General Biology</th>
<th>Number of Principles</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Nature of life</td>
<td>7</td>
</tr>
<tr>
<td>II. Earth's Food Supply</td>
<td>14</td>
</tr>
<tr>
<td>III. Knowing Plants and Animals</td>
<td>18</td>
</tr>
<tr>
<td>IV. Survival of Living Things</td>
<td>23</td>
</tr>
<tr>
<td>V. Caring for Plants and Animals</td>
<td>7</td>
</tr>
<tr>
<td>VI. Using Plants and Animals</td>
<td>10</td>
</tr>
<tr>
<td>VII. Behavior of Living Things</td>
<td>5</td>
</tr>
<tr>
<td>VIII. Health and Disease</td>
<td>7</td>
</tr>
<tr>
<td>IX. Reproduction and Development</td>
<td>6</td>
</tr>
<tr>
<td>X. Heredity and Variation</td>
<td>9</td>
</tr>
</tbody>
</table>
A Modified List of 106 Principles of General Biology Subsequent to Evaluation by a Jury

The changes and additions which were recommended by the jury were made. A list of 106 principles in the ten content areas is listed below. This modified list was considered to be technically accurate and covered the field of general biology.

I. Nature of Life

1. The cell is the structural and functional unit in most living things.

2. The cell consists of a mass of protoplasm which is usually differentiated into an inner portion called the nucleus, and an outer portion the cytoplasm; a plant cell possesses a cellulose wall, whereas the cell wall in animal cells consists of a membrane.

3. In higher forms, cells are grouped to form tissues with both general and specific functions.

4. In higher forms, tissues are organized into organs, and organs into organ systems, each carrying on the various functions of living things.

5. Oxygen is delivered to animal and plant cells, where it may assist in the oxidation of food materials, resulting in the release of energy.

6. Food materials may be absorbed as food soluble in water, or ingested by some animals as food particles.

7. The diffusion of molecules of a fluid through a semi-permeable membrane from a region of higher concentration to a region of lower concentration is an important process in living things.

II. Earth's Food Supply

8. Roots of plants are adapted structurally to absorb water from the soil and transport it to the leaves where it
may be used to form food; most of the water evaporates, if the leaves are thin.

9. The ultimate source of all energy is sunlight, and this energy is bound into food materials during photosynthesis.

10. Green tissues of plants are the principal food factories since they contain the chlorophyll in the chloroplast which is necessary for food making.

11. The oxygen of the atmosphere is removed by living things and returned to the atmosphere by chlorophyll-bearing plants during photosynthesis.

12. Food is produced by the green tissues of plants as simple carbohydrates, and synthesized into sugars, starches, fats and proteins.

13. A carbon cycle in nature occurs as a result of the decomposition of carbon compounds of organisms which replenishes the carbon supply in the atmosphere. The carbon dioxide is needed as raw material to produce carbohydrates.

14. Minerals for plant use must be soluble in water so that they may be taken into the body of the plants through the root hairs.

15. Seeds contain a plant embryo which can begin its growth only if it can absorb water and oxygen from its environment.

16. After a seed has germinated, it needs sunlight to continue its growth into a mature plant.

17. Nitrogen-needs of plants in nature are supplied by some nitric acid produced in the atmosphere as well as by nitrogen-fixing bacteria which are capable of taking free nitrogen from the air and combining it with oxygen to form nitrates, and by the mineral components of soil resulting from the breakdown of organic matter.

18. Saprophytes cause decay by which process necessary raw materials are produced from dead matter which may be used in the production of new organisms.

19. Buds are quite rich in food materials, and are frequently eaten by birds, squirrels and people.
20. Food materials stored in underground structures such as rhizomes, tubers, bulbs, and corms may provide the "undifferentiated" structures with nourishment.

21. Seeds and fruits contain food materials which have been stored as surplus food. This material may be used by the seedling during its growth, or may provide much of the food used by man, birds, and other animals.

### III. Knowing Plants and Animals

22. Trees show specific formations in the structure of leaves, bark, cones or flowers, buds and the way of branching which enables us to distinguish them.

23. There is a variation in the time of bloom among many plants. The flowers and seed which are produced are characteristic of the plant.

24. Some plants require special soil conditions for growth; some plants require an acid soil, whereas others will grow well only in alkaline soil.

25. Plants vary in the amount of sunlight which is required for continued optimum growth; some plants thrive best in the sunlight, whereas other plants require a definite amount of shade and will die in direct sunlight.

26. Although aquatic animals are alike in many ways, they do show structural differences in food-getting, respiration, and locomotion.

27. Animals not closely related may appear as similar life forms.

28. Some animals such as birds can be recognized by their color, form, song, activities, and by the nature of their homes.

29. Animals are classified into groups on the basis of specific structural characteristics which are possessed by the animals; animals having the same set of specified characteristics are then classified into a group.

30. With few exceptions, the range of temperature for the life activities of living things varies from many degrees below zero to nearly the boiling point of water.

31. Microorganisms are likely to appear in a habitat in
large numbers when conditions of moisture, temperature, and food availability is nearly optimum.

32. Animals possess certain structural and physiological characteristics which enable them to live in the different geographic zones in which we find them.

33. Plants not closely related may exhibit similar life forms.

34. Many kinds of plants and animals have entered and accepted our habitat due to the availability of food and man's care.

35. A "Balance of Nature" is accomplished through the interrelations of plants and animals with each other, and with their physical environment.

36. Many groups of animals live together and form different kinds of homes in the water, on land, and in vegetation; some homes serve as resting places for the adult animals, others house the young.

37. Many insects in their feeding habits interfere with the health and growth of man's cultivated varieties of plants, and with the health and growth of domesticated animals.

38. Man has tried to restore many animal habitats which have been endangered by man's change of the environment, in order to create favorable living conditions for the continued existence of species in certain land areas.

39. Animals help plants in different ways; some animals may eat animals which are destructive to plants; animals help to pollinate flowers, thus assuring some degree of fertilization; animals help to scatter seeds of plants which helps to insure some plant propagation; many animals are known to devour their own young, a form of behavior which is instinctive and helps to regulate the population growth.

IV. Survival of Living Things

40. Certain structures of mammals make it possible for animals to move on land or in the water, and to secure their food in different ways.
41. With an increase in body size and general complexity of organization of the body of an animal, there ensues a corresponding elaboration of the transportation mechanisms for food and oxygen.

42. Mouth parts of some animals make it possible for them to eat plant materials, whereas other animals are meat-eaters, or eat both plants and animals.

43. Birds secure their food from sources such as mud, water, land, and air through the use of their beaks, the type of beak limits to some extent the source which can be exploited.

44. The bodies of man and other animals require a constant supply of oxygen; some animals obtain their oxygen from liquids; whereas others can take oxygen directly from the atmosphere.

45. In man, food and oxygen are carried to all parts of the body through a system of blood circulation.

46. Blood in man is composed of different liquid and solid constituents; some parts conduct the food and oxygen to body tissues, whereas other components may combat disease germs to a limited extent, or stimulate body metabolism by carrying hormones from one part of the body to another.

47. The human body produces chemical substances called enzymes which are capable of breaking down insoluble substances into soluble materials.

48. Enzymes, or digestive juices are produced in different parts of the food tract, and act upon specific classes of foods.

49. Firm outer structures and special root systems of some plants are found to be resistant to the damaging effects of changing atmospheric conditions.

50. Green plants which last from one season to another, may or may not store food materials in the roots during the summer.

51. Most plants lacking chlorophyll cannot produce their own food materials, and must depend upon other plants for food, including man, and obtain this food by absorption of food from its host, or from existing organic food.
52. Some animals appear to have body structures which are resistant to the attacks of its enemies.

53. Under certain circumstances, color in animals may conceal them in their habitats, or call the attention of other animals toward themselves.

54. Birds adapt to changing atmospheric conditions of their environment; certain birds migrate at different times during the fall, and to different parts of the world depending upon the species.

55. Many animals which remain in their environment during the changing seasons are forced to change their ways of seeking food; in some instances, animals become dependent upon man for their survival.

56. Some plants change structurally in response to the changing seasons; some plants lose their leaves and enter a dormant period of survival; some plants retain all of their structure but enter a period of much reduced metabolism; some plants lose the entire plant structure above the ground, and develop a new set of structures in the spring.

57. Insects respond to the changing environment by laying eggs in cases, by digging into the earth, or by migrating from summer homes to winter homes. Most of the insects do not adapt to seasonal changes and die.

58. Changes in the earth’s surface conditions, and the inability of animals to respond effectively to past conditions may have helped to bring about the end of many animals.

59. Some animals are born helpless, and are completely dependent upon their parents; other animals are independent of their parents from the first day of their birth.

60. Some animals are incapable of continuing in their present environment, and need our help to survive.

61. Producing large numbers of offspring is some assurance that a few of the offspring will likely find a suitable place in which to grow and develop.

62. Man and his numerous activities have been responsible for the disappearance of more recent animals than any other factor in the environment.
V. Caring for Plants and Animals

63. Cultivated flowering shrubs and evergreens which are used around home for landscaping purposes, have been changed or "moved" to such an extent that they would not ordinarily exist without man's care.

64. The light requirement of plants varies with the species; some plants will thrive only in sunlight, whereas others thrive in shade or in partial shade, and would die in direct sunlight.

65. The moisture requirements of plants vary among certain species; some plants thrive only in damp places, whereas others require small quantities of moisture thereby enabling these plants to live in relatively dry places and in areas where rainfall is sparse.

66. Many plants die when moved into our homes in winter because of excessively high temperatures, low humidity and reduced light intensities. Some plants will die because the soil is warm and full of water and carbon dioxide that suffocate the roots.

67. Animals in captivity thrive best and reproduce their species when the environment intended to surround them simulates their original home surroundings.

68. Cultivation tends to rid the soil of undesirable plants; some plants consume much moisture and many valuable minerals from the soil, and in this way affect the growth of those plants which seem more important to man.

69. Animals eat different varieties of food materials, and thrive best when provided sufficiently with their specific dietary needs, particularly proteins, fats, vitamins, and complete mineral requirements.

VI. Using Plants and Animals

70. Plants aid in conserving and renewing the mineral content of soil; replanting trees and shrubs, and grasses helps to keep the soil intact and free from the ravages of wind and rain, and the plant roots act as "elevators" to bring minerals to the surface.

71. Plants serve man by providing him with the different classes of food which are necessary for his everyday activities.
72. Certain marine resources have been especially useful to man in providing for sports activities, food materials, and by providing material resources for the development of industries and subsequent employment.

73. Some larger animals exist in sufficient numbers to provide for sports activities such as hunting and fishing; some have been killed in such large numbers as to bring about the extinction of many wildfowl and some mammals.

74. Certain groups of bacteria and molds serve man in the manufacture of food varieties, and by decaying food materials.

75. Some birds contribute to man's welfare by keeping down insect populations which are vectors of disease and destroyers of vegetation and food. Mostly birds aid in restoring fertility to "worn out" soils and waters depleted of soluble minerals.

76. Skins of many reptiles are of special economic importance to us in providing clothing and luxuries which enable us to resist the changing environment.

77. The fermentation ability of some plants has made it possible for us to use them in cooking, baking, and in the beverage industries.

78. Parts of plants and animals, or their by-products, have helped to provide material resources for the manufacture of medications which have helped to prevent and/or cure diseases of the body.

79. Man, if he is to survive, must learn to use wildlife resources without at the same time leading to their disappearance.

VII. Behavior of Living Things

80. Although lacking in a nervous system, some simpler forms of plants and animals react in specific ways to stimuli such as sunlight, water, gravity and temperature.

81. All animals react to stimuli; the nature and extent of the reaction to certain stimuli will depend upon the complexity of the animal's nervous system as well as other bodily structures.
82. Higher forms of animals possess different kinds of sense organs which make it possible for these animals to become aware of their environment; in man, the sense organs of sight and hearing are very important.

83. Hormones are chemical substances produced in certain parts of the human body, and stimulate the body into specific activities depending upon the type of hormone which is secreted.

84. Some forms of behavior in man are the result of the involvement of his cerebral cortex, whereas other behavior does not require the facilities of cerebral centers of the brain.

VIII. Health and Disease

85. Communicable diseases are caused by specific microorganisms.

86. Disease germs may be spread from one place to another through different media; dust, liquids such as sputum, and droplets which are given off during coughing and sneezing. In some instances, food is a carrier of disease germs.

87. Certain harmful bacteria enter our bodies at specific points; the most common portals of entry are the mouth and nasal passages since these places usually provide the bacteria with food, moisture, and proper temperature for their development.

88. Bacteria will contaminate and spoil food whenever nearly optimum conditions of temperature and moisture exist in the food material.

89. Specific antibodies have been produced in other animals for purposes of developing immunity in man, and for curing some diseases in man.

90. The human body may be stimulated to produce disease-resisting antibodies by injections of poisons produced by certain harmful bacteria, or by injections of weakened, or attenuated bacteria for which a specific immunity is desired.

91. Some bacteria affect human tissues by the toxins which
they produce, whereas others affect tissues by feeding on body tissues and fluids thereby disrupting normal tissue function.

IX. Reproduction and Development

92. All cells arise through the division of previous cells, and living things arise from living things like themselves.

93. The protoplasm of plant and animal cells passes on from one generation to another as a result of cell division.

94. Cell division is a fundamental process of reproducing cells in organisms whose cells contain nuclei. Nuclear division sometimes occurs without cell division.

95. Every individual grows from a single cell; in some groups of plants and animals, unfertilised eggs develop into embryos, other individuals may develop from spores.

96. The bodies of some animals go through a series of body changes before they look and become like the adult of that species. A few animals become adult and remain in the larval stage.

97. The bodies of some animals are adapted to care for their young during the process of development of the embryo, whereas other animals provide some means within which the young develop outside of the body of the parent.

X. Heredity and Variation

98. Chromosomes are portions of the chromatin material within the nuclei of cells, and are most readily observed during the process of cell division.

99. The male and female sex cells contribute equally to the complement of hereditary characteristics in a fertilized cell.

100. Sperms and eggs from hybrid individuals combine at random in all ways possible according to chance during
the fertilization of an egg, hence giving rise to many combinations of hereditary characteristics.

101. Hereditary characteristics may not show in plants and animals for several generations, yet may be expressed in an offspring as a result of a given combination of genes.

102. Man has employed the knowledge of the inheritance of characteristics in living things to produce a few living things with characteristics to suit his needs.

103. A study of fossils indicates the past existence of some plants and animals which are now extinct, as well as some plants and animals which are living in different parts of the earth today and resemble the ancestral stock.

104. New types of living organisms may arise through mutation.

105. Adaptations which have allowed organisms to remain and reproduce will remain as features of those organisms, even if the adaptation appears to be "worthless."

106. All living things are subject to change both structurally and functionally. Some living things have not changed noticeably for millions of years.
CHAPTER IV

PREPARING A LIST OF PRINCIPLES OF BIOLOGY WHICH
ELEMENTARY SCHOOL TEACHERS SHOULD UNDERSTAND
IN ORDER TO TEACH ABOUT PLANTS AND ANIMALS

In order to ascertain which principles of general biology an elementary school teacher should understand in order to teach about plants and animals, the opinions of elementary school teachers were canvassed. The method by which this was done was to select a group of elementary school teachers and have this jury rate the 106 principles of general biology in terms of a rating scale.

A Jury of Elementary School Teachers to Rate the Principles of Biology

The jury consisted of fifty-six elementary school teachers who are currently engaged in teaching in grades one through six.

Bases for Selecting A Jury

The following bases were utilized in selecting elementary school teachers to membership in a jury for purposes of rating the 106 principles of general biology:

1. Evidence of strong interest in elementary science education by having published articles dealing with
elementary science, or

2. Recommendation to membership in a jury by a leader in the field of elementary science education.

Survey of educational journals and magazines.-- The following resources in the literature were surveyed to obtain names of elementary school teachers who published articles dealing with elementary science:

Childhood Education
Elementary School Journal
School Life
Science Education
The American Biology Teacher
The Grade Teacher
The Instructor
The Science Teacher

Criteria for recommending teachers as jurors.--
Letters of explanation concerning the recommendation of elementary school teachers to membership in a jury were sent to a number of leaders in the field of science education. These leaders were asked to submit five or more names and addresses of elementary school teachers who are doing outstanding work in elementary science. The following criteria were suggested to assist these leaders in recommending good science teachers:

1. This is a teacher of either grade one, two, three, four, five, or six.

2. The teacher uses actual experiences whenever possible to bring about meaningful understandings about plants and animals.
3. The teacher provides for individual differences.

4. The teacher provides science experiences built around solving problems.

5. Science is taught by this teacher as an integral part of the elementary school program.

A List of Elementary School Teachers Comprising the Membership of the Jury

During the process of determining the scale reliability of the evaluations of the 106 principles of biology by fifty-six elementary school teachers, the group was split into two groups, each consisting of twenty-eight members.

The following is a list of elementary school teachers in Group A:

Marjorie Abel
114 Davis Avenue
Brookline 46, Massachusetts
Grade 4

Alyce K. Bartholomew
Jefferson School
South Wabash Street
Michigan City, Indiana
Grade 1

Betty Adams
1420 Washington Avenue
Miami Beach, Florida
Grade 2

Mary Caudill
10 Osborne Drive
Fort Walton Beach, Florida
Grade 4

Adele W. Beckett
Public School Number 6
Long Island City, New York
Grade 3

Margaret F. Derr
Washington School
Emmanus, Pennsylvania
Grade 4
<table>
<thead>
<tr>
<th>Name</th>
<th>Address</th>
<th>School</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frances Dobeski</td>
<td>2510 Wabash Street</td>
<td>Michigan City, Indiana</td>
<td>4</td>
</tr>
<tr>
<td>Rachel S. Fabert</td>
<td>Columbia School</td>
<td>1111 North Neil Street</td>
<td>3</td>
</tr>
<tr>
<td>A. Fagerlie</td>
<td>919 West Washington Street</td>
<td>Muncie, Indiana</td>
<td>3</td>
</tr>
<tr>
<td>Frances Faltz</td>
<td>Blockman Union School</td>
<td>Santa Maria, California</td>
<td>3</td>
</tr>
<tr>
<td>John W. Hagen</td>
<td>Star Route, Box 83</td>
<td>Sunnymead, California</td>
<td>5</td>
</tr>
<tr>
<td>John H. Howard</td>
<td>700 Las Alturas Road</td>
<td>Santa Barbara, California</td>
<td>6</td>
</tr>
<tr>
<td>Thomas D. Kelley</td>
<td>214 York Street</td>
<td>Michigan City, Indiana</td>
<td>2</td>
</tr>
<tr>
<td>William Kenny</td>
<td>307 Redwood Avenue</td>
<td>Willits, California</td>
<td>5</td>
</tr>
<tr>
<td>Bernard Kreisberg</td>
<td>Central Beach Elementary School</td>
<td>Miami Beach, Florida</td>
<td>6</td>
</tr>
<tr>
<td>David A. Kyle</td>
<td>44 Rubic Road</td>
<td>Santa Barbara, California</td>
<td>4</td>
</tr>
<tr>
<td>Bill E. McArthur</td>
<td>Blumont School</td>
<td>Manhattan, Kansas</td>
<td>6</td>
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<tr>
<td>Margaret Meredith</td>
<td>515 South High Street</td>
<td>West Chester, Pennsylvania</td>
<td>5</td>
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<tr>
<td>Ruth H. Lee</td>
<td>Potowomut School</td>
<td>Warwick, Rhode Island</td>
<td>3</td>
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<tr>
<td>John H. Bartik</td>
<td>97 Bradley Place</td>
<td>Mineola, New York</td>
<td>1</td>
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<tr>
<td>Lillian Rowe</td>
<td>R. D. Number 2</td>
<td>Hudson, New York</td>
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<tr>
<td>Paul E. Ruttenbur</td>
<td>Central Beach Elementary School</td>
<td>Miami Beach, Florida</td>
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<tr>
<td>Lauretta Shafer</td>
<td>Artemus Ward School</td>
<td>Cleveland 11, Ohio</td>
<td>3</td>
</tr>
<tr>
<td>M. Louise Stabler</td>
<td>Charles Lose School</td>
<td>Williamsport, Pennsylvania</td>
<td>6</td>
</tr>
</tbody>
</table>
The following is a list of twenty-eight elementary school teachers in Group B:

Alfred Aiello
1905 Spring Road
Cleveland 9, Ohio
Grade 4

Dorothy C. Bliesch
George Washington School
Cleveland 11, Ohio
Grade 5

Joyce Block
Box 116
Casmalia, California
Grade 1

Louisa R. Brodine
1335 South Oak
Casper, Wyoming
Grade 4

William M. Cowan (Mrs.)
Lincoln School
Brookline 46, Massachusetts
Grade 4

Florence P. Erhart
Benton School
Marshall, Missouri
Grade 4

Malinda Dean Garton
Illinois State Normal University
Normal, Illinois
Grade 5

Frederica Upchurch
DuVal School
Fort Smith, Arkansas
Grade 2

Kathryn Vanderbeek
Hawthorne School
Oak Park, Illinois
Grade 5

Julian Greenlee (Mrs.)
2801 Coldstream Drive
Tallahassee, Florida
Grade 6

Maynard Hartman
Box 988 East Avenue
Pleasant Valley School
Chico, California
Grade 6

Isabel Howard
7452 Kostner Avenue
Skokie, Illinois
Grade 1

Lillian B. Kenyon
Montgomery Unit
Johnston, New York
Grade 4

Ethel MacDermand
Central School
Hilton, New York
Grade 1

Ethel H. Malady
Pennsylvania Training School
Canonsburg, Pennsylvania
Grade 5

Pansy Marshall
Chaires School
Tallahassee, Florida
Grade 6
<table>
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<tr>
<th>Name</th>
<th>Address</th>
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<th>Grade</th>
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<tr>
<td>Margaret Larcombe</td>
<td>317 Park Avenue, Vineland, New Jersey</td>
<td>Jefferson School</td>
<td>3</td>
</tr>
<tr>
<td>Mary Ann Marsh</td>
<td>Jefferson School, Hamilton, Ohio</td>
<td>Hamilton School</td>
<td>3</td>
</tr>
<tr>
<td>Bernard Moretti</td>
<td>Niagara Falls Elementary School, Niagara Falls, New York</td>
<td>Niagara Falls Elementary School</td>
<td>5</td>
</tr>
<tr>
<td>L. M. Ostrander</td>
<td>Fredonia State Teachers College, Fredonia, New York</td>
<td>Fredonia State Teachers College</td>
<td>2</td>
</tr>
<tr>
<td>Ermine Powell</td>
<td>3970 La Colina Road, Santa Barbara, California</td>
<td>Santa Barbara, California</td>
<td>3</td>
</tr>
<tr>
<td>Helen J. Rhodes</td>
<td>64 Laurel Avenue, Bloomfield, New Jersey</td>
<td>Bloomfield School</td>
<td>2</td>
</tr>
<tr>
<td>L. Schwartz</td>
<td>1420 Washington Avenue, Miami, Beach, Florida</td>
<td>Miami, Beach, Florida</td>
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</tr>
<tr>
<td>Frances M. Starks</td>
<td>107 Highland Avenue, Bastrop, Louisiana</td>
<td>Bastrop School</td>
<td>5</td>
</tr>
<tr>
<td>Arletta M. Tapner</td>
<td>Rockland Road, North Scituate, Rhode Island</td>
<td>North Scituate School</td>
<td>4</td>
</tr>
<tr>
<td>A. B. Unfer (Mrs.)</td>
<td>1457 Forest Avenue, Des Plaines, Illinois</td>
<td>Des Plaines School</td>
<td>6</td>
</tr>
<tr>
<td>Helen E. Walker</td>
<td>Crescent Farms, Newfield, New Jersey</td>
<td>Newfield School</td>
<td>2</td>
</tr>
<tr>
<td>M. Wiggins</td>
<td>G. Russell Brown School, Chattanooga, Tennessee</td>
<td>Chattanooga, Tennessee</td>
<td>6</td>
</tr>
<tr>
<td>Ida Wike</td>
<td>215 Main Street, Michigan City, Indiana</td>
<td>Michigan City, Indiana</td>
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</tr>
</tbody>
</table>

**Names of Leaders in the Field of Elementary Science Education Who Contributed Names of Good Elementary Science Teachers and/or Recommended Other Leaders in Elementary Science Education**

- Paul E. Blackwood
  Department of Health, Education and Welfare
  Washington 25, D. C.
- Glenn C. Blough
  Specialist in Elementary Science
  United States Office of Education
  Washington 25, D. C.
The Rating Form for the Evaluation of Principles of Biology

The rating form consisted of 106 statements of principles of general biology, using a three-point rating scale. To the left of each statement of a principle were the code letters "V", "I", and "O". A copy of the rating form is included in Appendix B. The meaning of the code letters was listed in a letter, a copy of which is also included in Appendix B.
Findings and Factual Interpretation

Treatment of the Data

Code values.-- The three code letters were assigned the following numerical values: VI = 4, I = 2, and O = 0. Each principle of biology was assigned an index of importance, or average judgment based on the sum total of the individual judgments of fifty-six teachers.

Index of Importance = \[
\frac{\text{Sum total judgment values}}{\text{Number of jury members}}
\]

Estimating the reliability of the scale values.-- In order to determine the consistency with which members of the jury rated the principles of biology, the Pearson's product-moment coefficient of reliability was computed by the split-half technique, and corrected for length by the well known Spearman-Brown formula. The correlation coefficients for each of the ten content areas are listed in Table III.

The group of fifty-six teachers was divided into groups A and B, so that each group consisted of twenty-eight jurors and represented the returns of teachers from grades one through six. This was necessarily done to employ the technique of determining coefficients of correlation by the split-half method. Groups A and B were formed in the following way:

1. The returns of fifty-six teachers were sorted into six groups representing the grades taught by these teachers.
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<tr>
<th>Content Area</th>
<th>Number of Principles</th>
<th>Pearson's Coefficient of Correlation</th>
<th>Reliability Coefficient*</th>
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<td>I. Nature of Life</td>
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<td>II. Earth's Food Supply</td>
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<td>III. Knowing Plants and Animals</td>
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<td>V. Caring for Plants and Animals</td>
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<td>0.97</td>
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<td>VI. Using Plants and Animals</td>
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<td>VII. Behavior of Living Things</td>
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<td>VIII. Health and Disease</td>
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<td>0.96</td>
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<tr>
<td>IX. Reproduction and Development</td>
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<td>0.98</td>
<td>0.98</td>
</tr>
<tr>
<td>X. Heredity and Variation</td>
<td>9</td>
<td>0.95</td>
<td>0.97</td>
</tr>
</tbody>
</table>

*Estimated scale reliability using fifty-six sets of scale values, as corrected for length by the Spearman-Brown formula.
2. The returns within each grade group were selected at random, and assigned in equal numbers to groups A and B. This distribution made it possible to represent all grade levels in each group.

Reliability of the scale values. — The data in Table III indicated that there was a high degree of consistency of opinion among a select group of teachers as to the importance of certain principles of general biology as basic acquisitions of prospective elementary school teachers. The estimated reliability of the scale values, using fifty-six sets of scale values, was very high; the coefficients of reliability for each of the ten content areas was 0.92, or better.

Additional evidence of the consistency of ratings by teachers. — It was noted that, as returns were made, the average judgment value for the principles of biology did not change much. A record was maintained of the average judgment value assigned to principles, as computed at the end of each of the following returns: eighteenth, then at the twenty-third, twenty-ninth, thirty-fourth, forty-second, forty-sixth, and finally at the fifty-sixth return. The average values were computed, and a comparison was made of each value along a continuum of returns. Table IV gives the data concerning the nature of the judgment values of principles of biology at the end of a certain number of
TABLE IV

The average judgment value ascribed to the principles of general biology which have been rated 3.0 or better by a select group of elementary school teachers to illustrate the consistency of the ratings from the eighteenth to the fifty-sixth return.

<table>
<thead>
<tr>
<th>Number of the Principle</th>
<th>The Number of Returns and the Average Judgment Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td>1</td>
<td>3.1</td>
</tr>
<tr>
<td>5</td>
<td>3.3</td>
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<tr>
<td>8</td>
<td>3.4</td>
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<tr>
<td>9</td>
<td>3.7</td>
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<tr>
<td>10</td>
<td>3.2</td>
</tr>
<tr>
<td>11</td>
<td>3.1</td>
</tr>
<tr>
<td>15</td>
<td>3.2</td>
</tr>
<tr>
<td>16</td>
<td>3.4</td>
</tr>
<tr>
<td>21</td>
<td>3.4</td>
</tr>
<tr>
<td>22</td>
<td>3.3</td>
</tr>
<tr>
<td>28</td>
<td>3.1</td>
</tr>
<tr>
<td>32</td>
<td>3.1</td>
</tr>
<tr>
<td>35</td>
<td>3.0</td>
</tr>
<tr>
<td>36</td>
<td>3.0</td>
</tr>
<tr>
<td>37</td>
<td>2.6</td>
</tr>
<tr>
<td>39</td>
<td>3.4</td>
</tr>
<tr>
<td>40</td>
<td>3.1</td>
</tr>
<tr>
<td>43</td>
<td>3.1</td>
</tr>
<tr>
<td>44</td>
<td>3.2</td>
</tr>
<tr>
<td>45</td>
<td>3.7</td>
</tr>
<tr>
<td>53</td>
<td>3.1</td>
</tr>
<tr>
<td>54</td>
<td>3.2</td>
</tr>
<tr>
<td>55</td>
<td>3.2</td>
</tr>
<tr>
<td>56</td>
<td>3.0</td>
</tr>
<tr>
<td>57</td>
<td>3.0</td>
</tr>
<tr>
<td>59</td>
<td>3.0</td>
</tr>
<tr>
<td>65</td>
<td>3.0</td>
</tr>
<tr>
<td>69</td>
<td>3.2</td>
</tr>
<tr>
<td>70</td>
<td>3.5</td>
</tr>
<tr>
<td>71</td>
<td>3.8</td>
</tr>
<tr>
<td>79</td>
<td>3.1</td>
</tr>
<tr>
<td>86</td>
<td>3.6</td>
</tr>
<tr>
<td>87</td>
<td>3.3</td>
</tr>
</tbody>
</table>
returns. In Table IV, only those principles were included which received an index of importance of 3.0, or better, which is at least halfway between "very important" and "important." Two principles, numbers thirty-six and forty-three, decreased two tenths of one index of importance.

A List of 106 Principles of General Biology in the Descending Order of Their Importance for Elementary School Teachers to Understand in Order to Teach About Plants and Animals

The average judgment value was computed for each principle, and this index of importance was used to establish the rank of a principle among the 106 principles. The following is a list of statements of principles, their rank and rating:

<table>
<thead>
<tr>
<th>Rank</th>
<th>Rating</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.68</td>
<td>Plants serve man by providing him with the different classes of food which are necessary for his everyday activities.</td>
</tr>
<tr>
<td>2</td>
<td>3.64</td>
<td>Roots of plants are adapted structurally to absorb water from the soil and transport it to the leaves where it may be used to form food; most of the water evaporates if the leaves are thin.</td>
</tr>
<tr>
<td>2</td>
<td>3.64</td>
<td>After a seed has germinated, it needs sunlight to continue its growth into a mature plant.</td>
</tr>
<tr>
<td>2</td>
<td>3.64</td>
<td>Disease germs may be spread from one place to another through different media: dust, liquids such as sputum and droplets which are given off during coughing and sneezing. In some instances, food is a carrier of disease germs.</td>
</tr>
</tbody>
</table>
**Rank** | **Rating** | **Principle**
---|---|---
5 | 3.57 | In man, food and oxygen are carried to all parts of the body through a system of blood circulation.
5 | 3.57 | Certain harmful bacteria enter our bodies at specific points; the most common portals of entry are the mouth and nasal passages since these places usually provide the bacteria with food, moisture, and proper temperature for their development.
7 | 3.50 | The ultimate source of all energy is sunlight, and this energy is bound into food materials during photosynthesis.
8 | 3.47 | Plants aid in conserving and renewing the mineral content of soil; replanting trees and shrubs, and grasses helps to keep the soil intact and free from the ravages of wind and rain, and the plant roots act as "elevators" to bring minerals to the surface.
9 | 3.43 | Animals help plants in different ways; some animals may eat animals which are destructive to plants; animals help to pollinate flowers, thus assuring some degree of fertilization; animals help to scatter seeds of plants which helps to insure some plant propagation; many animals are known to devour their own young, a form of behavior which is instinctive and helps to regulate the population growth.
9 | 3.43 | Birds adapt to changing atmospheric conditions of their environment; certain birds migrate at different times during the fall, and to different parts of the world depending upon the species.
11 | 3.39 | Some animals such as birds can be recognized by their color, form, song, activities, and by the nature of their homes.
12 | 3.35 | The cell is the structural and functional unit in most living things.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Rating</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>3.35</td>
<td>Seeds contain a plant embryo which can begin its growth only if it can absorb water and oxygen from its environment.</td>
</tr>
<tr>
<td>12</td>
<td>3.35</td>
<td>Seeds and fruits contain food materials which have been stored as surplus food. This material may be used by the seedling during its growth, or may provide much of the food used by man, birds, and other animals.</td>
</tr>
<tr>
<td>15</td>
<td>3.31</td>
<td>Trees show specific formations in the structure of leaves, bark, cones or flowers, buds, and the way of branching which enables us to distinguish them.</td>
</tr>
<tr>
<td>15</td>
<td>3.31</td>
<td>The bodies of man and other animals require a constant supply of oxygen; some animals obtain their oxygen from liquids; whereas others can take oxygen directly from the atmosphere.</td>
</tr>
<tr>
<td>17</td>
<td>3.28</td>
<td>Green tissues of plants are the principal food factories since they contain the chlorophyll in the chloroplast which is necessary for food making.</td>
</tr>
<tr>
<td>18</td>
<td>3.23</td>
<td>Under certain circumstances, color in animals may conceal them in their habitats, or call the attention of other animals toward themselves.</td>
</tr>
<tr>
<td>18</td>
<td>3.23</td>
<td>Bacteria will contaminate and spoil food whenever nearly optimum conditions of temperature and moisture exist in the food material.</td>
</tr>
<tr>
<td>20</td>
<td>3.18</td>
<td>Oxygen is delivered to animal and plant cells where it may assist in the oxidation of food materials, resulting in the release of energy.</td>
</tr>
<tr>
<td>20</td>
<td>3.18</td>
<td>Animals possess certain structural and physiological characteristics which enable them to live in the different geographic zones in which we find them.</td>
</tr>
<tr>
<td>20</td>
<td>3.18</td>
<td>A &quot;Balance of Nature&quot; is accomplished</td>
</tr>
<tr>
<td>Rank</td>
<td>Rating</td>
<td>Principle</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>20</td>
<td>3.18</td>
<td>through the interrelations of plants and animals with each other, and with their physical environment.</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>Many animals which remain in their environment during the changing seasons are forced to change their ways of seeking food; in some instances, animals become dependent upon man for their survival.</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>The oxygen of the atmosphere is removed by living things and returned to the atmosphere by chlorophyll-bearing plants during photosynthesis.</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>Certain structures of mammals make it possible for animals to move on land or in the water, and to secure their food in different ways.</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>Some plants change structurally in response to the changing seasons; some plants lose their leaves and enter a dormant period of survival; some plants retain all of their structure but enter a period of much reduced metabolism; some plants lose the entire plant structure above the ground, and develop a new set of structures in the spring.</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>Insects respond to the changing environment by laying eggs in cases, by digging into the earth, or by migrating from summer homes to winter homes. Most of the insects do not adapt to seasonal changes and die.</td>
</tr>
<tr>
<td>24</td>
<td>3.14</td>
<td>Some animals are born helpless, and are completely dependent upon their parents; other animals are independent of their parents from the first day of their birth.</td>
</tr>
<tr>
<td>29</td>
<td>3.11</td>
<td>Man, if he is to survive, must learn to use wildlife resources without at the same time leading to their disappearance.</td>
</tr>
<tr>
<td>30</td>
<td>3.07</td>
<td>The moisture requirements of plants vary among certain species; some plants thrive only in damp places, whereas others require small quantities of moisture, thereby...</td>
</tr>
<tr>
<td>Rank</td>
<td>Rating</td>
<td>Principle</td>
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<tr>
<td>------</td>
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<td>-----------</td>
</tr>
<tr>
<td>30</td>
<td>3.07</td>
<td>enabling these plants to live in relatively dry places and in areas where rainfall is sparse.</td>
</tr>
<tr>
<td>32</td>
<td>3.04</td>
<td>Animals eat different varieties of food materials, and thrive best when provided sufficiently with their specific dietary needs, particularly proteins, fats, vitamins, and complete mineral requirements.</td>
</tr>
<tr>
<td>33</td>
<td>2.96</td>
<td>Many insects in their feeding habits interfere with the health and growth of man's cultivated varieties of plants, and with the health and growth of domesticated animals.</td>
</tr>
<tr>
<td>34</td>
<td>2.93</td>
<td>Plants vary in the amount of sunlight which is required for continued optimum growth; some plants thrive best in the sunlight, whereas other plants require a definite amount of shade and will die in direct sunlight.</td>
</tr>
<tr>
<td>34</td>
<td>2.93</td>
<td>Birds secure their food from sources such as mud, water, land, and air through the use of their beaks; the type of beak limits to some extent the source which can be exploited.</td>
</tr>
<tr>
<td>34</td>
<td>2.93</td>
<td>The light requirement of plants varies with the species; some plants will thrive only in sunlight, whereas others thrive in shade or in partial shade, and would die in direct sunlight.</td>
</tr>
<tr>
<td>34</td>
<td>2.93</td>
<td>Communicable diseases are caused by specific microorganisms.</td>
</tr>
<tr>
<td>37</td>
<td>2.86</td>
<td>There is a variation in the time of bloom among many plants. The flowers and seed which are produced are characteristic of the plant.</td>
</tr>
<tr>
<td>37</td>
<td>2.86</td>
<td>Many groups of animals live together and form different kinds of homes in the water, on land, and in vegetation; some homes serve as resting places for the adult animals, others house the young.</td>
</tr>
<tr>
<td>Rank</td>
<td>Rating</td>
<td>Principle</td>
</tr>
<tr>
<td>------</td>
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</tr>
<tr>
<td>37</td>
<td>2.86</td>
<td>All cells arise through the division of previous cells, and living things arise from living things like themselves.</td>
</tr>
<tr>
<td>40</td>
<td>2.82</td>
<td>Man has tried to restore many animal habitats which have been endangered by man's change of the environment, in order to create favorable living conditions for the continued existence of species in certain land areas.</td>
</tr>
<tr>
<td>41</td>
<td>2.79</td>
<td>Animals in captivity thrive best and reproduce their species when the environment intended to surround them simulates their original home surroundings.</td>
</tr>
<tr>
<td>42</td>
<td>2.75</td>
<td>Higher forms of animals possess different kinds of sense organs which make it possible for these animals to become aware of their environment; in man, the sense organs of sight and hearing are very important.</td>
</tr>
<tr>
<td>43</td>
<td>2.71</td>
<td>Food is produced by the green tissues of plants as simple carbohydrates, and synthesized into sugars, starches, fats and proteins.</td>
</tr>
<tr>
<td>43</td>
<td>2.71</td>
<td>Buds are quite rich in food materials, and are frequently eaten by birds, squirrels and people.</td>
</tr>
<tr>
<td>43</td>
<td>2.71</td>
<td>The bodies of some animals are adapted to care for their young during the process of development of the embryo, whereas other animals provide some means within which the young develop outside of the body of the parent.</td>
</tr>
<tr>
<td>46</td>
<td>2.68</td>
<td>Changes in the earth's surface conditions, and the inability of animals to respond effectively to past conditions may have helped to bring about the end of many animals.</td>
</tr>
<tr>
<td>46</td>
<td>2.68</td>
<td>Parts of plants and animals, or their by-products, have helped to provide material resources for the manufacture of medications which have helped to prevent and/or cure diseases of the body.</td>
</tr>
<tr>
<td>Rank</td>
<td>Rating</td>
<td>Principle</td>
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<tr>
<td>------</td>
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</tr>
<tr>
<td>48</td>
<td>2.65</td>
<td>Many kinds of plants and animals have entered and accepted our habitat due to the availability of food and man's care.</td>
</tr>
<tr>
<td>48</td>
<td>2.65</td>
<td>Mouth parts of some animals make it possible for them to eat plant materials, whereas other animals are meat eaters, or eat both plants and animals.</td>
</tr>
<tr>
<td>48</td>
<td>2.65</td>
<td>The bodies of some animals go through a series of body changes before they look and become like the adult of that species. A few animals become adult and remain in the larval stage.</td>
</tr>
<tr>
<td>51</td>
<td>2.61</td>
<td>Minerals for plant use must be soluble in water so that they may be taken into the body of the plants through the root hairs.</td>
</tr>
<tr>
<td>51</td>
<td>2.61</td>
<td>Some plants require special soil conditions for growth; some plants require an acid soil, whereas others will grow well only in alkaline soil.</td>
</tr>
<tr>
<td>51</td>
<td>2.61</td>
<td>Man and his numerous activities have been responsible for the disappearance of more recent animals than any other factor in the environment.</td>
</tr>
<tr>
<td>51</td>
<td>2.61</td>
<td>Some birds contribute to man's welfare by keeping down insect populations which are vectors of disease and destroyers of vegetation and food. Mostly birds aid in restoring fertility to &quot;worn out&quot; soils and waters depleted of soluble minerals.</td>
</tr>
<tr>
<td>55</td>
<td>2.57</td>
<td>Specific antibodies have been produced in other animals for purposes of developing immunity in man, and for curing some diseases in man.</td>
</tr>
<tr>
<td>55</td>
<td>2.57</td>
<td>All living things are subject to change both structurally and functionally. Some living things have not changed noticeably for millions of years.</td>
</tr>
<tr>
<td>57</td>
<td>2.54</td>
<td>Cultivation tends to rid the soil of undesirable plants; some plants consume</td>
</tr>
<tr>
<td>Rank</td>
<td>Rating</td>
<td>Principle</td>
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<tr>
<td>------</td>
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</tr>
<tr>
<td>57</td>
<td>2.54</td>
<td>Much moisture and many valuable minerals from the soil, and in this way affect the growth of those plants which seem more important to man.</td>
</tr>
<tr>
<td>57</td>
<td>2.54</td>
<td>Certain marine resources have been especially useful to man in providing for sports activities, food materials, and by providing material resources for the development of industries and subsequent employment.</td>
</tr>
<tr>
<td>57</td>
<td>2.54</td>
<td>Some larger animals exist in sufficient numbers to provide for sports activities such as hunting and fishing; some have been killed in such large numbers as to bring about the extinction of many wildfowl and some mammals.</td>
</tr>
<tr>
<td>57</td>
<td>2.54</td>
<td>Certain groups of bacteria and molds serve man in the manufacture of food varieties, and by decaying food materials.</td>
</tr>
<tr>
<td>57</td>
<td>2.54</td>
<td>A study of fossils indicates the past existence of some plants and animals which are now extinct, as well as some plants and animals which are living in different parts of the earth today and resemble the ancestral stock.</td>
</tr>
<tr>
<td>62</td>
<td>2.47</td>
<td>Some animals appear to have body structures which are resistant to the attacks of its enemies.</td>
</tr>
<tr>
<td>62</td>
<td>2.47</td>
<td>Some animals are incapable of continuing in their present environment, and need our help to survive.</td>
</tr>
<tr>
<td>62</td>
<td>2.47</td>
<td>Many plants die when moved into our homes in winter because of excessively high temperatures, low humidity, and reduced light intensities. Some plants will die because the soil is warm and full of water and carbon dioxide that suffocate the roots.</td>
</tr>
<tr>
<td>62</td>
<td>2.47</td>
<td>Every individual grows from a single cell; in some groups of plants and animals, unfertilized eggs develop into embryos, other individuals may develop from spores.</td>
</tr>
<tr>
<td>Rank</td>
<td>Rating</td>
<td>Principle</td>
</tr>
<tr>
<td>------</td>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>66</td>
<td>2.43</td>
<td>Although aquatic animals are alike in many ways, they do show structural differences in food-getting, respiration, and locomotion.</td>
</tr>
<tr>
<td>66</td>
<td>2.43</td>
<td>The fermentation ability of some plants has made it possible for us to use them in cooking, baking, and in the beverage industries.</td>
</tr>
<tr>
<td>68</td>
<td>2.39</td>
<td>Blood in man is composed of different liquid and solid constituents; some parts conduct the food and oxygen to body tissues, whereas other components may combat disease germs to a limited extent, or stimulate body metabolism by carrying hormones from one part of the body to another.</td>
</tr>
<tr>
<td>59</td>
<td>2.32</td>
<td>The human body may be stimulated to produce disease-resisting antibodies by injections of poisons produced by certain harmful bacteria, or by injections of weakened, or attenuated bacteria for which a specific immunity is desired.</td>
</tr>
<tr>
<td>70</td>
<td>2.28</td>
<td>Producing large numbers of offspring is some assurance that a few of the offspring will likely find a suitable place in which to grow and develop.</td>
</tr>
<tr>
<td>71</td>
<td>2.25</td>
<td>In higher forms, cells are grouped to form tissues with both general and specific functions.</td>
</tr>
<tr>
<td>72</td>
<td>2.20</td>
<td>In higher forms, tissues are organized into organs, and organs into organ systems, each carrying on the various functions of living things.</td>
</tr>
<tr>
<td>73</td>
<td>2.18</td>
<td>Man has employed the knowledge of the inheritance of characteristics in living things to produce a few living things with characteristics to suit his needs.</td>
</tr>
<tr>
<td>74</td>
<td>2.14</td>
<td>Food materials may be absorbed as food soluble in water, or ingested by some animals as food particles.</td>
</tr>
</tbody>
</table>
Rank | Rating | Principle
---|---|---
75 | 2.06 | Most plants lacking chlorophyll cannot produce their own food materials, and must depend upon other plants for food, including man, and obtain this food by absorption of food from its host, or from existing organic food.
76 | 2.04 | Animals are classified into groups on the basis of specific structural characteristics which are possessed by the animals; animals having the same set of specified characteristics are then classified into a group.
77 | 2.00 | Although lacking in a nervous system, some simpler forms of plants and animals react in specific ways to stimuli such as sunlight, water, gravity and temperature.
78 | 1.93 | With few exceptions, the range of temperature for the life activities of living things varies from many degrees below zero to nearly the boiling point of water.
79 | 1.89 | Food materials stored in underground structures such as rhizomes, tubers, bulbs, and corms may provide the "undifferentiated" structures with nourishment.
80 | 1.86 | The cell consists of a mass of protoplasm which is usually differentiated into an inner portion called the nucleus, and an outer portion the cytoplasm; a plant cell possesses a cellulose wall, whereas the cell wall in animal cells consist of a membrane.
80 | 1.86 | Microorganisms are likely to appear in a habitat in large numbers when conditions of moisture, temperature, and food availability is nearly optimum.
80 | 1.86 | The protoplasm of plant and animal cells passes on from one generation to another as a result of cell division.
83 | 1.78 | Enzymes, or digestive juices are produced in different parts of the food tract, and act upon specific classes of foods.
A carbon cycle in nature occurs as a result of the decomposition of carbon compounds of organisms which replenishes the carbon supply in the atmosphere. The carbon dioxide is needed as raw material to produce carbohydrates.

The human body produces chemical substances called enzymes which are capable of breaking down insoluble substances into soluble materials.

Green plants which last from one season to another, may or may not store food materials in the roots during the summer.

The male and female sex cells contribute equally to the complement of hereditary characteristics in a fertilized cell.

Cultivated flowering shrubs and evergreens which are used around home for landscaping purposes, have been changed or "moved" to such an extent that they would not ordinarily exist without man's care.

New types of living organisms may arise through mutation.

All animals react to stimuli; the nature and extent of the reaction to certain stimuli will depend upon the complexity of the animal's nervous system as well as other bodily structures.

Firm outer structures and special root systems of some plants are found to be resistant to the damaging effects of changing atmospheric conditions.

Animals not closely related may appear as similar life forms.

Hereditary characteristics may not show in plants and animals for several generations, yet may be expressed in an offspring as a result of a given combination of genes.
<table>
<thead>
<tr>
<th>Rank</th>
<th>Rating</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>94</td>
<td>1.57</td>
<td>Some bacteria affect human tissues by the toxins which they produce, whereas others affect tissues by feeding on body tissues and fluids thereby disrupting normal tissue function.</td>
</tr>
<tr>
<td>95</td>
<td>1.53</td>
<td>Plants not closely related may exhibit similar life forms.</td>
</tr>
<tr>
<td>96</td>
<td>1.46</td>
<td>With an increase in body size and general complexity of organization of the body of an animal, there ensues a corresponding elaboration of the transportation mechanisms for food and oxygen.</td>
</tr>
<tr>
<td>97</td>
<td>1.43</td>
<td>Skins of many reptiles are of special economic importance to us in providing clothing and luxuries which enable us to resist the changing environment.</td>
</tr>
<tr>
<td>98</td>
<td>1.39</td>
<td>Cell division is a fundamental process of reproducing cells in organisms whose cells contain nuclei. Nuclear division sometimes occurs without cell-division.</td>
</tr>
<tr>
<td>99</td>
<td>1.21</td>
<td>Sperms and eggs from hybrid individuals combine at random in all ways possible according to chance during the fertilization of an egg, hence giving rise to many combinations of hereditary characteristics.</td>
</tr>
<tr>
<td>100</td>
<td>1.14</td>
<td>Nitrogen-needs of plants in nature are supplied by some nitric acid produced in the atmosphere as well as by nitrogen-fixing bacteria which are capable of taking free nitrogen from the air and combining it with oxygen to form nitrates, and by the mineral components of soil resulting from the breakdown of organic matter.</td>
</tr>
<tr>
<td>100</td>
<td>1.14</td>
<td>Some forms of behavior in man are the result of the involvement of his cerebral cortex, whereas other behavior does not require the facilities of cerebral centers of the brain.</td>
</tr>
</tbody>
</table>
| 102  | 1.10   | Adaptations which have allowed organisms to remain and reproduce, will remain as
<table>
<thead>
<tr>
<th>Rank</th>
<th>Rating</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>1.07</td>
<td>Saprophytes cause decay by which process necessary raw materials are produced from dead matter which may be used in the production of new organisms.</td>
</tr>
<tr>
<td>104</td>
<td>1.03</td>
<td>Hormones are chemical substances produced in certain parts of the human body, and stimulate the body into specific activities depending upon the type of hormone which is secreted.</td>
</tr>
<tr>
<td>105</td>
<td>0.91</td>
<td>Chromosomes are portions of the chromatin material within the nuclei of cells, and are most readily observed during the process of cell division.</td>
</tr>
<tr>
<td>106</td>
<td>0.82</td>
<td>The diffusion of molecules of a fluid through a semi-permeable membrane from a region of higher concentration to a region of lower concentration is an important process in living things.</td>
</tr>
</tbody>
</table>
CHAPTER V

DEVELOPING AND VALIDATING LABORATORY EXPERIENCE UNITS IN GENERAL BIOLOGY FOR UNDERGRADUATE ELEMENTARY EDUCATION MAJORS

Formulating a List of Criteria for Developing Laboratory Experience Units in General Biology

There was no single list of criteria in the literature which suited the purposes of the present development of experience units for prospective elementary school teachers. For this reason, the list of criteria was formulated after a survey of articles in educational journals and discussions in science books and laboratory manuals dealing with activities in biology for college students. Some books dealing with methods of science education were most helpful; among these books were the following: Making and Using Classroom Materials, by Glenn O. Blough; Elementary Science Education in American Schools, by Harrington Wells; Methods and Activities in Elementary School Science, by Blough and Huggett; Audio-Visual Methods, by Edgar Dale; and Elementary Science and How To Teach It, by R. Will Burnett. Some criteria were formulated independently of suggestions in the literature in order to suit the purposes of developing units of experiences for elementary education majors.
Eight Criteria for Developing Laboratory Experience Units in General Biology

Eight criteria were adopted for the development of experience units in general biology, as follows:

1. The laboratory experience unit should be selected and/or developed in terms of its possible contribution to some aspect of the principle of biology which is considered very important to know, as judged by a select group of elementary school teachers.

2. The laboratory experience should provide for an individual experience.

3. The procedures for the experience unit should be clear and concise.

4. The materials and equipment for the experience unit should be available in the college biology room, or easily obtained and/or constructed and accumulated by the student or instructor, or available as a community resource within a reasonable walking distance of the college.

5. The experience unit should include appended questions which are likely to stimulate reflective thinking.

6. The experience unit should be of sufficient scope to permit the student to draw conclusions.
7. The outcomes listed for the experience unit should be expected from student participation in the unit.

8. The experience unit is consistent with the purposes of a course in general biology for the preparation of elementary school teachers.

Developing Eight Laboratory Experience Units in General Biology

For purposes of illustration, and because it was not practicable here to use all of the principles considered important, eight laboratory experience units corresponding to the eight principles of biology were developed. The eight principles which were selected for development were the ones which were rated the highest by teachers. The number of principles was also ascertained by a dissertation committee after a consideration of the number of activities which would be required for the development of the eight units. Another reason for selecting eight principles for the development of units was that this number would be convenient to a jury in validating the completed experience units.

The activities within each experience unit in biology were centered about principles of biology. The number of the experience unit corresponds to the number of the principle to which it is assigned. A copy of the eight units which were sent to a jury for validation is included in Appendix C.
Eighth Principles of General Biology
with Titles of the Accompanying
Laboratory Experience Units
and Activities

Principle No. 8: Roots of plants are adapted structurally
to absorb water from the soil and transport it to the leaves where it may be
used to form food; most of the water evaporates if the leaves are thin.

LABORATORY EXPERIENCE UNIT NUMBER 8
Absorption and Translocation of Water in Plants

A. Form of Root Hairs
B. How Water Enters Plants
C. Passage of Water Through a Membrane
D. Movement of Soil Water in Hard Stems
E. Water Leaves the Plant
F. Amount of Water Loss from Plants

Principle No. 9: The ultimate source of all energy is
sunlight and this energy is bound into
food materials during photosynthesis.

LABORATORY EXPERIENCE UNIT NUMBER 9
Radiant Energy and Food Production in Plants

A. Role of Sunlight in Photosynthesis
B. Storage of Food in Seed Leaves
C. Release of Stored Energy During
   Germination of seeds

Principle No. 46: In man, food and oxygen are carried to
all parts of the body through a system
of blood circulation.

LABORATORY EXPERIENCE UNIT NUMBER 45
The Transportation System in the Human Body

A. Viewing of the film The Heart and
   Circulation
B. Blood Circulation in Capillaries
C. Pumping Action of the Heart in the Frog
D. Study of a Beef Heart and Model of the
   Human Heart
B. Heart Beat and Arterial Pulse (Human)
F. Effect of Exercise on the Rate of the Heart Beat

Principle No. 70: Plants aid in conserving and renewing the mineral content of the soil; re-planting trees and shrubs, and grasses helps to keep the soil intact and free from the ravages of wind and rain, and the plant roots act as "elevators" to bring minerals to the surface.

LABORATORY EXPERIENCE UNIT NUMBER 70
Plants and Soil Conservation

Field

A. Water Drainage in Barren Soil and in Soil Covered with Grasses
B. Temperature of Barren Soil and Soil Covered with Plant Growth
C. Soil Cover and Moisture Present in the Soil
D. Action of Raindrops on Barren Soil and on Soil Covered with Vegetation

Classroom (subsequent to field collection)

E. Water Run-off and Erosion of Barren Soil and of Soil Covered with Grass
F. How Humus Changes the Drainage in Soil
G. Replenishing Plant Nutrients by Legumes

Principle No. 71: Plants serve man by providing him with the different classes of food which are necessary for his everyday life.

LABORATORY EXPERIENCE UNIT NUMBER 71
Plants: Food for Man's Survival

A. Testing for Carbohydrates
B. Testing for Protein
C. Fats in Plant Food
D. Presence of Water in Plant Food
E. Testing for Vitamin C
Principle No. 86: Disease germs may be spread from one place to another through different media: dust, liquids such as sputum, and droplets which are given off during coughing and sneezing. In some instances, food is a carrier of disease germs.

LABORATORY EXPERIENCE UNIT NUMBER 86
Transmission and Distribution of Bacteria

A. Preparation of Sterile Media, Sterile Swabs, and Sterile Glassware
B. How Microbes Are Carried from One Place to Another: Dust, Personal Objects, and Droplets
C. Microscopic Study of Bacteria
D. Food As a Carrier of Bacteria

Principle No. 87: Certain harmful bacteria enter our bodies at specific points; the most common portals of entry are the mouth and nasal passages since these places provide the bacteria with food, moisture, and proper temperature for their development.

LABORATORY EXPERIENCE UNIT NUMBER 87
Requirements for the Growth of Bacteria

A. The Effect of Temperature on the Growth of Bacteria
B. Food Requirement for the Growth of Bacteria
C. Growth of Bacteria Under Varying Conditions of Moisture
D. Growth of Bacteria in Sunlight and in Darkness

The Rating Form to be Used in Evaluating Laboratory Experience Units in General Biology

The rating form consisted of a list of eight criteria which were used as guides in developing the units. Each criterion was numbered, and to the left of each number were
the letters "IC", "SC", "PC", and "NC" to constitute the code letters by which the criteria were considered by the jury. A copy of the rating form is included in Appendix D.

**Code**

The following explanation for the code was given in the letter of instructions:

- **IC** - This criterion was ideally considered in developing this experience unit in biology
- **SC** - Criterion was satisfactorily considered
- **PC** - Criterion was poorly considered
- **NC** - Criterion was not considered

**Validating Laboratory Experience Units in General Biology for Teachers**

The purpose of validating the laboratory experience units was to determine whether or not the units were developed according to the eight criteria. The criteria selected for the validation process were the same ones which were utilized in developing the units.

**Selecting A Jury**

The jury consisted of eight college instructors who teach a biological science which is required of prospective elementary school teachers. The names for this jury were selected from the list of instructors who submitted courses of study in biological science. A letter was sent to a
number of college instructors requesting their co-operation. The responsibility of the faculty member as a judge in this study was outlined carefully, and the nature of the scheme of evaluation was explained.

The following is a list of names and addresses of the college faculty who served as judges in evaluating and validating the eight laboratory experience units in biology:

Leonard K. Beyer  
State Teachers College  
Mansfield, Pennsylvania

Elizabeth Brinkley  
Associate Professor of Biology  
Henderson State Teachers College  
Arkadelphia, Arkansas

Helen Challand  
National College of Education  
Evanston, Illinois

Ralph Combs  
Associate Professor  
Northwestern State College  
Natchitoches, Louisiana

R. H. Cooper  
Head of Science Department  
Ball State Teachers College  
Muncie, Indiana

Marcus J. Fay  
Associate Professor of Biology  
Wisconsin State College  
Eau Claire, Wisconsin

Stanley Oexmann, Chairman  
Department of Biology  
Wisconsin State College  
Superior, Wisconsin

J. Ralph Wells, Head  
Department of Biological Science  
Kansas State Teachers College  
Pittsburg, Kansas
Each judge received a package of materials containing the following:

a. A copy of the instruction sheet, and eight complete laboratory experience units.

b. Eight copies of the rating form, each numbered for the convenience of the judges.

c. A 9½ x 12½ manilla envelope, stamped and self-addressed for the convenience of the judges.

d. A letter of appreciation.

Validating Laboratory Experience Units in General Biology for Teachers

Findings and Factual Interpretation

Assigning values to the rating scale.-- To determine the average judgment value assigned to the criteria within each laboratory experience unit, the code letters were given the following numerical values: IC = 6, SC = 4, PC = 2, and NC = 0.

Ratings of the units by individual judges.-- The ratings given to each of the experience units by the judges are summarized in tabular form, beginning with Table XIX in Appendix D. Each table represents the ratings given to each of the criteria for the eight experience units.

In order for the returns to be of value, in the event a unit scored an average judgment value of less than 4.0, the judges were instructed to indicate the reason why a
laboratory experience unit was given a rating of "P0", or "poorly considered". This is an important consideration since it would make it possible to correct a specific deficiency within a large experience unit.

**Validation of the experience units by eight judges.**

The results of the average ratings of the eight units by eight judges are summarized in Tables V and VI. There is no one laboratory experience unit in the tables which received an average judgment value of less than 4.0 for any of the eight criteria. Since the average judgment value for any criterion is 4.0, or better, all of the eight laboratory experience units were considered to be satisfactorily developed according to the criteria which were accepted for the development of experience units, as judged by eight judges.

There were no remarks of any kind by the jury of eight college instructors to indicate that any criterion, or any aspect of a criterion was difficult to interpret. Apparently the criteria were sufficiently apprehensible to enable the judges to proceed with the validation of the units.

It is necessary to indicate at this time what would need to be done in the event an experience unit received an average judgment value of less than 4.0 for any one of the criteria in an experience unit. It would be necessary to re-examine the ratings of all of the judges for a unit in which there was some apparent deficiency. Since the judges
TABLE V

THE TOTAL AND AVERAGE JUDGMENT VALUE FOR THE LABORATORY EXPERIENCE UNITS NUMBERS 8, 9, 16, AND 45 AS RATED BY EIGHT JUDGES

<table>
<thead>
<tr>
<th>Number of the Criterion</th>
<th>Number of the Laboratory Experience Unit</th>
<th>Total Value</th>
<th>Average Value</th>
<th>Total Value</th>
<th>Average Value</th>
<th>Total Value</th>
<th>Average Value</th>
<th>Total Value</th>
<th>Average Value</th>
</tr>
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<td>8</td>
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<td>5.0</td>
<td>40</td>
<td>5.0</td>
<td>38</td>
<td>4.7</td>
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</tr>
<tr>
<td>2</td>
<td>9</td>
<td>42</td>
<td>5.2</td>
<td>44</td>
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</tr>
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<td>42</td>
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<td></td>
<td>4.9</td>
<td></td>
<td>4.9</td>
<td></td>
</tr>
</tbody>
</table>
TABLE VI

THE TOTAL AND AVERAGE JUDGMENT VALUE FOR THE LABORATORY EXPERIENCE UNITS NUMBERS 70, 71, 86, AND 87, AS RATED BY EIGHT JUDGES

<table>
<thead>
<tr>
<th>Number of the Criterion</th>
<th>Number of the Laboratory Experience Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<tr>
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<td>Average Value</td>
</tr>
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<td>40</td>
</tr>
<tr>
<td>2</td>
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<tr>
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<tr>
<td>Total Value</td>
<td>340</td>
</tr>
<tr>
<td>Average Value</td>
<td>5.2</td>
</tr>
</tbody>
</table>
were instructed to give reasons why a criterion received a judgment value of "PC", or less than 4.0, it would be comparatively easy to isolate the defect in the preparation of a unit. Subsequent to correction of the deficiency, it would be necessary to re-submit the experience unit to all judges for further validation. Any changes in a unit previously validated, should be submitted to all judges in the jury. When a unit receives an average rating of 4.0, or better, then it would be considered satisfactory for use in a course in biological science which was primarily designed for prospective elementary school teachers.

Tables VII and VIII summarize the data of the average ratings of the eight units by the first five returns from the jury, whereas Tables V and VI summarize the data from the entire jury of eight judges. The ratings of both the five and eight judges showed that the eight units were rated in approximately the same way. Laboratory Experience Unit Number 86 was rated the highest with an average rating of 5.4 by eight judges; Laboratory Experience Unit Number 71, although rated 4.4, received the lowest rating of the eight units.

There did not appear to be any major differences in the average ratings for the criteria as computed from the total judgments in all of the eight units. Criteria which received the three highest ratings were numbers 2, 8, and 1, with ratings of 5.2, 5.2, and 5.1 respectively.
## TABLE VII

The total and average judgment value for the laboratory experience units numbers 8, 9, 16, and 45, as rated by five judges

<table>
<thead>
<tr>
<th>Number of the Criterion</th>
<th>Number of the Laboratory Experience Unit</th>
<th>8</th>
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<th>16</th>
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<td>Average Value</td>
<td>Total Value</td>
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<td>4.8</td>
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<td>26</td>
<td>5.2</td>
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<td>4.4</td>
<td>5.7</td>
<td>5.1</td>
</tr>
</tbody>
</table>

**Table VIII**

**The Total and Average Judgment Value for the Laboratory Experience Units Numbers 70, 71, 86, and 87, as Rated by Five Judges**
The strongest points in the development of the eight laboratory units were (1) that the experience units were consistent with the purposes of a course in general biology for the preparation of elementary school teachers, (2) that the laboratory experiences provided for an individual experience, and (3) that the laboratory experience units were selected and/or developed in terms of their possible contribution to some aspect of the principle of biology to which they were assigned.

Since the average ratings of the five judges are about the same as those of a larger jury, it would appear feasible that fewer than eight judges could be used. A jury of five instructors was just as useful in ascertaining the worthiness of laboratory experience units, as a jury of eight college instructors.
CHAPTER VI

SUMMARY AND CONCLUSIONS

Considerations in Formulating Experiences in Biology for Elementary Education Majors

1. To formulate a tentative list of principles of biology, educational periodicals and magazines, textbooks in biological science, elementary science textbook series, and fifty courses of study in biological science at state teachers colleges and state colleges, were examined. These sources were considered to be adequate to formulate a tentative list of principles of general biology.

2. In order to ascertain the technical accuracy of a tentative list of principles of general biology, it was necessary to consider the judgments of other faculty who were acquainted with general biology. It was also necessary that these instructors should also be teachers of a course in biological science that is required of elementary education majors.

A validated list of principles was prepared by submitting a tentative list of principles to five college instructors. Each instructor evaluated the list of principles in terms of their technical accuracy and completeness of coverage of the field of general biology.
3. One of the aspects of this study was to develop a list of principles which an elementary school teacher should understand in order to teach about plants and animals. An assumption was made that the best sources of opinion would be a select group of good elementary science teachers.

4. To select a group of good science teachers it was necessary to select them according to certain criteria. Teachers needed to be selected and/or recommended on the basis of five criteria, by leaders in the field of elementary science education. A high degree of interest in science education, by having published articles dealing with elementary science, was also used as a basis for selecting teachers for the jury. Leaders in elementary science education were most instrumental in suggesting names of good science teachers.

5. Some means was necessary to report the ratings of principles of biology. Indices of importance were computed by first assigning numerical values to the three-point scale, then computing the average judgment value for each principle. Using indices of importance, it was possible to list the principles in the rank order of their importance.

6. The purpose of rating the list of principles was to establish an index of importance for each of the 106 principles. Before the ratings of the jury were accepted, it was necessary to determine the consistency of the ratings by
estimating the reliability of the scale values. This was accomplished by computing the Pearson's coefficient of reliability using the split-half method, and correcting for length by the Spearman-Brown formula.

The fifty-six teachers were assigned to either group A or B, and the coefficients of correlation were estimated for each of the ten content areas. A coefficient of correlation was computed for each of the ten groups of principles in order to ascertain consistency within groups. With an evidence of a high degree of consistency of opinion among teachers concerning the importance of 106 principles, the ratings of the jury were accepted.

7. In selecting and developing laboratory experience units, it was necessary to formulate guides, or criteria by which such development would be uniform and helpful from one unit to another. For each principle there was one or more laboratory experience units. By definition, a principle of general biology encompasses a number of meanings which collectively contribute to the understanding of the principles, or to some aspect of a whole principle when many facts and meanings are included in this comprehensive generalization. Each experience unit consisted of one or more activities which sought to promote meanings concerning the principle to which the unit was assigned.

8. Illustrating the development of laboratory experience units, involved the selection of principles for the
development. The number of principles was determined by the likely number of activities within each unit. In some instances, three activities were sufficient for the development of a unit, whereas in other units a minimum of eight activities was required. For convenience of validation of the experiences to a jury, the number of units was kept to a minimum. Eight principles which were rated the highest by teachers were selected for the development of eight experience units. The eight units consisted of thirty-five individual activities, and received prompt validation by the jury.

9. The final step in the development and acceptance of the experience units in biology consisted of sending the units to a jury of college instructors of biological science. Prior to asking instructors to serve as judges, a selection of potential judges was made on the basis that this instructor considered and utilized the activity-method of approach to teaching general biology. This was expedited by checking the nature of the course of study in general biology which was submitted for the purposes of this study. The judges were instructed to evaluate the units in terms of a four-point rating scale to indicate the extent to which the eight criteria were considered in developing the eight units. When an experience unit received an average judgment value of 1.0, it was considered to be developed satisfactorily according to the criteria.
Conclusions

1. To compile a list of principles of biology which covered the field of general biology, the following methods proved to be satisfactory: (1) Survey of educational periodicals; (2) Examination of college textbooks in biology, and textbook series in elementary school science; and (3) Examination of courses of study in biology which concern those courses in biological science which are required of prospective elementary school teachers. It was recommended by five college faculty that one principle should be dropped from the list of 104 principles, and that three other principles should be added to the list to constitute a list of 106 principles of general biology.

2. The high degree of consistency of the data may have been the result of careful selection of elementary science teachers. The bases for the selection of a jury of elementary school teachers to evaluate a list of principles of general biology were most fruitful, as evidenced by the reliability of the scale values, and the consistency of the data. The methods of selection were: (1) Recommendation of elementary school teachers by leaders in the field of elementary science education, and (2) Evidence of a strong interest in elementary science by having published articles in periodicals and/or magazines.

3. Indices of importance, as computed from the total judgment values of the jury, were most useful in ranking
principles of biology, and deciding as to the acceptability of laboratory experience units.

4. There was a strong agreement among the select jury of fifty-six elementary school teachers concerning principles of biology which an elementary school teacher should understand in order to teach about plants and animals. The coefficient of reliability of the scale value for each content area was 0.92, or better. The Pearson's product-moment coefficient of reliability was computed by the split-half method, and corrected for length by the Spearman-Brown formula. The jury of fifty-six teachers was split into two groups, each containing twenty-eight teachers.

5. In the survey of textbooks in biology which were used by fifty state teachers colleges and state colleges preparing elementary school teachers, the maximum frequency of adoption of any one textbook was six. Twenty-three different textbooks dealing with biological science were used among the fifty colleges included in this survey.

6. Twenty-nine principles of general biology were rated less than 2.0, indicating these principles to be least important for an elementary school teacher to understand in order to teach about plants and animals. These principles were most common to the following content areas of biology as categorized on the rating form of 106 principles:

Heredity and Variation, 66 per cent of the principles were
rated less than 2.0; Behavior of Living Things, 60 per cent; and Reproduction and Development, 33 per cent of the principles.

7. Thirty-two principles were rated 3.0 or better, indicating these principles as rather important for an elementary school teacher to understand. These principles were most common to the following content areas of biology: Earth's Food Supply, 50 per cent of the principles in this area were rated 3.0 or better; Health and Disease, 42 per cent; and Survival of Living Things, 39 per cent.

8. The following content areas of general biology as categorized in this study, did not contain a single principle with a rating of 3.0 or better: Behavior of Living Things, Reproduction and Development, and Heredity and Variation.

9. There is no known list of criteria in the literature for the development of laboratory experience units which suited the purposes of this study, hence a list of eight criteria were formulated.

10. A list of principles of general biology was compiled which could be used by instructors of biology to develop laboratory experience units for prospective elementary school teachers.

11. This study explored and developed a technique for the selection, development, and validation of laboratory experience units. This technique should prove useful to
college instructors who teach courses in biological science that are required of prospective elementary school teachers.
PRINCIPLES OF BIOLOGY

I. NATURE OF LIFE

1. The cell is the structural and functional unit in most living things.

2. A cell consists of a mass of protoplasm which is usually differentiated into a central portion, the nucleus, and an outer portion the cytoplasm.

3. In higher forms, cells are grouped to form tissues with specific functions.

4. In higher forms, tissues are organized into organs, and organs into organ systems, the better to carry on the functions of the living things.

5. The living activities occur in the protoplasm; the sum of all these chemical and physical processes is metabolism.

6. Oxygen is delivered to the cells where it takes part in cell oxidation to produce energy.

7. Food must be soluble in water to be absorbed by living cells.

8. The diffusion of molecules through a semi-permeable membrane from a region of higher concentration to a region of lower concentration with the stoppage and flow of molecules of the solute, is the basic process in living plants and animals.

II. EARTH'S FOOD SUPPLY

9. Plants are adapted structurally to absorb water from the soil and transport it to the leaves where it is to be used to form food.

10. The ultimate source of all food energy is sunlight, and this energy is bound into food materials during photosynthesis.

11. Green plants are the principal food factories since they contain the chlorophyll necessary for food making.

12. The oxygen of the atmosphere is removed by living things, and returned to the atmosphere by chlorophyll-bearing plants during photosynthesis.

13. Food is produced by the plants as simple sugars, and synthesized into starches, fats, and proteins.

14. The carbon cycle in nature occurs as a result of the decomposition of carbon compounds of organisms which replenishes the carbon supply, in the atmosphere which is needed as the raw materials to produce food, in the form of carbon dioxide.

15. Minerals for plant use must be soluble in water so that it may be taken into the body of the plant through structures adapted for that purpose (root hairs).
16. Seeds contain a plant embryo which can begin its growth only in the presence of proper amounts of moisture and temperature.

17. After a seed has germinated, it needs sunlight to continue its growth properly into a seedling.

18. Nitrogen needs of plants in nature are supplied by nitrogen-fixing bacteria which are capable of taking free nitrogen from the air and combining it with oxygen to form nitrates, and by the mineral components of the soil resulting from the breakdown of soil structures.

19. Saprophytes cause decay by which process necessary raw materials are produced from dead matter for the growth of new organisms.

20. With the coming of Spring, stored food materials in the roots find their way up to the buds, there to provide food for new growth.

21. Food materials are stored in underground structures such as rhizomes, tubers, bulbs, and corms, and provide the embryonic structures with nourishment for growth and energy.

22. Seeds and fruits contain food materials which have been stored as surplus food. This food material will be used by the prospective seedling during its growth, or will provide much of the food used by man, birds, and some lower animals.

III. KNOWING PLANTS AND ANIMALS

23. Trees show specific formations in the structure of leaves, bark, cones or flowers, buds, and the way of branching which enable us to distinguish them.

24. Some plants will flower during different times of the year, and will tend to produce flowers and seed of the type which are characteristic of the plant.

25. Some groups of plants require different soil conditions for growth: some plants require an acid soil, whereas others will grow well only in an alkaline soil.

26. Plants vary in the amount of sunlight which is required for continued optimum growth; some plants thrive best in the sunlight, whereas other plants require a definite amount of shade and will die in direct sunlight.

27. Although aquatic animals are alike in many ways, they do show structural differences in food-getting, respiration, and locomotion.

28. Animals are classified into groups on the basis of specific structural characteristics which are possessed by the animals; animals having the same set of specified characteristics are then classified into a group.

29. Some animals such as birds can be recognized by their color, form, song, or by the nature of their home.

30. With few exceptions, the range of temperature for the life activities of living things varies from many degrees below zero to nearly the boiling point of water.
31. Microorganisms are likely to appear in a habitat when conditions of moisture, temperature and food availability is optimum.

32. Animals possess certain structural and physiological characteristics which enable them to live in the different geographic zones in which we find them.

33. Many kinds of plants and animals have entered and accepted our habitat due to the availability of food and man's care and protection.

34. Man has tried to restore many animal habitats which have been endangered by man's change of the environment, in order to create favorable living conditions for the continued existence of species in certain land areas.

35. A Balance of nature is attempted through the interrelations of plants and animals with each other, and with their physical environment.

36. Many groups of animals live together and form different kinds of homes in the water, on land, and in vegetation to provide for their young.

37. Many insects are so structured that their feeding habits interfere with the growth of man's cultivated varieties of plants, and with the growth of domesticated animals.

38. Animals help plants in different ways; animals eat animals which are destructive to plants, animals help to pollinate flowers to assure some degree of fertilization, and animals help to scatter seeds of plants which helps to insure some plant propagation.

IV. SURVIVAL OF LIVING THINGS

39. The structures of mammals are especially adapted for locomotion on land, and for food-getting.

40. With increase in size and complexity of the body of an animal, there ensues a corresponding elaboration of the transportation of food and oxygen in order to survive.

41. Mouth parts of some animals are adapted to consume plant materials, whereas other animals are meat-eaters, or eat both plants and animals.

42. Modifications of parts of the body of birds, such as the beak, enable different groups to secure their food in particular environments, and from sources such as mud, water, land, and air.

43. The body of man and other higher animals are adapted to provide the body with a constant supply of oxygen; some animals take oxygen from liquids, whereas others take oxygen directly from the atmosphere.

44. In man, food and oxygen are carried to all parts of the body through an organised system of blood circulation.

45. Blood in man is composed of specific structures so designed as to perform its specific functions to keep the organism healthy and alive.
146. The human body produces chemicals called enzymes which are capable of breaking down insoluble substances into soluble materials so that they may be absorbed by the body to be used to sustain life and growth.

147. Enzymes, or digestive juices are produced in different parts of the food tract of man, and act upon specific classes of foods in the different organs to make the food less complex and finally soluble in water.

148. Some plants possess firm outer structures and special root systems to enable them to withstand the changing atmospheric conditions.

149. Green plants which last from one season to another store food materials in the roots during the summer, and use this food in the Spring to start new growth.

150. Certain plants lacking chlorophyll cannot produce their own food materials, and rely upon the other plants for food, including man, and obtain this food by the absorption of food from its host, or from existing organic food.

151. Animals have in some instances, protective structures to help them resist the attacks of some of their enemies during the process of survival.

152. Plants possess certain protective structures to help them resist the attacks of some of their enemies during survival.

153. The biological functions of color are to conceal, to disguise, and to advertise.

154. Some animals require specific body weapons to protect themselves against their enemies, whereas others possess speed of movement.

155. Birds adapt to changing atmospheric conditions of their environment; certain birds migrate at different times during the Fall, and to different parts of the world depending upon the species.

156. Many animals which remain in their environment during the changing seasons are forced to change their ways of seeking food; in some instances, animals become dependent upon man for their survival.

157. Some plants change structurally in response to the changing seasons in order to withstand the rigors of winter; some plants lose their leaves and enter a dormant period of survival; some plants retain all of their structures but enter a period of much reduced metabolism; some plants lose the entire plant structure above the ground, and develop a new set of structures in the spring.

158. Insects respond to the changing environment by laying eggs in cases, by digging into the earth, or by migrating from summer homes to winter homes. Most of the insects do not adapt to seasonal changes and die.

159. Changes in the earth's surface conditions, and the inability of animals to adapt themselves to past conditions helped to bring about the end of many animals.

160. Some animals are born helpless, and are completely dependent upon their parents; other animals are independent of their parents from the first day of their birth.
61. Many animals are incapable of continuing in their present environment, and need our help to survive in large numbers.

62. Producing large numbers of offspring is some assurance that a few of the offspring will likely find a suitable place in which to grow and develop.

V. CARING FOR PLANTS AND ANIMALS

63. Cultivated flowering shrubs and evergreens which are used around the home for landscaping purposes, have been changed to such an extent that they would not ordinarily exist without man's care.

64. The light requirement of plants varies with the species; some plants will thrive only in sunlight, whereas others thrive in shade or in partial shade, and would die in direct sunlight (this is similar to No. 26 except for the way it is stated).

65. The moisture requirements of plants vary among certain species; some plants thrive only in damp places, whereas others require small quantities of moisture thereby enabling these plants to live in relatively dry places and in areas where rainfall is sparse.

66. Cultivation tends to rid the soil of undesirable plants; some plants consume much moisture and many valuable minerals from the soil, and in this way affect the growth of those plants which are important to man.

67. Animals eat different varieties of food materials, and thrive best when provided sufficiently with their specific dietary needs.

68. Animals in captivity thrive best and reproduce their species when the environment intended to surround them simulates their original home surroundings.

VI. USING PLANTS AND ANIMALS

69. Plants serve to help conserve the soil; replanting trees and shrubs, and grasses help to keep the soil intact and free from the ravages of wind and rain.

70. Plants serve man by providing him with the different classes of food which are necessary for his everyday activity.

71. Certain marine resources have been especially useful to man in providing for sports-activities, food materials, gems, and by providing material resources for the development of industries and subsequent employment.

72. Certain higher animals exist in sufficient numbers to provide for sports-activities such as hunting and fishing, whereas some have been killed indiscriminately in such large number that they are now on the threshold of extinction.
73. Certain groups of bacteria and molds serve man in the manufacture of food varieties, antibiotics, and by decaying food materials.

74. Birds contribute to man's welfare by keeping down insect populations which are vectors of disease, and destroyers of vegetation and food.

75. Skins of many reptiles and mammals are of special economic importance to us in providing clothing and luxuries to enable us to resist the changing environment.

76. The fermentation ability of some plants has made it possible for us to use them in cooking, baking, and in the beverage industries.

77. Parts of plants and animals, or their by-products, have helped to provide material resources for the manufacture of medications which have helped to prevent and/or cure diseases of the body.

VII. BEHAVIOR OF LIVING THINGS

78. Although lacking in a nervous system, some lower forms of plants and animals do react to stimuli such as sunlight, water, gravity, and temperature in specific ways.

79. All animals react to stimuli; the nature and extent of the reaction to certain stimuli will depend in part upon the complexity of the animal's nervous system.

80. Certain sense organs in higher forms of animals are especially developed to make animals aware of their surroundings; in man, the sense organs of sight and hearing are very important.

81. Hormones are chemical substances produced in certain parts of the human body, and stimulate the body into specific activities depending upon the type of hormone which is secreted.

82. Some forms of behavior in man are the result of the involvement of higher thought centers, whereas other behavior does not require the facilities of higher centers of the brain.

VIII. HEALTH AND DISEASE

83. Communicable diseases are caused by specific microorganisms.

84. Disease germs may be spread from one place to another through different media: dust, liquids such as sputum, and droplets which are given off during coughing and sneezing. In some instances, foods are carriers of disease germs.

85. Certain harmful bacteria enter our bodies at specific points; the most common portals of entry are the mouth and nasal passages since these places usually provide the bacteria with food, moisture, and proper temperature for their development.
86. Bacteria will contaminate and spoil food whenever optimum conditions of temperature and moisture exist in the food material.

87. Specific antibodies have been produced in other animals for purposes of developing immunity in man, and for curing some diseases in man.

88. The human body may be stimulated to produce disease-resisting antibodies by injections of poisons produced by certain harmful bacteria, or by injections of weakened, or attenuated bacteria for which a specific immunity is desired.

89. Some bacteria affect human tissues by the toxins which they produce, whereas others affect tissues by feeding on body tissues and fluids thereby disrupting normal tissue function.

IX. REPRODUCTION AND DEVELOPMENT

90. All cells arise through the division of previous cells, and all living things arise from living things.

91. The germ plasm of plant and animal cells passes on from one generation to another as a result of cell division.

92. Cell division is a fundamental process of reproducing cells in organisms whose cells contain nuclei.

93. All sexually reproduced individuals begin their careers as a single fertilized cell.

94. The bodies of some animals go through a series of body changes before they look and become like the adult of that species.

95. The bodies of some animals are adapted to care for their young during the process of development of the embryo, whereas others provide some means within which the young develop outside of the body of the parent.

X. HEREDITY AND VARIATION

96. Chromosomes are contained in the chromatin material within the nuclei of cells, and are formed during the process of cell division.

97. The male and female sex cells contribute equally to the complement of hereditary characteristics in a fertilized cell.

98. Hereditary factors combine at random in all ways possible according to chance during the fertilization of an egg, hence giving rise to many combinations of hereditary characteristics.

99. Hereditary characteristics may remain dormant in plants and animals for several generations, yet may be expressed in an offspring as a result of the right combination of genes.
100. Man has employed the knowledge of the inheritance of characteristics in living things to produce living things with characteristics to suit his needs.

101. A study of fossils indicates the past existence of some plants and animals which are now extinct, as well as some plants and animals which are living in different parts of the earth today and resemble the ancestral stock.

102. New types of living organisms may arise through mutation.

103. Animal adaptations which have allowed animals to remain and reproduce, will remain as features of an organism.

104. All living things are slowly changing, both structurally and functionally in response to changes in their physical environment.

Please check the following:

The list of principles of biology is technically accurate: YES [ ]

NO [ ]

The principles of biology in this list appears to cover the field of general biology: YES [ ]

NO [ ]

COMMENTS (Corrections or additions):

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Name: ____________________________ Date: ________________________

THANK YOU -
APPENDIX B
Dear Elementary School Teacher:

At the present time, I am attending North Texas State College for the purpose of completing my studies for the doctorate in education. My dissertation proposal has been approved, and I am now in the process of effecting this study which deals with the science preparation of prospective elementary school teachers.

One portion of my dissertation study requests that a jury of elementary school teachers evaluate a list of principles of general biology. A jury has been selected on the basis of one of the following: (a) a strong interest in elementary science education by having published articles in educational journals; or (b) having been recommended by a leader in elementary science education. You have been selected to be a member of this jury.

The reason for asking elementary school teachers to evaluate a list of principles of biology is to determine which principles in this list an elementary school teacher should understand in order to teach about plants and animals. Each juror is asked to evaluate the principles by placing an "X" over one of the letters which you will find to the left of each numbered statement. These letters represent the following:

VI - VERY IMPORTANT for an elementary school teacher to understand in order to teach about plants and animals.

I - IMPORTANT

O - JUST AS SOON OMIT THIS ONE

Since the membership of this jury is small, and every return is most important to me and to this study, your co-operation in returning your evaluation promptly would be most appreciated. The progress of this study is dependent upon your co-operation.

You are not asked to sign your evaluation; however, please list your name and address on the return envelope since it is necessary for me to include the name and correct school address of each jury member in the body of the dissertation. The returns from the jury will be pooled to determine which principles have been considered most important for prospective elementary school teachers to understand.

You may be interested in a summary report of my dissertation study. Should you wish to have a copy, please check in the appropriate space on page 1. I shall see to it that you receive a copy as soon as my study is completed.

I shall look forward to your return.

Sincerely,

B. John Syrocki
I. NATURE OF LIFE

1. The cell is the structural and functional unit in most living things.

2. The cell consists of a mass of protoplasm which is usually differentiated into an inner portion called the nucleus, and an outer portion the cytoplasm; a plant cell possesses a cellulose wall, whereas the cell wall in animal cells consists of a membrane.

3. In higher forms, cells are grouped to form tissues with both general and specific functions.

4. In higher forms, tissues are organized into organs, and organs into organ systems, each carrying on the various functions of living things.

5. Oxygen is delivered to animal and plant cells, where it may assist in the oxidation of food materials, resulting in the release of energy.

6. Food materials may be absorbed as food soluble in water, or ingested by some animals as food particles.

7. The diffusion of molecules of a fluid through a semi-permeable membrane from a region of higher concentration to a region of lower concentration is an important process in living things.

II. EARTH’S FOOD SUPPLY

8. Roots of plants are adapted structurally to absorb water from the soil and transport it to the leaves where it may be used to form food; most of the water evaporates, if the leaves are thin.

9. The ultimate source of all energy is sunlight, and this energy is bound into food materials during photosynthesis.

10. Green tissues of plants are the principal food factories since they contain the chlorophyll in the chloroplast which is necessary for food making.

11. The oxygen of the atmosphere is removed by living things and returned to the atmosphere by chlorophyll-bearing plants during photosynthesis.

12. Food is produced by the green tissues of plants as simple carbohydrates, and synthesized into sugars, starches, fats, and proteins.

13. A carbon cycle in nature occurs as a result of the decomposition of carbon compounds of organisms which replenishes the carbon supply in the atmosphere. The carbon dioxide is needed as raw material to produce carbohydrates.

14. Minerals for plant use must be soluble in water so that they may be taken into the body of the plants through the root hairs.

15. Seeds contain a plant embryo which can begin its growth only if it can absorb water and oxygen from its environment.

16. After a seed has germinated, it needs sunlight to continue its growth into a mature plant.

17. Nitrogen needs of plants in nature are supplied by some nitric acid produced in the atmosphere as well as by nitrogen-fixing bacteria which are capable of taking free nitrogen from the air and combining it with oxygen to form nitrates, and by the mineral components of soil resulting from the breakdown of organic matter.

18. Saprophytes cause decay by which process necessary raw materials are produced from dead matter which may be used in the production of new organisms.

19. Buds are quite rich in food materials, and are frequently eaten by birds, squirrels and people.

20. Food materials stored in underground structures such as rhizomes, tubers, bulbs, and corms may provide the “undifferentiated” structures with nourishment.

21. Seeds and fruits contain food materials which have been stored as surplus food. This material may be used by the seedling during its growth, or may provide much of the food used by man, birds, and other animals.

III. KNOWING PLANTS AND ANIMALS

22. Trees show specific formations in the structure of leaves, bark, cones or flowers, buds, and the way of branching which enables us to distinguish them.

23. There is a variation in the time of bloom among many plants. The flowers and seed which are produced are characteristic of the plant.

24. Some plants require special soil conditions for growth; some plants require an acid soil, whereas others will grow well only in alkaline soil.

25. Plants vary in the amount of sunlight which is required for continued optimum growth; some plants thrive best in the sunlight, whereas other plants require a definite amount of shade and will die in direct sunlight.

26. Although aquatic animals are alike in many ways, they do show structural differences in food-getting, respiration, and locomotion.

27. Animals not closely related may appear as similar life forms.

28. Some animals such as birds can be recognized by their color, form, song, activities, and by the nature of their homes.
Animals are classified into groups on the basis of specific structural characteristics which are possessed by the animals; animals having the same set of specified characteristics are then classified into a group.

With few exceptions, the range of temperature for the life activities of living things varies from many degrees below zero to nearly the boiling point of water.

Microorganisms are likely to appear in a habitat in large numbers when conditions of moisture, temperature, and food availability are nearly optimum.

Animals possess certain structural and physiological characteristics which enable them to live in the different geographic zones in which we find them.

Plants not closely related may exhibit similar life forms.

Many kinds of plants and animals have entered and accepted our habitat due to the availability of food and man's care.

A "Balance of Nature" is accomplished through the interrelations of plants and animals with each other, and with their physical environment.

Many groups of animals live together and form different kinds of homes in the water, on land, and in vegetation; some homes serve as resting places for the adult animals, others house the young.

Many insects in their feeding habits interfere with the health and growth of man's cultivated varieties of plants, and with the health and growth of domesticated animals.

Man has tried to restore many animal habitats which have been endangered by man's change of the environment, in order to create favorable living conditions for the continued existence of species in certain land areas.

Animals help plants in different ways; some animals may eat animals which are destructive to plants; animals help to pollinate flowers, thus assuring some degree of fertilization; animals help to scatter seeds of plants which helps to insure some plant propagation; many animals are known to devour their own young, a form of behavior which is instinctive and helps to regulate the population growth.

IV. SURVIVAL OF LIVING THINGS

Certain structures of mammals make it possible for animals to move on land or in the water, and to secure their food indifferent ways.

With an increase in body size and general complexity of organization of the body of an animal, there ensues a corresponding elaboration of the transportation mechanisms for food and oxygen.

Mouth parts of some animals make it possible for them to eat plant materials, whereas other animals are meat-eaters, or eat both plants and animals.

Birds secure their food from sources such as mud, water, land, and air through the use of their beaks; the type of beak limits to some extent the source which can be exploited.

The bodies of man and other animals require a constant supply of oxygen; some animals obtain their oxygen from liquids; whereas others can take oxygen directly from the atmosphere.

In man, food and oxygen are carried to all parts of the body through a system of blood circulation.

Blood in man is composed of different liquid and solid constituents; some parts conduct the food and oxygen to body tissues, whereas other components may combat disease germs to a limited extent, or stimulate body metabolism by carrying hormones from one part of the body to another.

The human body produces chemical substances called enzymes which are capable of breaking down insoluble substances into soluble materials.

Enzymes, or digestive juices are produced in different parts of the food tract, and act upon specific classes of foods.

Firm outer structures and special root systems of some plants are found to be resistant to the damaging effects of changing atmospheric conditions.

Green plants which last from one season to another, may or may not store food materials in the roots during the summer.

Most plants lacking chlorophyll cannot produce their own food materials, and must depend upon other plants for food, including man, and obtain this food by absorption of food from its host, or from existing organic food.

Some animals appear to have body structures which are resistant to the attacks of its enemies.

Under certain circumstances, color in animals may conceal them in their habitats, or call the attention of other animals toward themselves.

Birds adapt to changing atmospheric conditions of their environment; certain birds migrate at different times during the Fall, and to different parts of the world depending upon the species.

Many animals which remain in their environment during the changing seasons are forced to change their ways of seeking food; in some instances, animals become dependent upon man for their survival.
VI I O 56. Some plants change structurally in response to the changing seasons; some plants lose their leaves and enter a dormant period of survival; some plants retain all of their structure but enter a period of much reduced metabolism; some plants lose the entire plant structure above the ground, and develop a new set of structures in the spring.

VI I O 57. Insects respond to the changing environment by laying eggs in cases, by digging into the earth, or by migrating from summer homes to winter homes. Most of the insects do not adapt to seasonal changes and die.

VI I O 58. Changes in the earth's surface conditions, and the inability of animals to respond effectively to past conditions may have helped to bring about the end of many animals.

VI I O 59. Some animals are born helpless, and are completely dependent upon their parents; other animals are independent of their parents from the first day of their birth.

VI I O 60. Some animals are incapable of continuing in their present environment, and need our help to survive.

VI I O 61. Producing large numbers of offspring is some assurance that a few of the offspring will likely find a suitable place in which to grow and develop.

VI I O 62. Man and his numerous activities have been responsible for the disappearance of more recent animals than any other factor in the environment.

V. CARING FOR PLANTS AND ANIMALS

VI I O 63. Cultivated flowering shrubs and evergreens which are used around home for landscaping purposes, have been changed or "moved" to such an extent that they would not ordinarily exist without man's care.

VI I O 64. The light requirement of plants varies with the species; some plants will thrive only in sunlight, whereas others thrive in shade or in partial shade, and would die in direct sunlight.

VI I O 65. The moisture requirements of plants vary among certain species; some plants thrive only in damp places, whereas others require small quantities of moisture thereby enabling these plants to live in relatively dry places and in areas where rainfall is sparse.

VI I O 66. Many plants die when moved into one homes in winter because of excessively high temperature, low humidity, and reduced light intensities. Some plants will die because the soil is warm and full of water and carbon dioxide that suffocate the roots.

VI I O 67. Animals in captivity thrive best and reproduce their species when the environment intended to surround them simulates their original home surroundings.

VI I O 68. Cultivation tends to rid the soil of undesirable plants; some plants consume much moisture and many valuable minerals from the soil, and in this way affect the growth of those plants which seem more important to man.

VI I O 69. Animals eat different varieties of food materials, and thrive best when provided sufficiently with their specific dietary needs, particularly proteins, fats, vitamins, and complete mineral requirements.

VI. USING PLANTS AND ANIMALS

VI I O 70. Plants aid in conserving and renewing the mineral content of soil; replanting trees and shrubs, and grasses helps to keep the soil intact and free from the ravages of wind and rain, and the plant roots act as "elevators" to bring minerals to the surface.

VI I O 71. Plants serve man by providing him with the different classes of food which are necessary for his everyday activities.

VI I O 72. Certain marine resources have been especially useful to man in providing for sports-activities, food materials, and by providing material resources for the development of industries and subsequent employment.

VI I O 73. Some larger animals exist in sufficient numbers to provide for sports-activities such as hunting and fishing; some have been killed in such large numbers as to bring about the extinction of many wildfowl and some mammals.

VI I O 74. Certain groups of bacteria and molds serve man in the manufacture of food varieties, and by decaying food materials.

VI I O 75. Some birds contribute to man's welfare by keeping down insect populations which are vectors of disease and destroyers of vegetation and food. Mostly birds aid in restoring fertility to "worn out" soils and waters depleted of soluble minerals.

VI I O 76. Skins of many reptiles are of special economic importance to us in providing clothing and luxuries which enable us to resist the changing environment.

VI I O 77. The fermentation ability of some plants has made it possible for us to use them in cooking, baking, and in the beverage industries.

VI I O 78. Parts of plants and animals, or their by-products, have helped to provide material resources for the manufacture of medications which have helped to prevent and/or cure diseases of the body.

VI I O 79. Man, if he is to survive, must learn to use wildlife resources without at the same time leading to their disappearance.

VII. BEHAVIOR OF LIVING THINGS

VI I O 80. Although lacking in a nervous system, some simpler forms of plants and animals react in specific ways to stimuli such as sunlight, water, gravity, and temperature.
VI I O 81. All animals react to stimuli; the nature and extent of the reaction to certain stimuli will depend upon the complexity of the animal's nervous system as well as other bodily structures.

VI I O 82. Higher forms of animals possess different kinds of sense organs which make it possible for these animals to become aware of their environment; in man, the sense organs of sight and hearing are very important.

VI I O 83. Hormones are chemical substances produced in certain parts of the human body, and stimulate the body into specific activities depending upon the type of hormone which is secreted.

VI I O 84. Some forms of behavior in man are the result of the involvement of his cerebral cortex, whereas other behavior does not require the facilities of cerebral centers of the brain.

VIII. HEALTH AND DISEASE

VI I O 85. Communicable diseases are caused by specific microorganisms.

VI I O 86. Disease germs may be spread from one place to another through different media: dust, liquids such as sputum, and droplets which are given off during coughing and sneezing.

VI I O 87. Certain harmful bacteria enter our bodies at specific points; the most common portals of entry are the mouth and nasal passages since these places usually provide the bacteria with food, moisture, and proper temperature for their development.

VI I O 88. Bacteria will contaminate and spoil food whenever nearly optimum conditions of temperature and moisture exist in the food material.

VI I O 89. Specific antibodies have been produced in other animals for purposes of developing immunity in man, and for curing some diseases in man.

VI I O 90. The human body may be stimulated to produce disease-resisting antibodies by injections of poisons produced by certain harmful bacteria, or by injections of weakened, or attenuated bacteria for which a specific immunity is desired.

VI I O 91. Some bacteria affect human tissues by the toxins which they produce, whereas others affect tissues by feeding on body tissues and fluids thereby disrupting normal tissue function.

IX. REPRODUCTION AND DEVELOPMENT

VI I O 92. All cells arise through the division of previous cells, and living things arise from living things like themselves.

VI I O 93. The protoplasm of plant and animal cells passes on from one generation to another as a result of cell division.

VI I O 94. Cell division is a fundamental process of reproducing cells in organisms whose cells contain nuclei. Nuclear division sometimes occurs without cell-division.

VI I O 95. Every individual grows from a single cell; in some groups of plants and animals, unfertilized eggs develop into embryos, other individuals may develop from spores.

VI I O 96. The bodies of some animals go through a series of body changes before they look and become like the adult of that species. A few animals become adult and remain in the larval stage.

VI I O 97. The bodies of some animals are adapted to care for their young during the process of development of the embryo whereas other animals provide some means within which the young develop outside of the body of the parent.

X. HEREDITY AND VARIATION

VI I O 98. Chromosomes are portions of the chromatin material within the nuclei of cells, and are most readily observed during the process of cell division.

VI I O 99. The male and female sex cells contribute equally to the complement of hereditary characteristics in a fertilized cell.

VI I O 100. Sperms and eggs from hybrid individuals combine at random in all ways possible according to chance during the fertilization of an egg, hence giving rise to many combinations of hereditary characteristics.

VI I O 101. Hereditary characteristics may not show in plants and animals for several generations, yet may be expressed in an offspring as a result of a given combination of genes.

VI I O 102. Man has employed the knowledge of the inheritance of characteristics in living things to produce a few living things with characteristics to suit his needs.

VI I O 103. A study of fossils indicates the past existence of some plants and animals which are now extinct, as well as some plants and animals which are living in different parts of the earth today and resemble the ancestral stock.

VI I O 104. New types of living organisms may arise through mutation.

VI I O 105. Adaptations which have allowed organisms to remain and reproduce, will remain as features of those organisms, even if the adaptation appears to be "worthless."

VI I O 106. All living things are subject to change both structurally and functionally. Some living things have not changed noticeably for millions of years.

I would like a Summary Report of your dissertation: Yes [ ]

Grade taught (encircle one or more numbers): 1 2 3 4 5 6
TABLE IX

THE AVERAGE AND TOTAL JUDGMENT VALUE FOR THE PRINCIPLES OF BIOLOGY IN THE CONTENT AREA "NATURE OF LIFE", AS RATED BY TWO SELECT GROUPS OF ELEMENTARY SCHOOL TEACHERS

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TABLE X

THE AVERAGE AND TOTAL JUDGMENT VALUE FOR THE PRINCIPLES OF BIOLOGY IN THE CONTENT AREA "EARTH'S FOOD SUPPLY," AS RATED BY TWO SELECT GROUPS OF ELEMENTARY SCHOOL TEACHERS

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TABLE XI

The average and total judgment value for the principles of biology in the content area "Knowing Plants and Animals," as rated by two select groups of elementary school teachers.

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### TABLE XII

The average and total judgment value for the principles of biology in the content area "Survival of Living Things," as rated by two select groups of elementary school teachers.

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### TABLE XIII

The average and total judgment value for the principles of biology in the content area "Caring for Plants and Animals," as rated by two select groups of elementary school teachers.

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TABLE XIV

THE AVERAGE AND TOTAL JUDGMENT VALUE FOR THE PRINCIPLES OF BIOLOGY IN THE CONTENT AREA "USING PLANTS AND ANIMALS," AS RATED BY TWO SELECT GROUPS OF ELEMENTARY SCHOOL TEACHERS

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TABLE XV
THE AVERAGE AND TOTAL JUDGMENT VALUE FOR THE PRINCIPLES OF BIOLOGY IN THE CONTENT AREA "BEHAVIOR OF LIVING THINGS," AS RATED BY TWO SELECT GROUPS OF ELEMENTARY SCHOOL TEACHERS

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TABLE XVI
THE AVERAGE AND TOTAL JUDGMENT VALUE FOR THE
PRINCIPLES OF BIOLOGY IN THE CONTENT AREA
"HEALTH AND DISEASE," AS RATED BY
TWO SELECT GROUPS OF ELEMENTARY
SCHOOL TEACHERS

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TABLE XVII

THE AVERAGE AND TOTAL JUDGMENT VALUE FOR THE PRINCIPLES OF BIOLOGY IN THE CONTENT AREA "REPRODUCTION AND DEVELOPMENT," AS RATED BY TWO SELECT GROUPS OF ELEMENTARY SCHOOL TEACHERS

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APPENDIX C
Principle No. 8: Roots of plants are adapted structurally to absorb water from the soil and transport it to the leaves where it may be used to form food; most of the water evaporates if the leaves are thin.

LABORATORY EXPERIENCE UNIT NUMBER 8
Absorption and Translocation of Water in Plants

A. Form of Root Hairs
B. How Water Enters Plants
C. Passage of Water Through a Membrane
D. Movement of Soil Water in Hard Stems
E. Water Leaves the Plant
F. Amount of Water Loss From Plants
Procedures

A. Form of Root Hairs.— Put enough grass seed to cover the bottom of a Petri dish with a coat of seed, and add water to fill the dish one-half full. Replace the cover and let the dish stand at room temperature for five to six days. Remove a seedling from the dish and place it on a microscope slide. Cover the roots with a cover glass, and slowly add water with a dropper as shown in Diagram 1. Fill the spaces around the roots of the seedling with water.

![Diagram 1](image)

Examine the roots with a hand lens, then with the low power of your microscope. Look for tiny hair-like projections from the root.

Place another seedling on a slide and cover it with a cover glass. Instead of adding water under the cover glass, use a few drops of salt water (dissolve one teaspoonful of table salt in a drinking glass one-third full of water). Observe the reaction of the root to the salt water.

B. How Water Enters Plants.— Obtain a geranium or Coleus plant about eight inches high. Any plant with thin leaves should prove satisfactory for this activity. Prepare a 10 per cent solution of potassium permanganate (dissolve 10 grams of the dye in 100 cubic centimeters of water), and water your plant thoroughly each day with this solution. After several days, remove the plant from the soil and examine the leaves and stems for the presence or absence of the dye. Use a razor blade or sharp scalpel to cut across the stems and leaves.

C. Passage of Water Through A Membrane.— Fill a drinking glass with water up to one-half inch of the top. Bend a piece of coat-hanger wire twelve inches long into the shape shown in Diagram 2. Use pliers to help you bend the wire into the desired form. In order to make smooth turns of the wire to form a smooth circle for the egg to rest on, wrap the wire partly around a pipe or dowel one inch in diameter.
Tap the bottom of the wide end of a fresh egg, and peel off the shell to form a circle of about three-quarters of an inch in diameter. The egg membrane will be exposed and should not be broken or pierced in any way. Put the egg on the support so that the exposed membrane dips into the water. Cut a hole one-eighth of an inch in diameter at the narrow end of the egg, and insert a clear plastic drinking straw about three-quarters of an inch into the egg. Affix the straw to the shell with candle wax, cement, or plastic modeling clay, as shown in Diagram 3.

Let the egg remain dipped in the water for several hours. Observe what happens during the first hour, by checking the drinking straw at ten to fifteen minute intervals.

Change the water after completing the previous activity, and in place of the tap water, add two teaspoonfuls of table salt to a glass full of fresh water. Stir the solution until the salt dissolves completely. Observe the changes that may take place in the straw, recording the changes during five minute intervals for a period of about twenty minutes.
D. Movement of Soil Water In Hard Stems.-- Obtain branches of willow, maple, horse-chestnut, or other hard stems, and put them into a bottle containing red ink or eosin dye. Let the stems remain in this solution for at least three to four days. Remove the branches and cut the stem at different points along the stem. Cut one part of the stem vertically. Look for evidences of water penetration by looking for the presence of the dye or ink in the plant stem.

E. Water Leaves The Plant.-- Place on each side of a leaf of a geranium or scarlet runner plant [the scarlet runner plant may be grown from seed to a plant suitable for this experiment in three weeks time] a piece of cobalt chloride paper approximately 2 x 2 inches. Put another square piece of cobalt chloride paper on both sides of another leaf at another part of the plant. [To prepare the chloride paper, dissolve 20 grams of cobalt chloride in 100 cubic centimeters of water. Immerse the squares of filter paper into the solution, drain the excess solution from the paper and hang the squares to dry.]

Cover the squares with 2 x 2 glass slides [the glass slides used in mounting kodachrome 2 x 2 slides] and support the glass slides by clamping the glass slides together and supporting this weight by attaching the clamp to the ring stand as shown in Diagram L. Cover the pot with wax paper and seal the paper to the stem with scotch tape and plastic clay to make this connection water-tight. Observe the action of the leaf on the chloride paper at ten-minute intervals, and compare the action on the paper at the top and bottom of the leaf. Add a drop of water to a piece of a chloride paper and note the action of moisture on this paper.

F. Amount of Water Loss From Plants.-- Obtain two small plants with approximately equal areas of leaf surface; one plant such as geranium or Coleus, the other a plant with thick rubbery leaves. These plants should be in pots not to exceed a diameter of two and one-half inches, and should have a spread of leaves which should permit the plant to fit into a one quart wide-mouthed Mason jar.
Water each plant, then surround each pot with wax paper and seal as indicated in activity "E". Obtain two pieces of glass about four by five inches, and two wide-mouthed canning jars. Set up the demonstration as shown in Diagrams 5 and 6.

Be sure to seal both jars to the glass slides, and put both plants in direct sunlight. At intervals of one or more hours, compare the amount of loss of moisture from the plant with thin leaves with the plant with thick leaves.

**Appended Questions**

1. Why is the loss of moisture from plants more rapid in direct sunlight than in the shade?

2. In what form must substances be in order to move across plants walls, membranes, and into the conducting vessels of plants?

3. What factors may be responsible for the rise of water in plants, from the soil to height of one hundred or more feet?

4. Under what conditions is water likely to be extracted from the roots?

5. When dried prunes are placed in water overnight, they begin to swell. How do you account for this process in terms of the understandings which you have gained in this experience?

6. Compare the arrangement of the conducting vessels in a plant like geranium or Coleus with that of a stem of a hardwood like willow, maple, horse-chestnut, or other hardwood stem. What might be the possible reasons for the location of these conducting vessels from the standpoint of growth from one season to the other?

7. Why is it that a plant stem, even though it is severed from the parent plant, can still continue to absorb water, conduct the water in its vessels, and continue to lose water through its leaves?
8. What reasons would you offer in explaining the following phenomenon: About a week ago, about one shovelful of inorganic plant fertilizer was dug into the soil around a newly-planted shrub. This small plant now shows signs of dying, even though it has been thoroughly watered.

9. Why is it that plants with thick, fleshy leaves are more likely to survive in regions with very little rainfall than plants with thin leaves?

Outcomes

Specific Understandings

1. Water is absorbed from the soil by the plant through its root hairs.

2. Water is conducted from the roots to the leaves through conducting vessels.

3. Excess amounts of water absorbed by the plant are lost through the leaves of plants; the thinner the leaves the more pronounced is the loss of moisture from these plants when exposed to direct sunlight.

4. The rate of loss of moisture from leaves in direct sunlight varies; the thicker the leaves, the less the loss of moisture when compared with the loss from thin leaves.

5. Molecules of a liquid will move through a membrane from a region of lower concentration of salts in water to liquids of higher concentrations.
Principle No. 9: The ultimate source of all energy is sunlight and this energy is bound into food materials during photosynthesis.

LABORATORY EXPERIENCE UNIT NUMBER 9
Radiant Energy and Food Production in Plants

A. Role of Sunlight In Photosynthesis
B. Storage of Food In Seed Leaves
C. Release of Stored Energy During Germination of Seeds
Procedures

A. Role of Sunlight in Photosynthesis. — Obtain two geranium, Coleus, or fuchsia plants and place them in a dark place for two days. The plants may be placed in a closet, or under a paper box. After two days, put one plant in direct sunlight for several hours. Remove two leaves from the plant which has been placed in direct sunlight, and two leaves from the plant which has been in total darkness. Nick with a razor, or otherwise mark those leaves which had been in sunlight, and immerse the four leaves in boiling water for two minutes to kill the leaves. Remove the leaves and put them into a Petri dish containing hot wood alcohol (rubbing alcohol). Let the leaves remain in the alcohol for ten minutes, or until all traces of green coloring in the leaf have disappeared. Heat the wood alcohol in a narrow-mouthed pyrex flask, then pour the alcohol into the Petri dish. Cool ditto fluid has been found to be satisfactory for removing the chlorophyll, however the leaf has to remain in the fluid for a few hours.

Remove the leaves from the alcohol and put them into a solution of iodine in a Petri dish [Iodine Solution: 1 gram of potassium iodide and ½ gram iodine in 10 cubic centimeters of water. Mix the sodium and potassium iodide thoroughly, and add water to make a total of 250 cubic centimeters of solution]. Note the reaction of the leaves to the iodine solution. Try some of this iodine solution on some laundry starch, on a piece of potato, and on a piece of bread. Record the reaction of iodine with starch.

B. Storage of Food In Seed Leaves. — Fill a large drinking glass half-full with dry lima beans, and cover them with water overnight. The next day, split open the seeds, and put several drops of iodine solution on each half of the seed, as shown in Diagram 7. Record the changes that take place and determine whether or not the change is prominent over all parts of the surface of the lima bean seed leaves.

C. Release of Sored Energy During The Germination of Seeds. — Fill a large drinking glass half-full with dry, packaged lima bean seeds, and cover them with water overnight. Bore a hole one-quarter of an inch into the center of the cork of a thermos bottle (one pint capacity). Insert a Fahrenheit thermometer into the cork so that the bulb of the thermometer reaches about halfway into the bottle. Put the seeds into the thermos bottle, add about a third of a cup of water, and replace the cork. Seal the cork to the bottle with plastic clay, and seal around the thermometer in order to prevent heat from escaping from the bottle, as shown in Diagram 8.
Keep the bottle out of direct sunlight or other heat sources. Record the temperature in the inside of the bottle, and repeat the reading after fifteen minutes to obtain a correct reading of the temperature inside the bottle. Repeat readings during the second, third, and fourth days. Keep a record of the temperature inside the bottle during the time from onset of germination until the fifth day, and construct a graph to show the changes which have taken place.

**Appended Questions**

1. In the experiment on photosynthesis, what value was the "control plant?"
2. What was the purpose of removing the green coloring matter in the leaves with alcohol?
3. What can be said with regard to the value of using iodine solution as an indicator of certain food materials?
4. What are some probable reasons for the results in the activity concerned with the release of energy during seed germination? What was the original source of this energy?
5. Where does the plant get food material during its growth from a seed to a seedling?

**Outcomes**

**Specific Understandings**

1. Energy from the sun is necessary for food production by a green leaf.
2. A seedling obtains its food supply from food stored in the seed leaves, or cotyledons.
3. Heat energy is released during seed germination since the food is oxidized, thereby releasing bound heat energy.
4. The energy stored in a seed leaf has its origin in the sunlight used during food production.
Principle No. 16: After a seed has germinated, it needs sunlight to continue its growth into a mature plant.

LABORATORY EXPERIENCE UNIT NUMBER 16
Sunlight and Plant Growth

A. Sunlight and the Formation of Chlorophyll
B. Sunlight and Continued Plant Growth of Seedlings
Procedures

A. Sunlight and the Formation of Chlorophyll. — Soak ten lima bean seeds, scarlet runner seeds, or pea seeds in water for twenty-four hours. Put five seeds between two layers of moist cotton and let the dish with this cotton remain in a dark place. Embed the other five seeds in moist cotton and expose these seeds to sunlight. Do not cover the seeds with cotton, thereby permitting the seedlings to obtain sunlight during their growth. Examine the seeds each day and record the growth and color of those plants exposed to sunlight, and those plants retained in darkness.

B. Sunlight and Continued Growth of Seedlings. — Obtain two geranium, Coleus, or scarlet runner plants. Put one plant in a dark place (a closet or cover with a paper box), and place the other plant in direct sunlight. Water each plant daily, and record any changes between the two plants from day to day.

Obtain three small rhododendron plants and expose the plants to the following conditions:

1. Put one plant in a dark place.
2. Expose one plant to light, however place it in a shady place, away from sunlight.
3. Expose one plant to direct sunlight.

Record any changes which you may observe among these plants, as these plants continue to grow from day to day. Record the day, and the first visible change among the three plants.

Appended Questions

1. Why should the decrease in the amount of chlorophyll in the leaves of plants affect the production of food by these plants?

2. Why is it that plants can continue to germinate in the absence of light?

3. Is it possible for a green plant to reduce the amount of chlorophyll in its leaves and still continue to survive? Give reasons for your answer.

4. What important factor needs to be considered in planning to grow plants in different places inside your home? Use the knowledge gained during this activity.

5. If you were selecting different kinds of plants for landscaping your home, what important characteristic of plants would you need
to consider in order to promote good plant growth? Explain in terms of the light requirements of plants.

Outcomes

Specific Understandings

1. Seed germination can take place in the absence of light.

2. Light is not necessary for the germination of plants, however once the leaves begin to form, light is necessary for the development of chlorophyll.

3. Full grown plants need light in order to remain healthy and to survive.

4. Plants vary in the amount of sunlight required for survival; some plants grow well only in sunlight whereas others will grow satisfactorily in the shade and will not evidence good growth when exposed to direct sunlight.
Principle No. 45: In man, food and oxygen are carried to all parts of the body through a system of blood circulation.

LABORATORY EXPERIENCE UNIT NUMBER 45
The Transportation System In The Human Body

A. Viewing of the film The Heart and Circulation
B. Blood Circulation In Capillaries
C. Pumping Action of the Heart In The Frog
D. Study of A Beef Heart and Model of The Human Heart
E. Heart Beat and Arterial Pulse (Human)
F. Effect of Exercise On The Rate of The Heart Beat
Procedures

A. Viewing of the Film The Heart and Circulation. — To the instructor; Students will be asked to observe the film on the heart and circulation. This film will be used to introduce the subject of the transportation system in the human body for the following reasons: (1) Movement of the heart can be introduced at this time to all students since the film captures motion [students will observe the beating of the heart of an animal in further study], (2) the motion picture through its animated drawings can present a process which is difficult to perceive about the human heart in the laboratory, and (3) The film makes it possible to for the group as a whole to participate in a common experience which should prove helpful in further studies about the human heart.

Prior to the showing of the film, the instructor should discuss the general aspect of the circulatory system, pointing out the principal functions of this system. The action of the heart as a pumping station, and the meaning of a closed system of circulation should be emphasized. The students need to be oriented with respect to some of the content which they are to observe, hence the use of the mode of the human heart, a chart, or reference to drawings during a brief talk about the circulatory system should prove most helpful at this time. Students should be instructed to pay special attention to the following during the showing of the film:

1. The rhythmic beating of the heart in the experimental animals.
2. The function of the heart valves.
3. Path of blood through the heart.
4. The origin of the pulse beat.
5. The nature of the different kinds of blood vessels comprising the transportation system in man.

B. Blood Circulation In Capillaries. — Wrap a small aquarium fish or tadpole in moist cotton, exposing the tail of the animal. Put the animal on a piece of glass about four by five inches, as shown in Diagram 9.
Examine the thin end of the tail with a low power of a microscope, and look for tiny blood vessels through which blood is flowing. Keep in mind that both the size of the blood vessels and the speed of flow of blood in these vessels are exaggerated when viewed with a microscope. Look for blood vessels of different sizes and compare the flow of blood in these vessels.

In the event fish are not available, an anesthetized frog may be used. Cut out a hole equal to the size of the opening in the stage of the microscope, in a piece of cardboard 4 x 8 inches. Pin the outstretched web of the frog's leg over the aperture in the cardboard and superimpose this aperture over that in the stage, as shown in Diagram 10.

![Diagram 10](image)

Examine the web for tiny blood vessels in the thin membraneous portion of the web. Compare the speed of flow of blood in the larger vessels in the web with that in the much smaller blood vessels. As in the fishtail, both the speed of blood circulation and the size of the blood vessels are greatly exaggerated when observed by a microscope.

C. **Pumping Action of the Heart in the Frog.**—Examine a demonstration of an anesthetized or pithed frog showing an exposed heart. Note that the tissues over the heart have been removed with scissors and/or scalpel, and that the incision had to be made slightly to the left because of the sternum, or bone in the thoracic cavity. This bone had to be cut in order to expose the heart.

Observe the contraction of the heart, and ascertain by observation which part of the heart appears to contract with greater force. Record the rate of the heart beat in terms of the number of beats per minute, then pour warm water over the heart and record the rate of the heart beat again. Pour a few drops of ice water over the heart and observe the effect of cooling the heart.

D. **Study of A Beef Heart and Model of The Human Heart.**—Examine a beef heart which has been cut longitudinally by your instructor to expose
the chambers of the heart. Examine as follows:

1. Find the large, rather heavy-walled vessel which emerges from the left side of the heart. Compare the thickness of this vessel with the large blood vessels which lead into the upper right chamber of the heart.
2. Compare the walls of the two upper chambers of the heart with the walls of the lower chambers of the heart.
3. Examine the valves of vessels carrying blood away from the heart (vessels carrying blood away from both of the lower chambers of the heart), and the valves between the upper and lower chambers on both sides of the beef heart.
4. Examine the wall of muscle which divides both sides of the heart. Determine whether or not it would be possible for blood to go from the right side of the heart to the left side without going out of the heart.
5. Examine the model of a human heart and compare your observations of the beef heart with the structure of the human heart, using a model of the human heart.

E. Heart Beat and Arterial Pulse (Human).-- Find your pulse by placing your forefinger and the two adjoining fingers on your left wrist at the points indicated in Drawing 11.

Now try to find your partner's pulse in the same manner as you have found your pulse. Keeping one hand on your partner's pulse, find your partner's heart beat using a stethoscope. Does the heart beat and the pulse beat register at the same instant?

Determine the rate of the heart beat per minute, by taking three readings and calculating the average heart rate. Determine the rate of the pulse beat and compare this rate with the heart rate.

F. Effect of Exercise on the Rate of the Heart Beat.-- Ask your partner to sit down and rest for a few minutes. Calculate the average pulse
beat per minute while at rest. Next, ask your partner to jump alternately on each foot twenty-five times. Immediately after the exercise, tell your partner to sit down and proceed as follows:

1. Immediately take the pulse and count the number of beats for 30 seconds. Record the number of beats but be sure to keep your fingers on the pulse.
2. Rest for 30 seconds.
3. Take the pulse for another 30 seconds. This constitutes the one-minute reading. Record the pulse beat.
4. Rest for 30 Seconds.
5. Take the pulse for another 30 seconds. This constitutes the two-minute reading. Record the pulse beat.

Continue taking 30-second readings until the pulse rate per minute approximates the pulse rate while at rest.

Record your observations on the blackboard, indicating the pulse rate at rest, the pulse immediately after exercise, and the pulse rate at one-minute intervals subsequent to the reading after exercise. Calculate the average pulse per minute for your class. What is the average number of minutes required for the pulse to return to the rate at rest after exercise?

**Appended Questions**

1. Assume that you are a witness to an accident in which the individual has just cut his arm. The blood is spurting out from a vessel, and you are faced with the problem of helping to stop the flow of this blood. Is the blood coming out of a vein or artery, and where would you plan to apply pressure? What reasons would you offer in defense of your intended action?

2. Blood is flowing from a cut in the forearm in an even flow. How would you attempt to stop the flow of this blood? Would you apply pressure above or below the location of the cut on the arm? What reasons would you give in support of your action?

3. What part of the heart structure indicates that blood must leave the heart before it can go from the right side of the heart to the left side? Where does the blood go in the meantime?

4. In what ways would you consider the human heart to be like the beef heart?

5. Explain the formation or origin of the arterial pulse, and its ultimate disappearance in the veins?

6. Why is it likely to be expected that the musculature of the lower chambers of the heart should be greater than that of the chambers of the upper part of the heart?
7. Explain the action of the valves of the heart. What is referred to as a "heart murmur"?

Outcomes

Specific Understandings

1. The blood is sent out into a system of blood vessels under the pressure of the contracting muscles of the heart.

2. The heart is a muscular organ capable of exerting strong and continuous pressure.

3. Blood courses through a closed system of blood vessels.

4. The flow of blood in arteries is under direct influence of the beating heart and the elasticity of the walls of arteries, hence the spurting movement of blood in arteries. As blood continues into capillaries and then into the veins, the pressure forcing the blood to move away from the heart is lost.

5. The pulse beat in the wrist reflects the beating of the heart.

6. Valves located in strategic places in the heart and in certain blood vessels helps to channel blood in specific directions.
Principle No. 70: Plants aid in conserving and renewing the mineral content of the soil; replanting trees and shrubs, and grasses help to keep the soil intact and free from the ravages of wind and rain, and the plant roots act as "elevators" to bring minerals to the surface.

LABORATORY EXPERIENCE UNIT NUMBER 70
Plants and Soil Conservation

Field
A. Water Drainage In Barren Soil and in Soil Covered with Grasses
B. Temperature of Barren Soil and Soil Covered with Plant Growth
C. Soil Cover and Moisture Present in the Soil
D. Action of Raindrops on Barren Soil and on Soil Covered with Vegetation

Classroom (subsequent to field collection in some instances)
E. Water Run-off and Erosion of Barren Soil and of soil covered with Grass
F. How Humus Changes the Drainage in Soil
G. Replenishing Plant Nutrients by Legumes
A. Water Drainage in Barren Soil and in Soil Covered with Grasses.— Obtain several small fruit juice cans and cut off the top and bottom covers with a can opener. Notch one rim of each can with tin shears, and place a strip of adhesive tape around each can about one and one-half inches away from the notched edge, as shown in Diagram 12.

Select a place on the school grounds where there is barren soil as well as soil covered with vegetation. Push these cans into the soil down to the level indicated by the adhesive tape at such places as (a) under a shrub, (b) on the grass, (c) on barren ground, and (d) in a flower bed if present. Pushing and turning the can clockwise and counter-clockwise helps to dig the serrated edge into the ground. Fill each can to the top with water from a canning jar or pail, and record the number of seconds it takes the water to sink into the ground. Compare the rate of drainage in the soil at these different places. Compare the looseness of the soil which shows the highest rate of drainage with that having the lowest rate of drainage.

B. Temperature of Barren Soil and Soil Covered with Plant Growth.— Purchase two thermometers that are identical in size, type, and color. Satisfactory and inexpensive thermometers for this purpose can be purchased at a five-and-ten cent store. Check to make sure that the two thermometers register approximately the same temperature. Mark the two thermometers with adhesive tape or fingernail polish one inch from the bottom of the thermometer. Mark the thermometers "A" and "B", and record the difference in the reading between them. Put these instruments in direct sunlight as follows (also shown in Diagram 13):

1. Put the bulb end of the thermometer one inch under barren soil as shown in Diagram 13. Use the adhesive tape as a guide for submerging the bulb end of the instrument.

2. Put the bulb end of the second thermometer into the soil that is covered with grass. Use a knife to form a wedge in the soil to ease the work of putting the instrument below the surface of the soil, and to prevent damage to the thermometers.
After thirty minutes, record the temperature of the soil under both conditions of exposure to direct sunlight.

C. Soil Cover and Moisture Present in the Soil. Select two small areas on the school grounds where the soil is covered with grass, and where barren soil is exposed. Using a trowel, check for visible evidence of water in both areas. Note whether one soil is more moist than the other. Dig into the soil to see how far it is necessary to excavate before there is evidence of dampness in the soil, however do not exceed a depth of eighteen inches.

D. Action of Raindrops on Barren Soil and on Soil Covered with Vegetation. Put two stakes ten inches long partly into the ground, placing one stake in barren soil, the other in soil covered with grass. Pin a 5 x 8 card in upright position on each stake, at least two inches away from the ground as shown in Diagram 14.

Sprinkle water on the ground just in front of each stake from a can with a perforated bottom or from a sprinkling can. Hold the sprinkler about four feet above the ground, and note the action of raindrops on the soil as evidenced by the appearance of the cards. Compare the action of the raindrops on soil that is covered with vegetation with the effect of water on barren soil.
E. Water Run-off and Erosion of Barren Soil and on Soil Covered with Grass

1. Constructing a metal tray for erosion studies. Construct and assemble the metal tray as shown in Diagrams 15, 16, and 17.

A tinsmith or the industrial arts shop may have equipment to do a very speedy job of bending the tin according to the specifications. However, tin may be bent satisfactorily using a vise, hammer, and two pieces of metal or wood as illustrated in the diagrams.

![Diagram 15](image1.png)

![Diagram 16](image2.png)

Insert tin, bend smooth with a hammer

![Diagram 17](image3.png)

DIAGRAM 15

DIAGRAM 16

DIAGRAM 17
2. **Soil cover and water run-off.** Put a block of sod ten inches long and five inches wide, and three inches deep into the metal tray into section "A" as shown in Diagram 18. Place a piece of barren soil (clay) of the same dimension as the soil in "A", next to the sod. Note how the samples of soil are separated from each other by a piece of wood held in place with plastic clay.

![Diagram 18](image)

Connect the "Y" tube to a water source and let the water run very slowly over the samples of soil. Lift one end of the tray with a block of wood that will extend the width of the tray, to simulate sloping land. Let the water run over the soil for several minutes, and collect the water coming out of outlet A and B into separate flat containers. Compare the amount of water run-off from the different samples of soil.

Upon completion of this experiment, separate some of the grass roots from the soil. Note the extent to which roots hold particles of soil.

F. **How Humus Changes the Drainage in Soil.** Cut off both ends of several small fruit juice cans with a can openers, and only one end of three more cans. Cover one end of the cans open on both sides with cheesecloth and fasten the cloth to the can with a piece of string or a rubber band. Collect some clay and set up the mixtures of clay and humus as shown in Diagram 19. Good samples of humus can be collected from places where leaves are decaying in quantity such as in wooded areas, or around and underneath shrubs.

![Diagram 19](image)
Pour 100 cubic centimeters of water into each sample (a cupful of water will be ample for this demonstration), adding small quantities of water until the soil takes up all of the water. Record the time in seconds that is required for the water to penetrate the soil. Measure the amount of water which passed through each mixture with the aid of a graduated cylinder, or just estimate which soil retained the most water. Wait about thirty minutes and repeat this experiment. Note the amount of water which passes through each mixture, and the speed with which water passes through each sample of soil.

G. Replenishing Plant Nutrients by Legumes.—Collect roots of mature plants of clover, alfalfa, or timothy and remove the nodules which you see on the roots. Collect many of these nodules principally from alfalfa and clover, sufficient in number to constitute a small mass capable of being ground in a small mortar. Fill two small pots with a soil mixture consisting of equal parts of fine and coarse sand. Be sure to wash the sand in water to remove all traces of other soil, and select pots which are no larger than two and one-half inches in diameter. Mix the nodules which have been ground in the mortar with the sand in only one of the pots, and label this soil "containing nodules" for future reference. Plant seven seeds of oats in each pot, and water each soil daily. Allow the seeds to sprout from the soil, then continue to observe the growth each day, for about two weeks. Compare the growth of oats in each soil.

**Appended Questions**

1. Why is it that grass is grown on flat and sloping land adjoining highways?

2. Why is it important for us to try to improve the drainage of garden soils, and how can this be done on a small scale? Explain in terms of the understandings which you have gained from this experience.

3. Nurseries and other consultants on the growth of lawns advise that grass should be allowed to grow at least two and one-half inches high during the hot summer months before mowing the lawn. How would this practice help to protect the soil as well as the grass?

4. Why is it that strip-cropping, especially growth with plants such as timothy, alfalfa, and clover help to make the land more useful for farming?

5. How does vegetation on soil banks around the home help to conserve and prevent excessive erosion of the land?
Outcomes

Specific Understandings

1. Roots of plants hold soil particles together thereby helping to reduce the effects of erosion by running and falling water.

2. Grasses help to decrease the extent of run-off of water from sloping land by improving the drainage of soil, and reducing the speed of running water.

3. Roots of plants loosen the soil and in this way increase the rate of drainage of water into the soil.

4. Soil with vegetation cover is likely to show a greater rate of drainage than waste barren soil.

5. The temperature of soil with protective cover such as grasses is lower than that of barren soil; plants help to shield the soil from the direct rays of the soil.

6. Soil with protective cover tends to retain moisture for greater period of time; soil cover tends to reduce the rate of evaporation of water from the soil.

7. The minerals produced on the roots of legumes aid in renewing the mineral content of soil which is so necessary for plant growth.

8. Humus, the decaying substance of plant materials, helps to improve the drainage in some soils.
Principle No. 71: Plants serve man by providing him with the different classes of food which are necessary for his everyday life.

LABORATORY EXPERIENCE UNIT NUMBER 71
Plants: Food for Man's Survival

A. Testing for Carbohydrates
B. Testing for Protein
C. Fats in Plant Food
D. Presence of Water in Plant Food
E. Testing for Vitamin C
A. Testing for Carbohydrates.

1. Starch in plants. Crush several wheat or rice seeds in a mortar. Place some of this powder or flour on a glass slide and add two or three drops of 10 per cent solution of iodine. [see Unit No. 9]. Note the color formation and record the extent of changes taking place.

Soak several peas and lima beans in water for several hours. Put two or more drops of iodine solution on the inner sides of the split seeds. Note and record any color changes which take place. Add iodine solution to the cut surfaces of a potato, turnip, or carrot.

2. Testing for sugar. Dissolve one-half teaspoonful of table sugar in a test tube one-third full of water. Into another test tube put equal parts of Fehling's solution "A" and "B", mixing three cubic centimeters of each solution. Your instructor will provide you with the Fehling's solutions. Add several drops of the sugar solution to the Fehling's solution, and heat the mixture gently over a flame. Be sure to stir the contents by gently shaking the tube while you hold it slantwise as shown in Diagram 20.

Continue to heat the content to a boil for two minutes or until some changes in the solution are apparent. Perform the same test using only two drops of sugar solution, then only one drop of sugar solution. Compare the changes which take place in each test.

Perform the test for sugar using the following in place of the sugar solution:

1. Add fresh frozen peas to 5 cubic centimeters of Fehling's solution, mash them with a stirring rod, and allow the materials to settle for ten minutes. Pour off the solution into another tube through filter paper, and heat the filtered solution over a flame for three to five minutes.

2. Put two or three sweet grapes into a test tube containing 5 cubic centimeters of Fehling's solution. Crush the grapes with a stirring rod, and let the mixture stand for a few minutes. Filter the solution and heat the
filtrate over a flame for five minutes. Record changes which may take place, and compare these changes in the solution with those when varying amounts of sugar solution were used.

B. Testing for Protein.--- Perform the following test to see what changes indicate the presence of protein: Heat an egg in boiling water for ten minutes. Peel the egg and cut the white of the egg into tiny pieces. Put these pieces of egg white into a test tube, and add several drops of concentrated nitric acid. Heat the test tube very gently, and stir the contents of the tube constantly to prevent frothing or excessive bubbling of the contents. When a change is apparent, pour ten cubic centimeters of warm water into the test tube containing the egg white. When the acid has had a chance to mix with the water, pour out the liquid contents, then add several drops of ammonia water over the egg. Note the characteristic change that takes place when protein is present in a substance.

Perform the same test using small pieces of raw potato, fresh lima beans, and oatmeal.

C. Fats in Plant Food.--- Obtain a piece of glazed paper, peanuts, a small piece of chalk, an apple, and a tab of butter. Spread a small amount of butter over the glazed paper and wipe of any excess of fat. Record the change which takes place in the paper when fatty material is rubbed over glazed paper. Rub a piece of apple, chalk, or the cut edge of a peanut over the glazed paper, and record any changes that may take place.

D. Presence of Water in Plant Food.--- Place several fresh or frozen peas that have been allowed to thaw out in a flat dish into a test tube. Heat the contents over a flame for several minutes at high heat. What evidence do you find to indicate the presence of moisture in plant foods? Repeat this test using other plant foods such as apple, beans, celery, or lettuce.

E. Testing for Vitamin C.--- Obtain some canned lemon juice, or squeeze out the juice from a fresh lemon. Fold the filter paper as shown in Diagram 23.
Put the filter paper into a funnel, and filter the lemon juice. Measure out five cubic centimeters of filtered juice into one tube, and place five cubic centimeters of white vinegar into another test tube. Add five drops of methylene blue solution to each test tube, and note the color formation at this time. Put both test tubes in direct sunlight for 30 minutes. Note the characteristic change that takes place in the tube containing Vitamin C.

Repeat this test using the juice from the following: orange, grapefruit, and lime. Use a small flask, glass funnel, and filter paper to filter the liquid extracts as shown in Diagram 24.

\[ \text{The extracted juice is poured through the filter paper.} \]

\[ \text{The filtrate is used for the test.} \]

**Diagram 24**

---

**Appended Questions**

1. Plants store classes of food materials in different parts of its anatomy. Name two plants which store food in (a) leaves, (b) stems, and (c) roots.

2. From what source or sources do plants receive the raw materials to produce the different classes of food materials?

3. To what extent would you say man is dependent upon his plant environment for his survival?

4. Give some basic reasons why green plants have the ability to produce food materials whereas man cannot as yet produce food for his use.

5. How does the plant produce food materials such as proteins and fats when it actually produces sugar during photosynthesis?
Outcomes

Specific Understandings

1. Plants contain certain classes of food materials which man uses in order to survive.

2. The presence of certain classes of food materials can be detected through specific tests.

3. Certain classes of food materials are more abundant in some plants than in others.
Principle No. 86: Disease germs may be spread from one place to another through different media; dust, liquids such as sputum, and droplets which are given off during coughing and sneezing. In some instances, food is a carrier of disease germs.

LABORATORY EXPERIENCE UNIT NUMBER 86
Transmission and Distribution of Bacteria

A. Preparation of sterile media, sterile swabs, and sterile glassware.

B. How Microbes are Carried from One Place to Another: Dust, Personal Objects, and Droplets.

C. Microscopic Study of Bacteria

D. Food as a Carrier of Bacteria
A. Preparation of Sterile Media, Sterile Swabs, and Sterile Glassware.

1. Sterile media. Obtain nutrient agar which is available in powder form [the agar will be supplied by your instructor who will procure the agar from a biological supply house], and follow directions on the bottle to make 300 cubic centimeters of agar medium. Dissolve the agar in 200 cc. of water in a flask, and bring the solution to a boil. Allow the solution to cool, but not to the point where the agar begins to gel. Pour the agar into a 500 cc. graduated cylinder, or into a container so marked as to indicate the level at which 300 cc. would be contained in the container. If a large graduated cylinder is not available use a small one, pouring 300 cc. of water into a container and indicating the 300 cc.-level with adhesive tape. Add water to the agar to make 300 cc. of medium, and pour off 150 cc. of the agar into two smaller flasks. The agar is ready for sterilization.

2. Sterile swabs. Twist some absorbent cotton about the thicker ends of a toothpick, preparing at least a dozen of such swabs. Put the swabs into a test tube and plug the tube with cotton so that the cotton plug extends about one inch into the tube and one inch out of the tube for easy handling. The swabs are ready for sterilization.

3. Sterilized Petri dishes. Wash and dry a dozen Petri dishes. In the event the dishes are to be sterilized at home in an oven, wrap each dish in newspaper and secure the paper to the dish with string. Use a bow knot to facilitate the removal of the paper from the plate at the time of pouring the agar plates.

4. Sterilization process. Put a cotton plug into the flasks containing the agar solution. Put the flasks, swabs, and glassware into an autoclave for 20 minutes at 15 pounds pressure. Your instructor will help you to get this material sterilized for you, or you can have this done for you at your nearest health laboratory. Should this form of sterilization be impossible, then put all materials into an oven for 1½ to 60 minutes at a temperature of about 360 degrees Fahrenheit.

5. Pouring agar plates. Remove the cotton plug from one flask of agar, flame the lip of the flask over a flame, and proceed as follows:
   a. Raise the cover of a Petri dish and pour in enough agar to form a layer of agar about one-quarter of an inch thick, as shown in Diagram 25.
   b. Replace the cover and stir the entire dish in a clock-wise rotation to remove all air bubbles. Stir gently enough so that agar will not spill over the lip of the dish.
c. Let the agar harden, then invert the dish with its cover and put the agar plates into the refrigerator.
d. Prepare a dozen agar plates this way.

B. How Microbes are Carried from One Place to Another: Dust, Personal Objects, and Droplets.— Inoculate agar plates as follows:

1. Remove the cover of one agar plate for thirty minutes. Replace the cover and label this plate "Exposed to Air". Use a glass marking pencil or gummed labels.

2. Rub a dust cloth over some dusty furniture. Remove the cover of one agar plate and shake the dust over the agar. Label this plate "Exposed to Dust".

3. Rub a pocket comb gently over the agar in a Petri dish, and label this agar plate "Exposed to Personal Item - Comb".

4. Put a penny on the agar, remove the penny and label "Handled Objects - Money".

5. Remove some of the dirt from underneath the fingernail and "roll" the dirt over the agar. Label this plate "Dirt From Fingernails".

6. Touch the agar with a soiled handkerchief, and label the agar plate "Nasal Secretions".

7. Let two or three drops of tap water fall on the agar and label this agar plate "Exposed to Tap Water".

Set two agar plates aside without inoculating these plates and label the "Control Plates". Keep all agar plates at room temperature and examine them at the end of 24 hours and again at 48 hours. Count the number of colonies of bacteria (small bodies or aggregates of bacteria which will appear usually as white to gray bodies) and record the number of colonies in each plate which has been inoculated as well as the "control" plates.

C. Microscopic Study of Bacteria.— To be sure that the colonies on the agar plates are bacteria, and to see bacteria with the aid of a microscope, obtain the following materials:

1. Several microscope slides
2. A wire loop which is to be constructed as shown in Diagram 21
3. A solution of gentian or crystal violet (to be supplied by the instructor)
4. A glass dish, or metal pan approximately 5 inches wide, 8 inches long, and 3½ inches deep
5. Two pieces of glass tubing 12 inches long, and one piece 6 inches long.
7. A drinking glass.

Prepare a wire loop as follows: Heat one end of a piece of glass tubing twelve inches long until it is red hot and in a molten state. Insert a piece of nickel, nickel silver (electric-resistance wire), or steel wire about four inches long into the tip of the glass tube, as shown in Diagram 21.

Preparing and staining slides of bacteria. Set up a staining dish as shown in Diagram 27. To prepare the cross pieces of glass tubing it will be necessary to cut glass tubing. Measure off 3 inches on the glass tube and scratch into the glass at this point with the edge of a metal file. Take the tube in both hands, holding the tube with the side which has been scratched away from you. Press forward and crack the tube at the point where the scratch is located. The tube will break easily, and without much force.

Put a drop of sterile water, or tap water in the center of a microscope slide. Put the end of your wire loop into the flame until it becomes red hot, in order to kill any organisms which may be present on the loop. Let the wire cool off, then pick off a single colony of
bacteria from an agar culture plate of any of the first six agar plates which you had inoculated in Activity "B" of this experience unit. Mix the bacteria with the water to form a film about one-half inch in diameter. Flame the slide gently to speed up the drying of the film. This heating also helps to affix the film to the slide so that the bacteria will not wash off during the staining process. Put the slide on the glass holder over the dish, and add enough gentian or crystal violet to cover the film on the slide. Stain the bacteria for two minutes, then wash the dye away from the slide with water. Blot the film against a white absorbent paper such as mimeograph paper or filter paper. Put a drop or two of immersion oil, or mineral oil on the slide and examine the film under the low and high powers of your microscope.

D. Food as a Carrier of Bacteria.— Sandpaper a spot on the skin of an unspoiled orange. Touch this spot to the skin of an orange showing considerable decay in this area. Let the unspoiled orange remain at room temperature for several days. To direct immediate attention to the spot which is rubbed against a spoiled orange, draw a circle around this area with a glass marking pencil or with ink.

Obtain two apples, one which appears unspoiled, the other showing a definite area of spoilage. Sterilize a fork by immersing the forked end in 70 per cent alcohol, or into commercial rubbing alcohol. Plunge the fork into the decaying portion of the apple, then stab an unspoiled apple one or twice. Let the unspoiled apple remain at room temperature for a few days. Observe the apple each day, and record the changes that are taking place.

Appended Questions

1. Situation: During the beginning of the school year, one third grade teacher asked each child to bring a large box of cleansing tissues (kleenex) for their use during the school year.

Question: What necessary precaution has this teacher taken in this class? What may have been the reasons why this teacher has taken this action?

2. Situation: A child is trying to help with the cleaning in the home and starts to sweep the rooms, including sweeping the rugs and in general stirring considerable dust into the air.

Question: What possible menace is this situation to the child and to others in the home? Base your reasoning on your experience in this unit.

Question: Discuss the merits of the use of paper towels versus usage of a single cloth towel which may be changed from time to time by a caretaker.

4. Situation: A mother suffering from naso-pharyngitis decides to feed her infant. Before coming near to her child, she decides to put on a sterile face mask.

Question: Of what value are these precautions to the child? How can a sterilized mask be of help in this situation?

5. Situation: It was found that one apple in a bag of apples shows signs of decay.

Question: What precaution should be taken promptly? Upon what reasons would you base your actions?

Outcomes

Specific Understandings

1. Microbes may be spread from one infected area of one object to another object through contact.

2. Microbes may be spread through dust particles which act as a vehicle for bacteria.

3. Bacteria may be carried through human nasal secretions, or tiny droplets emitted during coughing or sneezing.

4. Bacteria are carried on personal objects such as combs.

5. Certain parts of body house bacteria; bacteria may be found abundantly under the fingernails.

6. Certain household duties involving uncontrolled cleaning, may enhance the spread of disease throughout the household.

7. Certain household practices may involve the use of articles which may foster the spread of bacteria.

8. Certain household and community practices may affect the carriage of microbes from one place or person to another place or person.
Principle No. 87: Certain harmful bacteria enter our bodies at specific points; the most common portals of entry are the mouth and nasal passages since these places usually provide the bacteria with food, moisture, and proper temperature for their development.

LABORATORY EXPERIENCE UNIT NUMBER 87
Requirements For The Growth Of Bacteria

A. The Effect of Temperature on the Growth of Bacteria
B. Food Requirement for the Growth of Bacteria
C. Growth of Bacteria Under Varying Conditions of Moisture
D. Growth of Bacteria in Sunlight and in Darkness
Procedures

A. The Effect of Temperature on the Growth of Bacteria.—Dip a sterile swab into sterile water (water boiled for five minutes), and press the cotton against the wall of the container to drain off excess water. "Mop" up the floor to pick up some dirt with the swab, and inoculate three agar plates by rubbing the agar with the swab in the general direction as shown in Diagram 28. This method is very important since it helps to thin out the number of bacteria as you streak across the plate, and makes it possible to count the individual colonies as well as to study individual colonies.

Mark these plates with glass marking pencil, or gummed labels as follows: "Cold", "Slightly Warm", and "Very Warm". Put the agar plates in places as follows:

1. Keep the "cold" plate in a refrigerator for 24 hours.
2. Put the plate marked "warm" in a dark place at room temperature (closet or paper box).
3. Put the plate marked "very warm" next to the radiators or in a sunny place, but be sure to cover the plate with black paper or put the plate into a small paper box.

After 24 hours, and again at the end of 48 hours, count the number of colonies of bacteria. Colonies of bacteria will appear as small aggregates of bacteria appearing as a white or gray clump. Compare the growth in the agar plates which have been inoculated and retained under different physical conditions of temperature, and ascertain under which conditions bacteria will grow more abundantly. Which condition of temperature approximates the temperature of the human body?

B. Food Requirement for the Growth of Bacteria.—Dissolve one bouillon cube in 150 cc. of water. Pour 5 cc. of this broth into several test tubes. Place these tubes with broth, and test tubes containing 5 cc. of tap water into a small pan of water. Be sure that the diameter of
the pan is narrow enough to permit the tubes to remain in an upright position. Plug each test tube with a cotton plug, and bring the water in the pan to boiling. Continue to heat the tubes with boiling water for ten minutes. Let the broth and water in the tubes cool down to room temperature, then inoculate two tubes containing broth and two tubes containing water with bacteria swabbed from the floor with sterile swabs. Use a new swab for each tube to be inoculated. Slant the test tube and mix the swab with the liquid in the tube. Mark two containers of sterile water as "controls". Keep all tubes at room temperature, and record the extent of change in the appearance of the liquid in the tubes after 24 and 48 hours.

C. Growth of Bacteria Under Varying Conditions of Moisture.— Obtain six agar plates and place them in a very warm place so that moisture will continue to be evaporated from the nutrient agar in the dish. Inoculate one plate every two days until you have used up the six plates. Record the growth each time after 24 hours of growth, counting the number of colonies. Use a loopful of the growth in the broth tubes which your instructor will provide you with each time, as the bacteria for inoculating your agar plates. Compare the growth of bacteria in the agar plates as the moisture continues to evaporate from the nutrient agar.

D. Growth of Bacteria in Sunlight and In Darkness.— Obtain two agar plates and enough black wrapping (opaque paper of any color) paper to wrap one agar plate. Inoculate the two agar plates with a moist swab which has been used to "mop" the floor. Wrap one of the plates in paper, the other remains unwrapped. Put both plates in direct sunlight, and observe the growth of bacteria after 24 hours in both plates. Compare the growth of bacteria under conditions of sunlight and darkness, when bacteria have the necessary food, temperature, and moisture.

Appended Questions

1. In what ways may the mouth and the nasal passages provide bacteria with the necessary conditions for the growth of bacteria?

2. In what way can we discourage the rapid growth of bacteria in our mouth?

3. What means are utilized in hospitals and homes to decrease the harmful bacteria from entering the mouth and nasal passages of one person to another. What protection do these means offer to the human body?

4. Based on evidence in this experience unit, of what value is it to air out bedlinen and wearing apparel?
Outcomes

Specific Understandings

1. Cold temperatures of about 30 degrees Fahrenheit inhibit or greatly reduce the rate of growth of bacteria.

2. Although bacteria will grow at temperatures of 68-70 degrees, bacterial growth is more abundant at temperatures approximating body temperature, or 98.6 degrees Fahrenheit.

3. Direct sunlight greatly reduces the extent and rate of growth of bacteria.

4. Given proper conditions of moisture, temperature, and food, bacteria will grow more luxuriantly in darkness than in light.

5. Bacteria must have food, moisture, and warm temperatures in order to grow rapidly and multiply.
APPENDIX D
INSTRUCTIONS FOR THE JUDGE:

Included in this package are eight laboratory experience units and eight rating forms. You will note that the number of experiences has been reduced from the proposed ten to eight in view of the fact that it was necessary to increase the number of activities to provide sufficient scope for the experience unit. Each experience consists of two or more activities.

The eight principles chosen for the development of the units. Eight principles were chosen which were rated the highest by a select group of elementary school teachers. This group of teachers was asked to rate one hundred and six principles of general biology in terms of the importance of understanding these principles in order to teach about plants and animals.

Considerations. The main purpose of this dissertation is to relate a process of selecting, developing, and validating laboratory experiences. It is not intended that (a) the activities selected for the experience unit are either the best or the only ones, which could be useful in a particular experience unit, or that (b) the number of activities suggested for each unit is the necessary number. It is not intended at this time to present either the kind and number of activities which will fully realize an understanding of the principle. However, the number of activities should help to meet the criteria by which the units have been developed.

Rating Form. Eight criteria listed for the evaluation of an experience unit are listed on a separate sheet. Consider the unit as a whole in evaluating the unit. There will be only eight checks for each unit. In developing and/or selecting the experience unit, eight criteria were used—these are the same criteria by which the judges are asked to evaluate the units. The code is listed on the rating form sheet.

The experience units have been developed with full intention to meet the criteria, however should an experience unit receive a rating for one of the criteria of less than "SC" such as "PC", then would you please indicate the reason on the rating form, and I will make the correction and re-submit the experience unit to you.

Definition of an Experience Unit. For the purposes of this study an experience unit will be considered to be two or more activities in general biology which are centered about a principle of biology for the expressed purpose of developing meanings which will help collectively to understand a major principle of biology, or some aspect of the principle.

Returning the Evaluation. A large manilla self addressed, stamped envelope is enclosed for your convenience. It will not be necessary to return the laboratory experience units, just the rating form.
RATING FORM: CRITERIA FOR SELECTING AND/OR DEVELOPING LABORATORY EXPERIENCE UNITS IN GENERAL BIOLOGY FOR PROSPECTIVE ELEMENTARY SCHOOL TEACHERS

LABORATORY EXPERIENCE UNIT NO. ______

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<td>1.</td>
<td>The laboratory experience unit should be selected and/or developed in terms of its possible contribution to some aspect of the principle to biology which is considered very important to know, as judged by a select group of elementary school teachers.</td>
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<td>The laboratory experience should provide for an individual experience.</td>
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<td>The procedures for the experience unit should be clear and concise.</td>
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<td>4.</td>
<td>The materials and equipment for the experience unit should be available in the college biology room, or easily obtained and/or constructed and accumulated by the student or instructor, or available as a community resource within a reasonable walking distance of the college.</td>
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<td>The experience unit should include appended questions which are likely to stimulate reflective thinking.</td>
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<td>The experience unit should be of sufficient scope to permit the student to draw conclusions.</td>
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<td>The outcomes listed for the experience unit should be expected from student participation in the unit.</td>
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<td>8.</td>
<td>The experience unit is consistent with the purposes of a course in general biology for the preparation of elementary school teachers.</td>
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IC = Ideally Considered  PC = Poorly Considered  SC = Satisfactorily Considered  NC = Not Considered

(Check the letters to indicate your evaluation)
TABLE XIX

RATING OF EIGHT LABORATORY EXPERIENCE UNITS BY JUDGE NUMBER 1 *

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Total Judgment Value
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* The number assigned to a judge does not correspond to the position of the judge in the alphabetical listing of the eight judges.
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TABLE XXI

RATING OF THE EIGHT LABORATORY EXPERIENCE UNITS BY JUDGE NUMBER 3

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TABLE XXII

RATING OF THE EIGHT LABORATORY EXPERIENCE UNITS BY JUDGE NUMBER 4

<table>
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<th>Number of the Criterion</th>
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TABLE XXV.
RATING OF THE LABORATORY EXPERIENCE UNITS BY JUDGE NUMBER 7

<table>
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<table>
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<th>44</th>
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<td>6.0</td>
<td>4.0</td>
<td>6.0</td>
<td>5.5</td>
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### TABLE XXVI

**Rating of the Eight Laboratory Experience Units by Judge Number 8**

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<td><strong>Total Judgment Value</strong></td>
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