

A STUDY OF THE ATTITUDES OF PROSPECTIVE
ELEMENTARY SCHOOL TEACHERS TOWARD
BIOLOGICAL SCIENCE

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DONALD ALBERT SNITGEN

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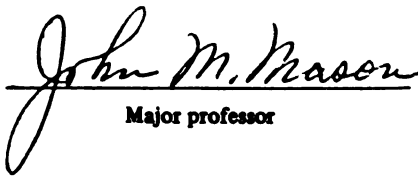
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ABSTRACT

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By

Donald Albert Snitgen

A number of science educators have shown concern for the effect teacher education courses have on the attitudes of prospective elementary school teachers toward science. Studies were reported in the literature which dealt with attitude toward science in general and some which included the development of attitude measuring instruments designed to assess attitudes toward science. However, there have been no investigations dealing with attitudes toward biological science specifically nor have any instruments been constructed with which to measure these attitudes.

The investigative purpose of this research was to determine the effect a biological science course, taught by a combination lecture and auto-tutorial technique, had on prospective elementary school teachers' attitudes toward biological science. The Biological Science Attitude Scale was constructed by the investigator in order to measure these attitudes.

The study was conducted in the Science and Mathematics Teaching Center at Michigan State University. The subjects consisted of experimental groups comprised of elementary

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education majors enrolled in Biological Science 202 during winter and spring terms, 1970. The control groups were comprised of elementary education majors who had never taken Biological Science 202. The controls were selected from elementary education majors enrolled in Mathematics 201 during winter and spring terms, 1970. The treatment of major interest was the Biological Science 202 course, and the statistical procedures for this investigation were one-way analyses of covariance with pretest scores serving as covariables.

The Biological Science Attitude Scale was constructed according to the Thurstone equal-appearing intervals technique. Test-retest reliability was computed and found to be $r = 0.633$. Split-half test reliability was calculated and was found to be $r_{tt} = 0.86$. Validity of the instrument was assumed as a consequence of the process by which the attitude statements were subjected to judgment by a panel of staff members and graduate assistants in the Science and Mathematics Teaching Center and a sample of elementary education majors enrolled in Biological Science 202.

The F-ratios obtained after subjecting the data to a one-way analysis of covariance was found to be less than the values necessary to show a significant difference at the 0.05 level. As a consequence, none of the hypotheses tested were rejected. Based on these data it was concluded

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that completion of the Biological Science 202 course, by elementary education majors did not change their attitudes toward biological science. Although the students' attitudes toward biological science were not significantly increased, neither were they significantly decreased. As measured by the Biological Science Attitude Scale, the students entered the Biological Science 202 course with positive attitudes toward biological science and these attitudes were not decreased as a consequence of having taken the course. Based upon the data obtained in this investigation, the Biological Science 202 course seems to have maintained the positive attitudes toward biological science with which the students entered the course.

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By
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CHAPTER I

INTRODUCTION

The effect of instruction upon an individual's acquisition of knowledge and skills in specific educational areas has been the subject of many investigations. The results of such studies usually indicated significant gains which were inferred to be attributable to the instructional method employed in the particular study. There is no question that educational instruction should provide a means for increasing one's knowledge and skills. There is also "... no question that what we teach is often different from what we tell. Sometimes we teach the beauty and importance of a subject as well as the substance of it. Sometimes, though we teach people to dislike, and then to avoid, the very subject we are teaching them about."¹ This problem becomes critical if the people being taught a subject are preparing to become elementary school teachers who will be expected to devote at least part of their time

¹Robert F. Mager, Developing Attitude Toward Learning (Palo Alto: Fearon Publishers, 1968), p. vi.

teaching that subject. Mager elaborated on this problem:

If one of our goals is to influence the student to think about, learn about, talk about, and do something about our subject, sometime after our direct influence over him comes to an end, how can we say we have been successful if the student actively avoids any further mention of the subject?

Whatever else we do in the way of influencing the student, the least we must strive to achieve is to send him away with favorable rather than unfavorable feelings about the subject or activity we teach. This might well be our minimum, and universal goal in teaching.²

The problem of students' attitudes toward their formal school experiences has received some attention. There appears to be a need, however, for additional studies related to the attitudes of students toward particular subject matter areas. The present study was concerned with the attitudes of elementary education majors toward biological science as they began a course in biological science in contrast to their attitudes at the completion of the course. The study should be of interest to educators in the field of elementary education and to teachers of biological science for prospective elementary teachers. One task in preparing the prospective elementary teacher is to maintain and, if possible, increase the trainees' attitudes toward the discipline areas which they will be called upon to teach in their professional careers.

²Ibid., p. 10.

Need for the study. Several individuals have indicated a need for studies such as the present one. Schwirian pointed out:

Positive attitudes toward science and its role in society are not an automatic consequence of our age---an age in which the world in general and Western society in particular are enjoying the fruits of science in the form of the highest standard of living in history. Appreciation is not equivalent to understanding.... The development of healthy, positive attitudes regarding the scientific enterprise and its practitioners is one of the major responsibilities of science educators at all levels.

Central to this task of attitude education is identification and description of the nature of the attitudes we wish to instill and the development of instruments with which we may assess these attitudes....³

Schwirian also emphasized the need for science educators to be concerned about the attitudes of elementary school teachers toward science. She said:

Curriculum reform attempts for elementary school science are currently very noticeable, very fashionable, often well-financed, and too often, unsuccessful. ... I suggest that a major problem lies in the attitudinal set of the classroom teacher. If one sees little or no value or relevance in the processes of science or the scientific enterprise, one is unlikely to devote the great quantities of time and energy required to make curriculum revision truly successful.⁴

³Patricia M. Schwirian, "On Measuring Attitudes Toward Science," Science Education 52:172-173, March, 1968.

⁴Patricia M. Schwirian, "Characteristics of Elementary Teachers Related to Attitudes Toward Science," Journal of Research in Science Teaching 6:203, 1969.

Matala and McCollum⁵ indicated, "Status studies have their contribution to make, but a crying need today is for the design, trial, and evaluation of better procedures for teaching science information, problem solving technics, attitudes, and appreciations." Smith⁶ concluded that his review showed, "... a desirable tendency toward a broader spectrum of concern, but still lacking are systematic longitudinal studies showing the impact of varied methods and materials on student attitudes, understanding, performance and motivation."

Bruce⁷ said that "... it appears ... a far greater proportion of the literature devoted to science teacher education is concerned with descriptive reporting and what might be termed 'reasoned editorializing' than with research findings that might lead to sound modifications of practice." Soy⁸ commented on pre-service elementary

⁵Dorothy C. Matala and Clifford G. McCollum, "Science in the Elementary Grades," Review of Educational Research 27:323, October, 1957.

⁶Herbert A. Smith, "Curriculum Development and Instructional Materials," Review of Educational Research 39:409, October, 1969.

⁷Mathew H. Bruce, "Teacher Education in Science," Review of Educational Research 39:415, October, 1969.

⁸Eloise Marian Soy, "Attitudes of Prospective Elementary Teachers Toward Science as a Field of Specialty," School Science and Mathematics 67:515-516, June, 1967.

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education by saying:

As the new science programs come into being, it is time for all of us---elementary and junior high teachers and principals; teachers, counselors, and administrators at the high school and college levels---to ask ourselves the question, 'What can be done to give these preservice elementary teachers more satisfying experiences in science?'"

Kleinman,⁹ reporting on possible reasons for a low percentage of women scientists in the United States, said:

If, ..., the number of women in the science pool is a function of negative attitudes towards science inculcated early, then the way to increase the number of women in science is to introduce favorable attitudes toward science early. This can be done by improved science education for elementary teachers. If elementary teachers can be assisted to teach science with some degree of satisfaction and pleasure two important purposes will be accomplished: 1) favorable attitudes will be developed among all children toward science and 2) the cultural bias against women 'messing around' with science will be overcome.

Another educator who pointed out the importance of the relationship between attitudes and elementary science teaching was DeRoche when he wrote:

The elementary teacher is still the focal point of the elementary school science program. Some teachers pay lip-service to the objectives of science education. Other teachers treat science as if it were part of the reading program. Still others consider science as a vital part of the curriculum and thus teach it as such. It is generally agreed that a good program in any elementary classroom depends upon the teacher's attitude

⁹ Gladys S. Kleinman, "The Key to the Science Womanpower Pool: Teacher Education," School Science and Mathematics 68:317, April, 1968.

toward science and her ability to teach the specific content in science.¹⁰

Jacobs stressed the importance of attitude formation to the elementary teacher education program when he pointed out:

One of the purposes of teacher education is to effect a change in the behavior of students so that they can show an inclination or predisposition to act in certain ways in given situations, it should be the purpose of a teacher education program to mold attitudes that will equip the prospective teacher to deal with the teaching role in a way that will bring the greatest benefit to his students in terms of their individual growth toward living in a free and democratic society.¹¹

Aiken and Aiken concluded their literature review on attitudes concerning science with the following recommendation:

..., it may be observed that teachers of science ---at least to a greater extent than teachers of mathematics---seem to have recognized that the teaching of attitudes is a part of their task. The research reports and other papers which we have reviewed also indicate that teachers can help develop positive attitudes toward science.

Although the average student shows a greater preference for science than mathematics and certain other school subjects, the growing impact of science on our daily lives necessitates continued

¹⁰Edward F. DeRoche, "A Study of a Teaching Procedure in Elementary Science," The Catholic Educational Review 65:524, November, 1967.

¹¹Elmer B. Jacobs, "Attitude Change in Teacher Education: An Inquiry into the Role of Attitudes in Changing Teacher Behavior," The Journal of Teacher Education 19:410, Winter, 1968.

study of ways in which to assess and improve these attitudes. Of particular importance in further research on attitudes toward science is the development of more precise measures of attitudes toward the various aspects of science.¹²

This partial literature review shows that educators are concerned with the importance of teachers' attitudes toward science and with the need to incorporate techniques for developing positive attitudes into teaching education programs. While the direct teaching for attitude development has been advocated by several educators, most college science courses, however, are designed primarily for the acquisition of cognitive objectives. With respect to attitudes, the belief is often held that inherent in the implementation of the course students will acquire desirable attitudes toward the subject matter area. A few studies have shown this to be possible, while others have shown that scientific attitudes were not concomitant outcomes of science instruction. As indicated by Mager,¹³ there is also the question as to whether or not students acquire negative feelings as a result of educational experiences. Thus, there is a need for research concerned with ways to incorporate attitude development within a given science course

¹² Lewis R. Aiken and Dorothy R. Aiken, "Recent Research on Attitudes Concerning Science," Science Education 53:303, October, 1969.

¹³ Mager, op. cit., p. 10.

and also for studies to ascertain the effect that established courses may have upon students' attitudes.

This investigation was concerned with the effect a required biological science course for elementary education majors had on the attitudes of prospective teachers toward the science of biology. Although a number of studies reported in the literature dealt with investigating attitudes toward science, scientists, and scientific careers,¹⁴ there were none known to this researcher which dealt specifically with attitudes toward the science of biology. Neither were there any measurement instruments designed specifically for the purpose of assessing attitudes toward biological science.

The study. The study was carried on in the Science and Mathematics Teaching Center at Michigan State University winter and spring terms, 1970. The Science and Mathematics Teaching Center is administratively responsible for Biological Science 202 which is a required science course for elementary education majors. Each term students in Biological Science 202 were administered, as a pretest and posttest, a Biological Science Attitude Scale as a measure of their attitudes toward biological science. Students completing both the pretest and posttest administrations in a given term constituted Experimental Groups I and II

¹⁴Aiken and Aiken, op. cit., pp. 295-305.

respectively. Control groups for the study consisted of elementary education majors who had never taken Biological Science 202, including the terms during which the study was conducted. Since Mathematics 201 is a required course for all elementary education majors at Michigan State University, the investigator decided to select the control groups from students enrolled in the course. Students constituting the control also completed pretest and posttest administrations of the Biological Science Attitude Scale and were designated Control Groups I and II for winter and spring terms respectively. The Biological Science Attitude Scale was developed by the investigator.

Changes occurred in the Biological Science 202 course during the two terms in which the study was conducted. These changes were the result of the natural evolution of the course and were not experimental manipulations directed by the investigator. The course as it existed during the two terms is described in detail in Chapter III.

Purposes of the study. The main purposes of this study were: (1) to determine whether or not the taking of Biological Science 202 produced any change in attitudes of the elementary education majors toward biological science; and, (2) to develop an instrument for measuring attitudes toward biological science as a psychological object.

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Statement of hypotheses. The central hypothesis tested in this study was: Elementary education majors, as measured by posttest scores on the Biological Science Attitude Scale, who completed Biological Science 202 had significantly different attitudes toward biological science than a control group of elementary education majors enrolled in Mathematics 201 who had not been exposed to Biological Science 202. For the purposes of this study the central hypothesis was subdivided into three experimental hypotheses. The three experimental hypotheses, stated in the null form, were:

1. There is no significant difference in attitudes of elementary education majors enrolled in Biological Science 202 during winter term, 1970, and a control group of elementary education majors enrolled in Mathematics 201 during winter term, 1970.
2. There is no significant difference in attitudes of elementary education majors enrolled in Biological Science 202 during spring term, 1970, and a control group of elementary education majors enrolled in Mathematics 201 during spring term, 1970.
3. There is no significant difference in attitudes of elementary education majors enrolled in

Biological Science 202 during winter term, 1970,
and elementary education majors enrolled in
Biological Science 202 during spring term, 1970.

Definition of terms. The terms operationally defined
for use in this study are:

Attitude: "... attitude is the sum total of a
man's inclinations and feelings, prejudice or bias, pre-
conceived notions, ideas, fears, threats and convictions
about any special topic."¹⁵

Psychological Object: "... any symbol, phrase,
slogan, person, institution, ideal, or idea toward which
people can differ with respect to positive or negative
affect."¹⁶ For the purpose of this study, biological
science was the psychological object.

Attitude Scale: "An attitude-measuring instrument
the units of which have been experimentally determined and
equated; designed to obtain a quantitative evaluation of
an attitude;...."¹⁷ The attitude scale constructed for

¹⁵L. L. Thurstone and E. J. Chave, The Measurement of Attitude (Chicago: University of Chicago Press, 1929), pp. 6-7.

¹⁶Allen L. Edwards, Techniques of Attitude Scale Construction (New York: Appleton-Century-Crofts, Inc., 1957), p. 2.

¹⁷Carter V. Good (ed.), Dictionary of Education (2nd ed.; New York: McGraw-Hill Book Company, Inc., 1959), p. 477.

use in this study was the Biological Science Attitude Scale.

Elementary Education Majors: For the purposes of this study, the terms "elementary education major" and "prospective elementary school teacher" were used interchangeably. The term elementary education major includes the subjects of this study who were majoring in the elementary education curriculum at Michigan State University and enrolled in either Biological Science 202 or Mathematics 201 during winter and spring terms, 1970. Students majoring in elementary special education were also in the category, elementary education majors, as used in this study.

Biological Science: The science which is specifically concerned with the study of life.¹⁸ For the purpose of this study the term "biological science" and the "science of biology" were used synonymously.

Basic assumptions. The following assumptions were made in pursuing the study:

1. Elementary education majors at Michigan State University were able to understand the directions for completing the Biological Science Attitude Scale.

¹⁸William T. Keeton, Biological Science (New York: W. W. Norton and Company, Inc., 1967), p. 1.

2. Elementary education majors were able to comprehend the statements on the Biological Science Attitude Scale.
3. Elementary education majors would give an honest response as to whether they agreed or disagreed with the statements on the Biological Science Attitude Scale.
4. The time and place of administration of the Biological Science Attitude Scale had no effect on the subjects' attitude scores.
5. The various stimuli existing in the environment, such as television programs, movies, newspaper articles, and/or fictional books had no significant influence on the attitudes of the subjects toward biological science.

Delimitations of the study. The subjects in this study were drawn from a population of elementary education majors at Michigan State University, East Lansing, Michigan who were enrolled in Biological Science 202 or Mathematics 201 during winter and spring terms, 1970. Any generalizations that are made based on this study should be restricted to populations that are similar to the population from which the sample in this study was drawn. The findings reflect only upon the effect a college science course, such as Biological Science 202, has on attitudes

toward biological science of elementary education majors as measured by the Biological Science Attitude Scale.

Another limitation of the study was the way the subjects were selected. Intact classes which included elementary education majors in Biological Science 202 and Mathematics 201 who had been assigned according to the regular enrollment procedure were used for experimental groups and control groups respectively. Although this design does not control for all possible confounding variables, precision can be increased by using a pretest and analysis of covariance.¹⁹

A third limitation of this investigation was that the responses of the elementary education majors must be considered valid representations of their perceptions of the attitude statements on the Biological Science Attitude Scale. In a similar situation Pfeifle²⁰ commented, "This limitation is not unique.... Responses dealing with opinions, beliefs, or perceptions are a common characteristic in investigations of this nature."

¹⁹ Donald T. Campbell and Julian C. Stanley, Experimental and Quasi-Experimental Designs for Research (Chicago: Rand McNally and Co., 1969), pp. 47-48.

²⁰ Henry H. Pfeifle, "An Investigation Into the Relationship of Practicum Experience to Clients' Ratings of Counselors" (unpublished Doctor's dissertation, The University of Miami, 1969), p. 12.

Another limitation of the study was the fact that the data were limited to only those subjects who responded to both the pretest and posttest administration of the Biological Science Attitude Scale. For example, there were some students who took the pretest and then withdrew from the Biological Science 202 course. Also, some students missed taking the pretest due to late enrollment and took only the posttest.

Summary and overview. A number of science educators have shown concern for the effect teacher education courses have on the attitudes of prospective elementary school teachers toward science. Studies were reported in the literature which dealt with attitude toward science in general and some which included the development of attitude measuring instruments designed to assess attitudes toward science. However, there have been no investigations dealing with attitudes toward biological science specifically nor have any instruments been constructed with which to measure these attitudes.

The investigative purpose of this research was to determine the effect a biological science course, taught by a combination lecture and auto-tutorial technique, had on prospective elementary school teachers' attitudes toward biological science. The Biological Science Attitude

Scale was constructed by the investigator in order to measure these attitudes.

Assumptions incorporated into this study included elementary education majors' ability to understand the directions, comprehend the statements, and respond honestly while taking the Biological Science Attitude Scale. Time and place of administration of the instrument were considered, and the instrument was assumed to be valid. Exposure to environmental stimuli was considered and it was assumed there was one experimental variable to which only the experimental groups were exposed.

Delimitations of the study included the source and location of the sample and the absence of random assignment of subjects to treatment groups. The study was further limited by the subjects' perceptions of the statements on the attitude instrument and by the use of data consisting of only pretest and posttest scores of those subjects who took both the pretest and posttest.

Chapter II presents a review of the literature. A detailed description of the study is presented in Chapter III. Chapter IV includes a detailed description of the procedure by which the Biological Science Attitude Scale was constructed and a review of the literature pertinent to attitude scale construction. The findings of the study

are presented in Chapter V. A summary of the study, conclusions, and recommendations are given in Chapter VI.

CHAPTER II

REVIEW OF RELATED LITERATURE

A cursory review of the literature dealing with attitudes revealed a considerable body of published information. In view of the vast coverage of attitudinal studies, the investigator limited the following review to studies and reports which he considered appropriate to the present investigation. This chapter has been organized into the following sections: (1) background and definitions of attitude; (2) importance of attitudes in science education; (3) elementary teachers' or prospective teachers' attitudes toward science or science teaching; and, (4) effect of biological science courses on attitudes. A review of the literature relating to attitude measurement is presented in Chapter IV.

¹
Background and definitions of attitude. Allport¹ reported on the history of the attitude concept in his chapter on "Attitudes" in A Handbook of Social Psychology. He said, "Like most abstract terms in the English language, attitude has more than one meaning. Derived from the Latin aptus, it

¹Gordon W. Allport, "Attitudes," A Handbook of Social Psychology (Worcester, Mass.: Clark University Press, 1935), pp. 798-805.

has on the one hand the significance of 'fitness' or 'adaptedness,' and like its byeform aptitude connotes a subjective or mental state of preparation for action."² In the field of art, the term referred to the outward or visible posture of a figure in statuary or painting. Allport pointed out that, "The first meaning is clearly preserved in modern psychology in what are often referred to as 'mental attitudes'; and the second meaning in 'motor attitudes.'"³

Herbert Spencer in 1862 and Alexander Bain in 1868 were two of the earliest psychologists to employ the term attitude in their writings.⁴ Allport⁵ attributed to Lange in 1888 the first explicit recognition of attitude within the domain of laboratory psychology. Thomas and Znaniecki in 1918 were credited "...for instituting the concept of attitude as a permanent and central feature in sociological writing...."⁶ They defined social psychology as the scientific study of attitudes.⁷ Allport⁸ felt that it "...is

²Ibid.

⁸Ibid., p. 59.

³Ibid.

⁴Ibid.

⁵Ibid.

⁶Ibid., p. 802.

⁷Gordon W. Allport, "The Historical Background of Modern Social Psychology," The Handbook of Social Psychology eds. Gardner Lindzey and Elliot Aronson (Reading, Mass.: Addison-Wesley Publishing Co., 1968), pp. 59-60.

probably the most distinctive and indispensable concept in contemporary American social psychology." According to Allport, the term attitude first began to appear in psychology textbook indices in 1900 with one text containing the term prior to that time. He also reported that between 1900 and 1925 attitude appeared in the indices of twelve textbooks and by 1932 the number had increased to sixteen.⁹

A review of the literature dealing with the history of the attitude concept shows that, although the attitude concept had its beginnings in the late 1800's, it is essentially a twentieth century phenomenon. The review also indicates social psychologists were responsible for culturing the concept of attitude as a human attribute to be studied.

In his review of the literature on attitudes, Sherman listed some of the definitions of attitude used from 1920-1932. Some of the definitions included in his review were: (1) attitude is a properly settled behavior, a settled manner of acting because of habitual feeling or opinion; (2) the attitude is in part the residual effect of the act, but it remains as a predisposition to certain forms of subsequent activity. The motive or intention is an integral part of the act, and no estimate of the quality of the act can be made without considering the inner experience; (3) a set of

⁹Ibid., pp. 59-60.

mind which determines ones response to particular situations; (4) an attitude is a complex of feelings, desires, fears, convictions, prejudices or other tendencies that have given a set or readiness to act to a person because of varied experiences; (5) an attitude is a general emotional and intellectual predisposition to act in a positive or negative direction as a result of personal experience and inborn tendencies; and, (6) an attitude is an incompleated or suspended or inhibited act.¹⁰ Droba¹¹ said, "An attitude is a certain subjective state of preparation to action....overt behavior will follow as a result of the attitude." He distinguished between attitudes and motive since "Attitudes point out the direction an activity will take; motives are the starters of the activity."

Allport¹² said an attitude is "...a mental and neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related."

¹⁰M. Sherman, "Theories and Measurement of Attitudes," Child Development 3:15-16, 1932.

¹¹D. D. Droba, "The Nature of Attitudes," Journal of Social Psychology 4:447-449, 1933.

¹²Allport, "Historical Background," p. 63.

Shaw and Wright¹³ "... limit the theoretical construct of attitude to an affective component which is based upon cognitive processes and is an antecedent of behavior...."

They defined attitude as

... a relatively enduring system of evaluation, affective reactions based upon and reflecting the evaluative concepts or beliefs which have been learned about the characteristics of a social object or class of social objects.¹⁴

Halloran¹⁵ pointed out most definitions of attitude possess two common factors: first, an attitude is an inferred entity which is not measured directly; and, second, an attitude is a tendency to act. The definition formulated by Thurstone and Chave contained these attributes and was the definition which was used in this study. They defined attitude as "... the sum total of a man's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats and convictions about any specific topic."¹⁶

Importance of attitudes in science education. Attitudinal goals have been a concern of science educators for many years. In 1903 Bailey said the main objective of nature

¹³Marvin E. Shaw and Jack M. Wright, Scales for the Measurement of Attitudes (New York: McGraw-Hill Book Co., 1967), p. 20.

¹⁴Ibid.

¹⁵J. D. Halloran, Attitude Formation and Change (Great Britain: Leicester University Press, 1967), p. 14.

¹⁶Louis L. Thurstone and E. J. Chave, The Measurement of Attitude (Chicago: University of Chicago Press, 1929), pp. 6-7.

study was "... to put the pupil in a sympathetic attitude toward nature for the purpose of increasing the joy of living."¹⁷

Twiss explained that the aims of the science teacher must be the imparting of insight into the meaning and value of science, to infect pupils with the scientific spirit, and to train them in the methods of thinking and investigations common to all the sciences. Pupils should be enabled

... to approach with the scientific attitude of mind, and to attack by orderly and scientific methods, those problems with which the experience of their present and future lives must inevitably confront them.¹⁸

In 1925 Downing wrote:

If one is striving to establish in the pupil the scientific attitude of mind it is because it will serve him in the solution of his life problems as citizen, homemaker, and worker.¹⁹

Ten years later Downing elaborated:

The scientific attitude is more than an intellectual assent to the proposition that the scientific method of thought is a desirable method of procedure. It is an impelling attitude and is therefore at least partially saturated with emotional elements. The scientific attitude is a fervid conviction that

¹⁷L. H. Bailey, The Nature-Study Idea (New York: Doubleday, Page, and Company, 1903), p. 4.

¹⁸George Ransom Twiss, A Textbook in the Principles of Science Teaching (New York: The Macmillan Company, 1917), pp. 18-19.

¹⁹Elliot Rowland Downing, Teaching Science in the Schools (Chicago: The University of Chicago Press, 1925), p. 81.

problems within the range of science can only be successfully solved by the scientific method of thinking.²⁰

In 1929 Bowden²¹ concluded there could be little danger of decay in a society if a sufficiently large number of individuals had a scientific attitude. Scientific attitudes were frequently mentioned as an important outcome of science teaching in the Thirty-first Yearbook of the National Society for the Study of Education.²² Powers summarized the feelings of the Yearbook Committee when he stated:

The major generalizations of science and the associated scientific attitudes are so important and so extensive in scope that the student may live with them throughout his life. Definable educational values from science teaching will have been attained if students acquire (1) an ability to utilize the findings of science that have application in their own experiences; (2) and ability to interpret the natural phenomena of their environment; and (3) an appreciation of scientific attitudes through an understanding of, and ability to use, some of the methods of study that have been used by creative workers in the field of science....²³

²⁰Elliot Rowland Downing, An Introduction to the Teaching of Science (Chicago: The University of Chicago Press, 1935), p. 90.

²¹A. O. Bowden, "Scientific Attitude," School Executives Magazine 48:328, March, 1929.

²²S. R. Powers, "The Plan of the Public Schools and the Program of Science Teaching," A Program for Science Teaching, Thirty-first Yearbook of the National Society for the Study of Education, Part I (Illinois: Public School Publishing Company, 1932).

²³Ibid., p. 10.

In 1933 Noll said, "It is perhaps not too much to say that a large proportion of our present-day ills and troubles is directly traceable to false, prejudiced, and generally unscientific thinking."²⁴ He went on to elaborate the following points:²⁵

1. The scientific attitude is one of the most desirable for individuals to acquire.
2. The scientific attitude, like other attitudes, is based upon habits of thinking which can be defined.
3. These habits of thinking can be developed in the pupil just as other habits can.
4. The results of such training can be measured.

Mulliken,²⁶ writing in 1937, felt "The trouble with the world today, most scientists believe, is not that there is too much science, but rather that the scientific attitude --the essence of science--is far too little understood and too inadequately applied to human problems."

In 1938 Ebel²⁷ said a fundamental obligation of science teaching was an imparting of the scientific attitude.

²⁴Victor H. Noll, "The Habit of Scientific Thinking," Teachers College Record 35:1-9, October, 1933.

²⁵Ibid., p. 4.

²⁶Robert S. Mulliken, "Science and the Scientific Attitude," Science 86:66, July, 1937.

²⁷R. L. Ebel, "What is the Scientific Attitude," Science Education 22:1, January, 1938.

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"Probably all educators will agree," said Conley²⁸ in 1939, "that one of the important tasks of the junior college in the field of general education is the teaching of the scientific attitude."

The committee for the Forty-sixth Yearbook²⁹ stressed the learning of scientific attitudes as an important objective for science teaching. Thirteen years later writers of the Fifty-ninth Yearbook³⁰ emphasized the learning of scientific attitudes.

In addition to scientific knowledge and skills attention should be given to the development of attitudes, wrote Washton.³¹ It is difficult to separate the development of scientific attitudes from the learning of knowledge.³²

²⁸W. H. Conley, "Teaching the Scientific Attitude in the Junior College," National Education Association Proceedings 1939, p. 614.

²⁹Nelson B. Henrey (ed.), Science Education in American Schools, Forty-sixth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1947), pp. 28-31.

³⁰Paul L. Dressel, Mary Alice Burmester, John M. Mason, and Clarence H. Nelson, "How the Individual Learns Science," Rethinking Science Education, Fifty-ninth Yearbook of the National Society for the Study of Education, Part I (Chicago: University of Chicago Press, 1960), pp. 39-62.

³¹Nathan S. Washton, Teaching Science Creatively in the Secondary Schools (Philadelphia: W. B. Saunders Company, 1967), p. 50.

³²Ibid., p. 135.

Miller and Blaydes felt

If there is any one thing that the study of science should do for the student it is to produce a scientific attitude toward all problems that arise in his daily life. Facts, if not used, may be forgotten, but the establishment of an attitude which impels an individual to look at each problematic situation in an analytical fashion, to attack it in a scientific manner, to demand proof in the form of adequate facts results in a habit of thinking which can and will be used regularly by the individual in making the innumerable adjustments that are necessitated by a constantly changing society.³³

Science educators, said Blough and Schwartz, have been saying for years that the study of science should help children develop scientific attitudes, but more needs to be done about it.³⁴ Voss and Brown stated, "Attitudes and appreciations are...functions of the environment and can be developed through learning processes."³⁵

In Biology Teachers' Handbook it was pointed out:

Among behaviors important to success at enquiry are those sometimes termed affective or attitudinal. Although a variety of these seem to pervade the entire enquiry process, no consistent method of identifying, describing or measuring their extent is now available. Their importance, however, is not to be negated or minimized. As more is known about

³³ David F. Miller and Glenn W. Blaydes, Methods and Materials for Teaching the Biological Sciences (New York: McGraw-Hill Book Company, Inc., 1962), p. 22.

³⁴ Glenn O. Blough and Julius Schwartz, Elementary School Science and How to Teach It (New York: Holt, Rinehart, and Winston, 1964), p. 16.

³⁵ Burton E. Voss and Stanley B. Brown, Biology as Inquiry: A Book of Teaching Methods (St. Louis: The C. V. Mosby Company, 1968), p. 15.

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them, they will be accorded more specific and detailed attention and treatment.³⁶

This portion of the review of the literature has shown that science educators have recognized attitude as an important aspect of learning outcomes related to science teaching. The concept of scientific attitudes was not an integral part of the present study but frequent reference to them in the literature points out the concern science educators have had for the affective domain. This concern has continued from the early 1900's to the present.

Elementary teachers' or prospective teachers' attitudes toward science or science teaching. Greenblatt³⁷ studied the relationship between elementary teachers' attitudes and elementary students' attitudes. Though the study was quite limited, evidence indicated a strong correlation between teachers' preferences for school subjects and their students' preferences for school subjects. This correspondence was especially evident with children of higher intelligence. A study by Bixler³⁸ indicated a relationship between teachers'

³⁶Evelyn Klinckmann (supervisor), Biology Teachers' Handbook (2nd ed.; New York: John Wiley and Sons, Inc., 1970), p. 48.

³⁷E. L. Greenblatt, "An Analysis of School Subject Preferences of Elementary School Children of the Middle Grades," The Journal of Educational Research 55:555, August, 1962.

³⁸J. E. Bixler, "The Effect of Teacher Attitude on Elementary Children's Science Information and Science Attitude," Dissertation Abstracts 19:2531-2532, April, 1959.

attitudes toward science and changes in pupils' attitudes toward the subject. Taylor³⁹ conducted a study on fourth grade children and found a significant relationship between teachers' attitudes and students' achievement in science.

Victor⁴⁰ conducted a study to find out why elementary school teachers dislike teaching science. A questionnaire was administered to 106 elementary teachers, of which 90 per cent were women. Reasons given by the women for their reluctance to teach science included a feeling by the women that science was a male domain, that they were unfamiliar with the science content, and that they might lose face in their classrooms if they tried to teach science.

Soy⁴¹ conducted a study on 422 elementary education majors at State College of Iowa. The purpose of the research was to investigate factors associated with the choice of subject fields by students and to find out why so few of the students chose science as a subject field. The sampling instrument used was a questionnaire. Responses to the

³⁹A. L. Taylor, "Teacher Attitudes, Pupil Behavior, and Content Attributes in Relation to the Use of Programmed Science Materials at the Fourth Grade Level," Dissertation Abstracts 26:5924-5925, April, 1966.

⁴⁰E. Victor, "Why Are Elementary School Teachers Reluctant to Teach Science?" Science Teacher, 28:17-19, November, 1961.

⁴¹Eloise M. Soy, "Attitudes of Prospective Elementary Teachers Toward Science as a Field of Specialty," School Science and Mathematics 67:508-512, June, 1967.

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questionnaire showed the choice of subject fields as: art, 8.1 percent; foreign language, 4.0 percent; language arts, 40.0 percent; mathematics, 9.8 percent; science, 7.1 percent; and social science, 31.1 percent. It was noted that of the group which chose science as a subject field over 60 percent came from farm homes. The most frequently given reasons for not choosing a science subject field were:

- (1) I am not much interested in this field;
- (2) The required courses in this area were hard for me;
- (3) Majors and minors in this department make very strong competition in the elective courses; and
- (4) I like this area, but I could not choose a group of electives in which I was sure of succeeding.⁴²

Wytiaz⁴³ conducted a survey of fifth-grade teachers in which she used a questionnaire containing questions concerned with classification, attitudes, and preparation. She found the teachers were about equally divided as to whether they felt they did or did not have a sufficient background for teaching elementary science. Close to 70 percent had not taken any in-service courses in science. The teachers felt

⁴² Ibid.

⁴³ Patricia Lorraine Wytiaz, "A Study of the Attitudes of Fifth-grade Teachers of Cumberland County New Jersey Toward Science and Their Preparation for Teaching it in the Elementary School," Science Education 46:151-152, March, 1962.

best prepared to teach about plants. The study also revealed the teachers had a favorable attitude toward taking science courses but they would have to be given the opportunity to do so. Most of the teachers felt science was valuable to elementary children. They indicated that a student preparing for teaching should gain a good background of scientific knowledge while in college and should be provided with a good science-teaching methods course.

Leake⁴⁴ investigated the effect science extension courses had on the attitudes of in-service elementary teachers. The data showed no significant change in attitudes toward science of the elementary teachers after having been exposed to the extension program in science.

Oshima⁴⁵ compared two methods of teaching a science methods course for prospective elementary school teachers. The teaching techniques consisted of a lecture-demonstration method and an individual investigation method. The dependent variables were attitudes toward science, confidence toward teaching science, achievement in science, and student teaching behaviors in science. The results indicated the two different

⁴⁴John Benjamin Leake, "A Study of Attitudes of Elementary Teachers Toward Science," Dissertation Abstracts 27:4155-4156, April, 1967.

⁴⁵Eugene Akio Oshima, "Changes in Attitudes Toward Science and Confidence in Teaching Science of Prospective Elementary Teachers," Dissertation Abstracts 27:4157-4158, April, 1967.

methods produced no significant changes in attitudes toward science. The experimental groups showed significant gains in confidence in teaching science, but no significant differences were found between the groups in science achievement. The confidence in teaching scores of the experimental group were significantly higher than those of the control group.

Diehl⁴⁶ studied the effects of an experimental course in physical science on the attitudes of prospective elementary school teachers. The experimental group had non-directive teaching and a pervasive laboratory approach. The control group had lectures and a fixed laboratory experience. The results did not reveal a significant difference between the change scores of the two groups on a measure of rigidity or on the prospective teachers' social outlook toward science.

Pickering conducted a study to determine

... the relative effects of inquiry-laboratory experiences, inquiry-demonstration experiences, and lecture experiences on the prospective elementary teachers' attitude toward science, toward teaching science, toward different methods of teaching science, and on their science competencies.... and whether the prospective teacher's choice of upper or lower elementary training was related to these attitudes or competencies.⁴⁷

⁴⁶T. H. T. Diehl, "A Study of Attitude and Thought Pattern Changes Resulting from the Use of a Physical Science Course for Nonscience Majors," Dissertation Abstracts 28:874-875, July, 1967.

⁴⁷Robert S. Pickering, "An Experimental Study of the Effects of Inquiry Experiences on the Attitudes and Competencies of Prospective Elementary Teachers in the Area of Science," (unpublished Doctor's dissertation, Michigan State University, 1970), p. 149.

Pickering concluded:

...when inquiry-laboratory, inquiry-demonstration, or lecture techniques were used there was no significant difference in attitude toward science, attitude toward different methods of teaching science, or in science competency. In addition, the level of teacher preparation did not seem to matter when attitudes toward science, toward teaching science, or toward different methods of teaching science were the criteria under investigation. However, the data...did reveal that the inquiry-laboratory was significantly more effective in improving attitudes toward teaching science than either the inquiry-demonstration or lecture methodologies.⁴⁸

As part of his research, Pickering⁴⁹ conducted an extensive review of the literature with regard to the relationship of attitude to other educational factors. Although some of the studies reviewed by him did not relate specifically to elementary education there were implications for that field. Pickering's summary included the following points: (1) there is a significant relationship between achievement and attitude toward a given subject area; (2) at present, the evidence does not support a relationship between depth of understanding of a subject and attitude toward the subject; (3) at present, the evidence does not support a relationship between a teacher's attitude toward a subject and pupil achievement in that subject; (4) the evidence indicated a significant relationship between teacher attitude toward a subject and student attitude; (5) the research is presently insufficient with

⁴⁸Ibid., p. 159.

⁴⁹Ibid., pp. 41-42.

respect to the relationship between attitudes and creativity; (6) there is no significant relationship between attitudes and I.Q.; and, (7) sex was neither directly related to attitude nor was it a significant variable.

Effect of biological science courses on attitudes.

Three studies were concerned with biological science as the psychological object toward which an attitude may be held. Dudycha⁵⁰ compared college freshmen with seniors as to their attitude toward evolution. Comparison of responses to a questionnaire developed by Dudycha indicated seniors were better informed, more open-minded, and more inclined to believe in evolution than freshmen. Gray⁵¹ reported the construction of a "test, without results,...for application in a nature study course for upper intermediate grades." Whiteman⁵² conducted a study in which he compared two college biology courses with respect to the effect they had upon students' attitude toward conservation. Using an instrument

⁵⁰G. J. Dudycha, "Beliefs of College Students Concerning Evolution," Journal of Applied Psychology 18:85-96, February, 1934.

⁵¹H. A. Gray, "An Approach to the Measurement of Biological Attitudes and Appreciations," Psychological Abstracts 8:682, December, 1934.

⁵²Edon Eugene Whiteman, "A Comparative Study of the Effect of a Traditional and a Specially Designed College Course in Biology Upon Conservation Attitudes," Dissertation Abstracts, 26:4150, February, 1966.

designed by Laug, entitled Attitude Toward Conservation, a significantly positive change in attitudes was found as a consequence of a specially designed college biology course.

Several studies have been done which dealt with biological science courses as the psychological object. Some of the studies were concerned with high school courses and some at the college level.

Tamir⁵³ investigated the impact of high school science, with special reference to BSCS biology, on achievement and attitudes of students enrolled in a college introductory biology course. Using a questionnaire as a measure of the dependent variable, he concluded students who had been exposed to BSCS Yellow Version held the most positive attitudes toward the biology course.

The effects of laboratory centered instruction in biology on the improvement of student critical thinking skills and the development of positive student attitudes toward a biology course were investigated by Edgar.⁵⁴ Remmer's A Scale to Measure Attitude Toward Any School Subject was used to

⁵³Pinchas Tamir, "An Analysis of Certain Achievements and Attitudes of Cornell Students Enrolled in Introductory Biology with Special Reference to Their High School Preparation," Dissertation Abstracts 29:3924, May, 1967.

⁵⁴Irvin T. Edgar, "A Study of the Effects of Laboratory Centered Instruction on Student Critical Thinking Skills and Attitudes in Biology," Dissertation Abstracts 29:3910, May, 1969.

detect any change in student attitudes. The analysis of the data revealed no significant difference in the students' attitudes.

BSCS biology was compared to traditional biology with respect to student attitudes toward biology by Craven.⁵⁵ Using the Remmer instrument, Craven found no significant difference in student attitudes toward biology as a consequence of having taken the courses.

Novak⁵⁶ attempted to compare two college botany courses with respect to scientific attitudes with one a conventionally taught course and the other a project centered course. Using an instrument, constructed by Novak, no significant difference was detected between the two methods. Test reliability data were presented, but no description of test items per se or of the construction technique used was revealed.

Using Brandyberry's Science Attitude Scale, Murphy⁵⁷ was unable to find a significant change in scientific attitudes

⁵⁵Bobby E. Craven, "A Study of the Effects of Traditional and BSCS Biology on the Attitudes of High School Students," (unpublished Doctor's dissertation, University of Mississippi, 1969), pp. 70-72.

⁵⁶Joseph D. Novak, "Experimental Comparison of a Conventional and a Project Centered Method of Teaching a College Botany Course," Journal of Experimental Education 26:229, March, 1958.

⁵⁷Glenn W. Murphy, "Content Versus Process Centered Biology Laboratories, Part II: The Development of Knowledge, Scientific Attitudes, Problem-Solving Ability, and Interest in Biology," Science Education 52:151-158, March, 1968.

when comparing two methods of teaching college biology. One course was content centered and the other was process centered.

Using high school biology students as subjects, Coulter⁵⁸ investigated the effectiveness of inductive-laboratory, inductive-demonstration, and deductive-laboratory instruction with respect to scientific attitudes. Both inductive methods resulted in an increase of positive scientific attitudes over the deductive method. High school biology was the subject of another investigation which measured attitudes toward a biology course by Yager, et al.⁵⁹ They found no significant differences for critical thinking, understanding, attitudes toward biology, or achievement.

The relative effectiveness of two methods of teaching college biology was compared by Mason.⁶⁰ One instructional method stressed scientific methods of thinking and the other stressed factual information. Scientific attitudes were among other criteria used in the investigation and were measured by

⁵⁸John C. Coulter, "The Effectiveness of Inductive Laboratory, Inductive Demonstration and Deductive Laboratory in Biology," Journal of Research in Science Teaching 4:185-186, 1966.

⁵⁹Robert E. Yager, Harold B. Engen, and Bill C. F. Snider, "Effects of the Laboratory and Demonstration Methods Upon the Outcomes of Instruction in Secondary Biology," Journal of Research in Science Teaching 6:76-86, 1969.

⁶⁰John M. Mason, "An Experimental Study in the Teaching of Scientific Thinking in Biological Science at the College Level," Science Education 36:270-284, December, 1952.

two tests, one constructed by Noll and one constructed by Mason. In situations where the instructional method was the same in lecture and laboratory and in lecture situations the scientific thinking method was more effective in increasing scientific attitudes than the descriptive method when measured by Mason's instrument. Noll's test revealed no significant difference between any of the teaching methods, but showed a significant increase in scientific attitudes in all sections during the school year.

Summary. Although early use of the term attitude occurred in the late 1800's, the attitude concept is essentially a 20th century phenomenon. Attitudes became of concern to science educators early in the 20th century. In most cases, reference was made to the "scientific attitude" concept which is composed of a set of scientific habits of thinking. Research relating attitudes to science education also dealt with attitudes toward science, scientists, and science careers, or attitudes toward science courses.

There were some research findings which have important implications for science educators. There are indications from the evidence that teachers' attitudes affect pupils' attitudes in various ways. Among these are pupils' preference for school subjects, pupils' attitude toward science subjects, and their achievement in science. The research has also revealed some of the reasons why elementary teachers are reluctant to teach science in their classrooms.

A number of studies have dealt with the effect different courses and different methods of teaching have had on attitudes toward science and scientific attitudes. Some findings show significant results while many do not. Although there were a number of studies involving biological science courses, this investigator found none using the criterion of change in attitude toward biological science. In view of the importance placed on attitudes of one form or another by science educators this researcher concluded that a review of the literature indicated a need for studies dealing with specific areas of science. Further, the literature review pointed to a need for a measurement instrument which would determine attitudes toward specific areas of science such as biological science.

A review of the literature on definitions of attitude resulted in a variety of meanings, most of which referred to attitude as an inferred entity which is not measured directly and that attitude is a tendency to act. The definition put forth by Thurstone and Chave was used for the purpose of this study.

CHAPTER III

DESCRIPTION OF THE STUDY

The present chapter presents the design of the study, the subjects involved in the investigation, and a detailed description of Biological Science 202 as implemented during the course of the investigation. The collection and treatment of data are also covered briefly in the chapter.

Background of the study. Elementary education majors at Michigan State University, in addition to the courses in the university college and to specific education courses, are required to take Biological Science 202, Physical Science 203, and Mathematics 201. The two science courses are administered by the Science and Mathematics Teaching Center and the mathematics course is under the direction of the mathematics department.

The Biological Science 202 course is implemented by a combined lecture and auto-tutorial method. The course was handled by Dr. Jean Enochs and Dr. Richard Sauer during the terms this study was conducted. The investigator was one of eight graduate assistants assigned to the course.

While the development of positive attitudes toward biological science was not a specific objective which was

directly taught for in the course, the objectives were considered to be concerned not only with the acquisition of knowledge but also behavioral objectives which characterize scientific endeavor. Thus, the course afforded a treatment for ascertaining whether or not student attitudes toward biological science were concomitant outcomes of the course.

Design of the study. The study was designed as an ongoing feature of the Biological Science 202 course at Michigan State University during winter and spring terms, 1970. The study was concerned with the effect Biological Science 202, a combined lecture and auto-tutorial course, had on the attitudes of elementary education majors toward biological science. The elementary education majors enrolled in the course each term constituted Experimental Groups I and II respectively. The independent variable was the instructional materials and procedures employed in teaching Biological Science 202. The changes in the course, described later in this chapter, which occurred between winter and spring terms were not part of the experimental design of the study. The changes were a consequence of the natural evolution of the Biological Science 202 course and were described in the event they may have had an affect on students' attitudes.

The study was designed to have as control groups elementary education majors who had not had Biological

Science 202. Since Mathematics 201 was a required course for all elementary education majors and due to the fact that the enrollments in this course were usually large, the decision was made to attempt to secure the control students from the students enrolled in Mathematics 201. Permission was granted by the instructor for the investigator to solicit the cooperation of students in Mathematics 201 for the purpose of serving as control groups for the study.

The students' attitude toward biological science was measured by an instrument developed by the writer, called the Biological Science Attitude Scale. Students in Experimental Groups I and II and the students in Control Groups I and II were pre- and posttested on this instrument. The development of the instrument is presented in Chapter IV.

Subjects. The subjects, as indicated previously, were elementary education majors who had enrolled through regular university procedures in Biological Science 202 and Mathematics 201 winter and spring terms, 1970. Table 1 shows the distribution of the 426 students, by curriculum areas, who were enrolled in Biological Science 202 during winter term, 1970. There were 275 elementary education majors or 64.5 percent of the students enrolled in the course. Of these 275 students, 196 completed both the pretest and posttest administration of the Biological Science Attitude Scale and constituted Experimental Group I. The students that served as the control for

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TABLE 1

DISTRIBUTION OF STUDENTS BY CURRICULUM DURING WINTER
TERM, 1970, ENROLLMENT IN BIOLOGICAL SCIENCE

Curriculum	Number	Percent
Elementary and Special Education	275	64.5%
Social Science	40	9.4
Social Work	17	4.0
University College	17	4.0
Psychology	16	3.8
Home Economics	10	2.4
Political Science	10	2.4
Agriculture - Undergraduate	7	1.6
Justin Morrill College	4	.9
All Others*	30	7.0
Total	426	100.0%

*All Others includes: sociology, television and radio, art, physical science, mathematics and statistics, anthropology, geography, urban planning and landscape architecture, arts and letters, literature, economics, advertising, theatre, education-graduate, health, physical education and recreation, mechanical engineering, biological science, police administration and public safety, pre-veterinary, and English language center.

Experimental Group I were designated as Control Group I and was composed of 29 elementary education majors enrolled in Mathematics 201, winter term, 1970. The criteria used in selecting the control students were: 1) they had not taken Biological Science 202 or were not taking the course winter term, 1970; 2) they enrolled in Biological Science 202 spring term, 1970; and 3) they completed both the pretest and posttest administration of the Biological Science Attitude Scale.

During Spring term, 1970, 349 students enrolled in Biological Science 202. Of these students, 73.6 percent were elementary education majors. Experimental Group II was composed of 141 of these students who completed both the pre- and posttest administration of the Biological Science Attitude Scale. This group of 141 students did not include the 29 students who served as Control Group I which was described previously. The Control Group II was composed of 16 regularly enrolled elementary education majors in Mathematics 201 during spring term, 1970. The criteria used in selecting these students were: 1) they had not taken Biological Science 202 or were not taking the course spring term, 1970; 2) they indicated they planned to take Biological Science 202 either summer term, 1970, or fall term, 1970; and 3) they completed both the pretest and posttest administrations of the Biological Science Attitude Scale. Table 2 summarizes the experimental and control groups as to terms and number of students comprising each group.

TABLE 2
EXPERIMENTAL AND CONTROL GROUPS FOR
WINTER AND SPRING TERMS, 1970

	Winter Term, 1970	Spring Term, 1970
Experimental Groups	Experimental Group I contained 196 Elementary Education Majors Enrolled in Biological Science 202	Experimental Group II contained 141 Elementary Education Majors Enrolled in Biological Science 202
Control Groups	Control Group I contained 29 Elementary Education Majors Enrolled in Mathematics 201	Control Group II contained 16 Elementary Education Majors Enrolled in Mathematics 201

Biological Science 202, winter term, 1970. There were some changes made in the Biological Science 202 course between winter and spring terms. Therefore, a description of the course as it was implemented each term follows. The Biological Science 202 course during winter term was a combination lecture and auto-tutorial course. The course was comprised of the following divisions:

General Assembly Session	1 hour/week
Independent Study Session	3 hours/week
Small Assembly Session	1 hour/week
Oral Quiz Session	$\frac{1}{2}$ hour/week

General Assembly Session, winter term, 1970. The student was scheduled to attend a General Assembly Session at either 10:20 a.m. or 3:00 p.m. on Monday. These sessions were essentially expository in nature and were conducted by Dr. Sauer. At times mimeographed supplemental study aids, designed to exemplify a particular biological concept such as the nitrogen cycle, were distributed to the students. When applicable to the unit being studied, 16 mm. films were shown and guest speakers were used. The students were encouraged, but not required, to obtain a textbook¹ which was used as a supplemental aid.

Attendance at the General Assembly Session was not mandatory. Although the students were encouraged to attend, roll was not taken.

As part of the student evaluation procedure there was a common mid-term and a common final examination. Both these tests were administered in the General Assembly Session at the appropriate time.

Independent Study Session, winter term, 1970. The portion of the Biological Science 202 course entitled Independent Study Session consisted of an auto-tutorial laboratory situation. The subject matter of the course was divided into nine units during the term with a study guide, prepared

¹William T. Keeton, Elements of Biological Science (New York: W. W. Norton and Company, Inc., 1960).

by Dr. Enochs, for each unit. In addition, Dr. Enochs prepared a set of objectives for each unit. The students were each supplied with a study guide and the objectives. Objectives for units 1-9 are included in Appendix E.* Table 3 shows an outline of the topics covered during each unit of study.

The auto-tutorial laboratory, referred to as the Learning Center, was equipped with 36 carrels. Included in each carrel was a cassette tape recorder, a pass-strip slide projector, and a fluorescent lamp. When a student wished to work in the Learning Center he was assigned to one of these carrels by a student assistant who was on duty whenever the laboratory was open.

It was the responsibility of each student to complete the necessary work on each unit during times consistent with his schedule. The Learning Center was open from 8:00 a.m. to 10:00 p.m. Monday through Thursday and 8:00 a.m. to 5:00 p.m. on Friday. A student could come in to work in the Learning Center at any time during this period provided a carrel was vacant. Each unit was designed by Dr. Enochs to require a minimum time expenditure by the student of about four hours to complete.

*The objectives are essentially the same as those used during spring term and are not duplicated in a separate appendix for that term.

TABLE 3
 OUTLINE OF TOPICS COVERED IN BIOLOGICAL SCIENCE 202
 WINTER TERM, 1970

Unit	Topics	Organisms
1	Introduction Nature of Science Nature of Life Context of Life Organizing Biology (lecture) The Microscope The Metric System	Taxonomy
2	Cell Anatomy Cell Diversity Brownian Motion, diffusion, osmosis Patterns of Nutrition Organic Chemistry (lecture)	Lower Animals
3	Autotrophic Life: Producers Plant Anatomy Plant Nutrition Photosynthesis	Mollusks, Annelids, Echinoderms
4	Heterotrophic Life: Consumers Food Chains Animal Nutrition Mammalian Anatomy Comparative Anatomy	Arthropods
5	Cell Nutrition Respiration: Anerobic Respiration: Aerobic Control: cellular Control: organismal	Chordates I
6	Continuity of Life Cellular Reproduction Plant Reproduction Plant Development	Chordates II

TABLE 3 (continued)

Unit	Topics	Organisms
7	Molecular Reproduction Animal Reproduction Animal Development	Decomposers
8	Interactions of Organisms Cycling of material in Ecosystems Flow of energy in Ecosystems Ecology Succession	Lower Plants
9	Populations Human Population Explosion Pollution of the Biosphere	Flowering Plants

As a student entered the Learning Center, he could determine the availability of carrels by observing a rack attached to the wall, near the entrance, with numbered slots. As a carrel was assigned, a card was placed in the slot corresponding to the number of that carrel and the card was removed when the carrel was vacant.

A tray containing earphones for the tape recorder, a tape cassette, an envelope containing pass-strip slides, and additional materials, such as microscope slides and dissecting kits were issued to each student by a student assistant. The additional materials were supplied as demanded by the unit being studied during a given week.

The student would proceed to a carrel and be seated. The tape cassette was placed in the tape recorder and turned on. Via the earphones the student would be introduced to the unit under study. All the tapes were produced by Dr. Enochs with various kinds of directions given on the tapes. For instance, the student might have been directed to an exercise in the study guide or told to go observe a display at one of two demonstration tables. The demonstration tables were each divided into four sections so there were a total of eight sections in all, and it was possible to have as many different demonstrations. At the demonstration table, the student would have undertaken a variety of exercises such as studying a display, viewing an 8mm film loop, viewing a film strip, observing specimens under a microscope, or performing a laboratory exercise. When an exercise at a particular demonstration table was completed the student returned to his carrel and received further instructions.

There was a graduate assistant on duty at all times to offer assistance to the students. The students were urged to seek aid from these assistants whenever they felt it necessary.

Upon completion of the required work in the Independent Study Session, the student took a written sixteen point quiz over the material. He did so by requesting a copy of the quiz from the undergraduate student assistant on duty and took the quiz under the student assistant's supervision. The quiz

could be taken any time during the day while the Learning Center was open. Students who completed the unit in the Independent Study Session during the first part of the week could take the quiz on Thursday or Friday of that week. Students whose schedules necessitated their working on the unit during the latter part of the week took the quiz on Monday or Tuesday of the following week. This quizzing procedure was to become altered due to a structural change in the course. The Oral Quiz Session, to be described later in this chapter, was used during the first four weeks of the course to administer an oral quiz to the students. After that time, the use of oral quizzes was terminated and, thereafter, the allotted time for the Oral Quiz Session was used to administer the written quiz.

The written quizzes consisting of sixteen multiple choice questions were prepared by Dr. Sauer. The quiz answer sheets were scored by Dr. Sauer and returned to the Oral Quiz Session instructor. After all the students had taken the quiz, a copy, with the correct answers marked, was placed on display in the Learning Center each week.

Small Assembly Session, winter term, 1970. The Small Assembly Sessions met for one hour per week and were scheduled during the latter part of the week, i.e., Thursday and Friday. Attendance at these sessions was voluntary. The students signed a roster at the beginning of the term

indicating their preference of a meeting time. There were eight different times from which to choose; three on Thursday afternoon and five on Friday.

The purpose of the Small Assembly Sessions was to review the unit just completed and to answer students' questions pertaining to the objectives for that unit prior to their taking the written quiz.

These sessions usually had a small attendance. For example, one section, for which approximately 25 people had signed up, was usually attended by from 3-5 students. Attendance was similarly small in other sections.

Oral Quiz Session. The Oral Quiz Sessions met for $\frac{1}{2}$ hour per week at a scheduled time and attendance was mandatory. These sessions were conducted by graduate assistants, Dr. Sauer, and Dr. Enochs. Each quiz instructor was assigned to a specific number of Oral Quiz Sessions. The purpose of these sessions was to administer a 10 point oral quiz to each student. The questions were designed to measure the extent to which the students had accomplished the objectives for that unit. This procedure was followed for four weeks, but due to dissatisfaction of the students and teaching staff the students were asked to complete a questionnaire concerning their feelings toward the oral quiz practice. Responses to the questionnaires showed the majority of students had negative feelings toward the oral quizzes and consequently the decision.

was made to discontinue them. The Oral Quiz Session time was thereafter used to administer the sixteen point multiple choice quiz described earlier.

Optional term projects, winter term, 1970. In order that the student might earn extra credit, the option to complete a term project was offered. The student could earn a maximum of five points by doing a project. Examples of projects which were done by students included rearing guppies, germinating a variety of seeds, keeping pets, or making a leaf collection. The objective of having the students do such projects was to provide them with an opportunity to become involved in activities similar to those they might encounter in the elementary classroom.

The student was directed to make daily observations and keep a record of those observations. The projects which were done were displayed in the Learning Center so other students could also benefit from the experience. The records kept by the students were turned in to the Oral Quiz instructor at the end of the term.

Determination of final course grades, winter term, 1970. Each Oral Quiz instructor was responsible for keeping a record of each of his student's scores on work done during the term. Student evaluation consisted of the eight written quizzes, the four oral quizzes prior to their being discontinued, a mid-term examination, and a final examination. At

the end of the term all the teaching personnel in the course met to decide on a grading scale for that term. The range of total points, from highest to lowest, was determined, and the frequency of students falling within each total point category was determined. At this point, a grading scale was established. After the grading scale was established those students who had completed an optional term project had whatever number of points received added on to their point total. As a consequence, many students who did a project received a higher grade than they would have based on their point total alone.

Biological Science 202, spring term, 1970. The Biological Science 202 course during spring term 1970, was a combination lecture and auto-tutorial course. The course was comprised of the following divisions:

General Assembly Session	1 hour/week
Independent Learning Session	4 hours/week
Small Assembly Session	1 hour/week

General Assembly Session, spring term, 1970. The General Assembly sessions during spring term were essentially the same as they were winter term. However, rather than both the General Assembly Sessions meeting on Monday as they did winter term, one section met at 9:10 a.m. on Monday and one section met at 9:10 a.m. on Wednesday. The students which attended the Monday sessions were directed to go to the Independent Learning Session (referred to as the Independent

Study Session during winter term) any time between 8:00 a.m. and 10:00 p.m. Monday through Wednesday. Students assigned to the Wednesday General Assembly Session attended the Independent Learning Session any time Wednesday through Thursday, 8:00 a.m. until 10:00 p.m., and 8:00 a.m. until 5:00 p.m. on Friday. Although the teaching personnel did not strictly enforce this schedule, it was evident the students generally complied with it, since it was helpful to them to attend the General Assembly Session prior to working on the unit in the Independent Learning Session.

Independent Learning Session, spring term, 1970. The Independent Learning Session was essentially the same spring term as the Independent Study Session of winter term. One difference was that the students could not attend the Independent Learning Session at any time during the week as they could during winter term, but attended according to the schedule outlined in the previous section.

Small Assembly Session, spring term, 1970. The Small Assembly Sessions met for one full fifty minute period. During the first thirty minutes of the session, the students had the opportunity to ask questions and discuss that week's unit being covered in the General Assembly Session and the Independent Learning Session. During the last twenty minutes of the period, a fifteen point multiple choice quiz was administered. The questions were designed to determine whether

or not the student had accomplished the written objectives for that unit. As was true of winter term the quizzes were constructed by Dr. Sauer who also took the responsibility of having them graded. Each student was supplied with objectives for each unit.

The Small Assembly Sessions were scheduled on Wednesday, Thursday, Friday, and Monday. Those students who were scheduled for the Monday General Assembly Session were assigned to either a Wednesday or Thursday Small Assembly Session and those students who were scheduled for the Wednesday General Assembly Session were assigned to either a Friday or Monday Small Assembly Session. By this procedure, the students were given adequate opportunity to complete their work in the Independent Learning Session between the time they met in their General Assembly Session and their Small Assembly Session. Unlike the General Assembly Session, attendance was mandatory at the Small Assembly Session and roll was taken.

The instructors for the Small Assembly Sessions consisted entirely of graduate assistants and each graduate assistant was assigned one or more of these sessions. He was responsible for keeping a record of the students' grades in each of his sections and determining their grade for the course.

Determination of final course grades, spring term, 1970. Each Small Assembly Session instructor was responsible

for keeping a record of each of his student's scores on work done during the term. Student evaluation consisted of eight written quizzes, a mid-term examination, and a final examination. At the end of the term all the teaching personnel met to decide on a grading scale using the procedure described for winter term. Again, after the grading scale had been established, any student who had completed an optional term project had these points added directly on to his point total.

Order of presentation of topics, spring term, 1970.

The topics covered during winter and spring terms were essentially the same, but the order of presentation was changed. Rather than beginning the term with an emphasis on taxonomy, as was done winter term, taxonomy was dealt with at the end of spring term. The reason for this change was based on the assumption that the concept of taxonomy would be more easily understood after the students had become familiar with the plant and animal phyla.

Administration of the Biological Science Attitude Scale, winter term, 1970. During winter term the Biological Science Attitude Scale* was administered as a pretest to all the students enrolled in Biological Science 202 at the Oral Quiz Sessions during the first meeting of these sessions. The posttest was administered during the final examination

*A sample of the instrument as it was administered is contained in Appendix A.

of the course. The pretest was administered to all students enrolled in Mathematics 201, winter term, 1970, which included Control Group I, during a lecture in the first week of winter term.* The elementary education majors who were enrolled in Mathematics 201 during winter term and then took Biological Science 202 during spring term, took the Biological Science Attitude Scale along with the rest of the biology students at the beginning of spring term. This testing, for the students who had been pretested in Mathematics 201 winter term, served as the posttest for Control Group I.

Administration of the Biological Science Attitude Scale, spring term, 1970. During spring term the Biological Science Attitude Scale was administered as a pretest to all the students enrolled in Biological Science 202 during the Small Assembly Sessions at their first meeting. The posttest was administered during the final examination of the course during the last week of the term. The elementary education majors that completed both administrations of the attitude scale constituted Experimental Group II.

The Biological Science Attitude Scale was administered to all the students enrolled in Mathematics 201, which

*A sample of the instrument as it was administered during spring term is contained in Appendix B. The instrument was identical for winter term except the cover sheet contained the words "spring term" rather than "fall term" or "summer term" in Part A-II.

included Control Group II, in a lecture during the first week of spring term. The posttest was administered in Mathematics 201 during the final examination of the course the last week of the term.

Scoring the Biological Science Attitude Scale responses. The students responded to the Biological Science Attitude Scale by placing their answers on optical scanning sheets which were machine scored. The computation of a student's score is described in Chapter IV. The data were then transferred to computer cards which were used for statistical analysis. The serving of scoring the answer sheets and transferring the data to computer cards was provided by the Test Scoring Service, Michigan State University. The students were instructed not to place their names on the answer sheets and were assured their names would remain anonymous. They were asked to place their student identification number on the answer sheets, however, so their pretest scores could be matched with their posttest scores.

Treatment of the data. Since intact samples of subjects, elementary education majors enrolled in Biological Science 202 and Mathematics 201, were used, random assignment of subjects to treatment groups was not possible. In such a situation, McNemar² suggested comparing adjusted posttest

²Quinn McNemar, Psychological Statistics (4th ed.; New York: John Wiley and Sons, Inc., 1969), pp. 413-414.

scores using analysis of covariance as a statistical technique. The pretest scores were used as covariables. The data for this study, then, were analyzed with analysis of covariance with unequal cell frequencies. With the aid of Mr. James Mullin in the Applications Programming Department of the Michigan State University Computer Center, the data were prepared for analysis on the 3600 Computer using a program³ at the Computer Laboratory. The program was designed to adjust for unequal cell frequencies.

SUMMARY

This study was conducted in the Science and Mathematics Teaching Center at Michigan State University. The subjects consisted of experimental groups comprised of elementary education majors enrolled in Biological Science 202 during winter and spring terms, 1970. The control groups were comprised of elementary education majors enrolled in Mathematics 201 during winter and spring terms, 1970. The treatment of major interest was the Biological Science 202 course. This course was a combination lecture and auto-tutorial course designed especially for students majoring in the elementary education curriculum. The purpose of the study was to determine the effect Biological Science 202 had

³Michigan State University Agricultural Experiment Station STAT Series Description No. 18, November, 1969.

on the attitudes of elementary education majors toward biological science. In order to measure these attitudes the Biological Science Attitude Scale was constructed by the investigator. The statistical procedures for this investigation were one-way analysis of covariance.

CHAPTER IV

CONSTRUCTION OF THE BIOLOGICAL SCIENCE ATTITUDE SCALE

While attitude scales, such as those developed by Silance and Remmers¹ and Remmers² were designed to ascertain student attitude toward any school subject and one by Hand³ could be used in any college course, a search of the literature failed to reveal an attitude scale designed to measure attitude toward biological science. Thus, the investigator developed, as one of the main purposes of this study, a scale which was designed specifically to measure attitudes toward biological science. This chapter reviews briefly some of the methods of attitude scale construction and presents in detail the procedures used in developing a Biological Science Attitude Scale.

¹E. B. Silance and H. H. Remmers, "An Experimental Generalized Master Scale: A Scale to Measure Attitudes Toward Any School Subject," Purdue University Studies in Higher Education 35:84-88, 1934.

²H. H. Remmers (ed.), A Scale to Measure Attitude Toward Any School Subject (Lafayette, Inc.: Purdue Research Foundation, 1960).

³J. A. Hand, "A Method of Weighting Attitude Scale Items From Subject Responses," Journal of Clinical Psychology 9:37-39, 1953.

Methods of attitude scale construction. The importance and use of scales in measuring attitudes may be inferred from Edwards' statement:

The impetus given to research involving social attitudes by the writings of L. L. Thurstone in the 1920's has maintained itself for over a quarter of a century. During this time there has been a continued interest upon the part of psychologists, political scientists, sociologists, and educationists in the use of scales for measuring attitudes.⁴

While scales have been used widely in attempting to ascertain the attitudes of individuals, there is no general agreement as to a preferred technique for measuring attitudes. However, the two basic techniques which have been applied most frequently in the development of attitude scales are: (1) the use of a judging group; and (2) a method based upon direct responses of agreement or disagreement with attitude statements.⁵

The judgment technique of attitude scale construction includes the method of paired comparisons, the method of equal-appearing intervals, and the method of successive intervals all of which were developed by Thurstone. The direct response method includes the method of summated ratings

⁴Allen L. Edwards, Techniques of Attitude Scale Construction (New York: Appleton-Century-Crofts, Inc., 1967), p. vii.

⁵Ibid.

developed by Likert and the method of scalogram analysis developed by Guttman.⁶

Osgood, Suci, and Tannenbaum⁷ in their book, The Measurement of Meaning, present another method of attitude scale construction. They include attitude "... as one of the major dimensions of meaning-in-general and thus...extend [to it] the measurement procedures of the semantic differential...."⁸ They describe the semantic differential device as:

... a very general way of getting at a certain type of information, a highly generalizable technique of measurement which must be adapted to the requirement of each research problem to which it is applied.⁹

In addition to the attitude scale construction techniques mentioned, Shaw and Wright¹⁰ call attention to three infrequently used methods. These include Coomb's unfolding technique, Hammond's error-choice technique, and Lazarfeld's latent distance procedure.

⁶Ibid., pp. 19-20.

⁷Charles E. Osgood, George J. Suci, and Percy H. Tannenbaum, The Measurement of Meaning (New York: Basic Books, Inc., 1966).

⁸Ibid., p. 189.

⁹Ibid., p. 78.

¹⁰Marvin E. Shaw and Jack M. Wright, Scales for the Measurement of Attitudes (New York: McGraw-Hill Book Co., 1967), p. 560.

With respect to the question of which scaling method should be used for a particular research problem, Oppenheim¹¹ has indicated that the Thurstone procedure of equal-appearing intervals would probably be most appropriate for studies dealing with group differences. He contends that attitude scales are relatively crude measuring devices and that they serve mainly to divide people into broad groups with regard to a particular attitude.¹² Since the present study dealt with group differences, the method of equal-appearing intervals was selected as the technique for developing the Biological Science Attitude Scale.

Attitude scale development by the equal-appearing intervals technique. The steps in constructing an attitude scale by the equal-appearing intervals technique, as outlined by Shaw and Wright, are:

... (1) A large number of items concerning the object of the attitude in question are formulated; (2) these items are sorted by a sizable number of judges into 11 piles or categories which appear to the judges to be equally spaced in terms of the degree to which agreement with the item reflects the underlying attitude; (3) the piles are numbered from 1 to 11, and a scale value is computed for each item, taken as the median of the position given the item by the group of judges; (4) the interquartile range, or Q value, is computed as a measure of

¹¹A. M. Oppenheim, Questionnaire Design and Attitude Measurement (New York: Basic Books, Inc., 1966), p. 123.

¹²Ibid., p. 121.

interjudge variability, and all items for which there is much disagreement are rejected; and (5) a small number of items for the final scale are selected so that they are spread more or less evenly along the attitude continuum.¹³

These steps were followed in preparing the attitude scale for use in the present study. With respect to step number 1, Edwards¹⁴ says that "The items making up an attitude scale are called statements. A statement may be defined as anything that is said about a psychological object. The class of all possible statements that could be made about a given psychological object is often called a universe of content or simply a universe." The first step, then, in the construction of the attitude scale developed for this study was to obtain statements representing the universe of interest. According to Edwards, statements may be written by the test maker, obtained from newspaper editorials and magazine articles, taken from books about the object, or obtained by asking individuals to write short descriptions of their feelings about the psychological object.¹⁵

For the present study, the investigator selected 100 statements. Some of the statements were obtained from secondary and/or elementary science teaching methods texts

¹³ Shaw and Wright, op. cit., pp. 21-22.

¹⁴ Edwards, op. cit., p. 10.

¹⁵ Ibid.

and some were developed by the investigator. In selecting the statements, an attempt was made to have statements which spanned the psychological continuum from strongly negative through neutral to strongly positive with regard to feelings about biological science. Each of the 100 statements was typed on a 3x5 card and each card was given an identifying number on the back. The statements were edited by the investigator in accordance with the criteria cited by Edwards.

These criteria are:

1. Avoid statements that refer to the past rather than to the present.
2. Avoid statements that are factual or capable of being interpreted as factual.
3. Avoid statements that may be interpreted in more than one way.
4. Avoid statements that are irrelevant to the psychological object under consideration.
5. Avoid statements that are likely to be endorsed by almost everyone or by almost no one.
6. Select statements that are believed to cover the entire range of the affective scale of interest.
7. Keep the language of the statements simple, clear, and direct.
8. Statements should be short, rarely exceeding 20 words.
9. Each statement should contain only one complete thought.
10. Statements containing universals such as all, always, none, and never often introduce ambiguity and should be avoided.

11. Words such as only, just, merely, and others of a similar nature should be used with care and moderation in writing statements.
12. Whenever possible, statements should be in the form of simple sentences rather than in the form of compound or complex sentences.
13. Avoid the use of words that may not be understood by those who are to be given the completed scale.
14. Avoid the use of double negatives.¹⁶

Review of techniques for obtaining judgments of statements. The sorting procedure as first described by Thurstone and Chave consisted in printing each attitude statement on a separate card. Then individuals, serving as judges, were asked to sort the cards containing the statements into piles. There were eleven cards lettered A through K which were placed in order in front of the person doing the sorting with the A card to the extreme left and the K card to the extreme right. The individuals were told the A card represented favorable feelings toward the psychological object, the K card represented unfavorable feelings toward the psychological object, and the F card represented neutral feelings toward the psychological object.¹⁷ Thurstone and Chave believed it was important that the other cards not be

¹⁶ Edwards, op. cit., pp. 13-14.

¹⁷ L. L. Thurstone and E. J. Chave, The Measurement of Attitude (Chicago: The University of Chicago Press, 1929), pp. 30-31.

defined so that the intervals between successive cards would represent equal-appearing intervals. Each person was asked to judge the feeling expressed by each statement in terms of the 11 intervals by placing the statement cards onto the lettered card most closely representing the degree of favorableness or unfavorableness. In order to sort 130 statements, Thurstone and Chave used 300 judges.¹⁸ However, there has been research¹⁹ which showed that reliable scale values could be obtained using as few as 15 judges.

Several investigators have varied the method of obtaining judgments. Edwards²⁰ noted that Ballin and Farnsworth used a graphic-rating method. The subjects gave their judgments of favorableness or unfavorableness of the statements by placing a check on an eleven inch line. The line was afterwards divided into eleven equal intervals and the number of checks in each interval counted. Another variation, used by Seashore and Hevner,²¹ consisted of printing the statements in booklets with the numbers one to eleven printed to the left of the statement. Subjects made their judgments by circling the number corresponding to the category in which they believed the statement fell. Webb²² had the subjects

¹⁸Edwards, op. cit., p. 94.

¹⁹Ibid., p. 95.

²¹Ibid., p. 96.

²⁰Ibid.

²²Ibid., p. 97.

place their responses on an IBM answer sheet which had five spaces for each statement. The first space was defined as very unfavorable and the fifth space was defined as very favorable. An IBM graphic-item counter was used to tabulate the judgments of the subjects. Correlation computations made which compared the instruments constructed from statements using these various judgment techniques and instruments constructed using statements judged by Thurstone and Chave's technique revealed values of .90 or higher. This evidence indicates that the different methods of obtaining judgments of statements were not important variables related to the scale values of the statements.²³

It should be noted that some research has been done regarding the effect of the attitudes of the judges on the sorting process. After a review of the literature, Shaw and Wright²⁴ concluded that there was reason to believe that the individuals making the judgments were influenced by their own attitudes. It appears judges make finer discriminations among statements near their own position on the attitude continuum. However, the evidence, in the main, supports the validity of scale construction by the equal-appearing intervals technique.

²³Ibid., pp. 95-98.

²⁴Shaw and Wright, op. cit., pp. 560-561.

Procedures used in the present study for obtaining judgments of the attitude statements. In order to obtain individuals to judge the statements for the construction of the Biological Science Attitude Scale, personnel in the Science and Mathematics Teaching Center at Michigan State University were asked to serve as judges. Seventeen persons connected with the Center agreed to participate in judging the attitude statements. The backgrounds of these subjects were as follows: six of the individuals were staff members with two having the Ph.D. degree in a biological science discipline, three having the Ph.D. degree in education with cognate training in physical science, and one having the Ed.D. degree in mathematics education; and eleven were graduate students with five having a baccalaureate degree with a background in biological science, four having a master's degree with physical science backgrounds, one with a master's degree with a biological science background, and one was a medical student.

The judging process was similar to that outlined by Thurstone and Chave. However, instead of lettering the sorting-category cards from A to K, the cards were numbered from one to eleven. In addition, highly unfavorable was printed at the bottom of card one, neutral was printed at the bottom of card six, and highly favorable was printed at the bottom of card eleven. In preparation of sorting, the

number one card was placed on a table so that it would be to the extreme left of the person doing the sorting and the number eleven card to the extreme right.

Before starting the evaluations, the person was presented with a card with the following information which he was requested to read.

DIRECTIONS

I am attempting to construct a test which will measure the attitudes of students toward biological science.

Written on the cards are statements, ranging from highly favorable to highly unfavorable, toward biological science.

In front of you is a scale numbered from one (1) to eleven (11).

(1) One equals highly unfavorable.

(6) Six equals neutral.

(11) Eleven equals highly favorable.

Place the cards containing the statements in piles along the scale according to how favorable or unfavorable you think the statement is. I am not trying to measure your attitude. I am trying to obtain your opinion as to how favorable or unfavorable you think the statements are.

Do not attempt to place an equal number of cards in each pile. There has been no attempt to write an equal number of statements which would fit in each category. You may even find that some numbers along the scale will be left blank.

After the person who was to do the judging had completed reading the directions, he was asked by the investigator if there were any questions. If there were no questions or after the questions had been answered, the subject was handed the deck of cards containing the 100 statements. The deck had been thoroughly shuffled so the statements were in random order. After reading each statement,

the judge placed the card on one of the numbered sorting category cards which corresponded to how favorable or unfavorable he felt the statement was toward biological science. When the sorting process was completed the investigator recorded, on the back of the statement card, the number of the pile into which the statement had been placed. For example, if attitude statement number 37 was judged slightly unfavorable and placed on card five by the judge, the number five was written on the back of the card containing statement number 37. While such numbers appeared on the cards after the first judging, the judges were asked not to look at the numbers before making their own judgments. In the writer's opinion the presence of these numbers on the cards did not bias the results. This process for sorting the cards was repeated with each of the seventeen individuals who had agreed to serve as judges.

Computation of S values. Once the statements had all been sorted into categories by the judges, a scale or S value for each attitude statement was computed. The S values actually classify a statement as to its favorableness or unfavorableness. These S values were necessary in constructing the attitude scale and were the basis for computing an attitude score for those taking the attitude scale. The S value was defined²⁵ as the median of the distribution of judgments

²⁵Edwards, op. cit., p. 87.

for each statement and was computed by means of the following formula:²⁶

$$S = l + \left(\frac{.50 - \sum p_b}{p_w} \right) i$$

where S = the median or scale value of the statement

l = the lower limit of the interval in which the median falls

$\sum p_b$ = the sum of the proportions below the interval in which the median falls

p_w = the proportion within the interval in which the median falls

i = the width of the interval and is assumed to be equal to 1.0

The data obtained from the judgment process were recorded in a summary table like the one shown in Table 4 on page 83. The actual computation of S for item 1 in Table 4 follows:

$$l = 10.5; \sum p_b = 0.24; p_w = 0.76; i = 1.0$$

substituting into the above formula

$$S = 10.5 + \left(\frac{.50 - .24}{.76} \right) 1.0$$

$$S = 10.84$$

²⁶Ibid.

Computation of Q values. The interquartile range or Q value was computed as a measure of the variation of the judgments for each statement. The Q value served as a measure of a statement's ambiguity. That is, the larger the Q value the more ambiguous the statement.²⁷ The Q value was used as a criterion for selecting statements for the final attitude scale. In the instrument developed by Thurstone and Chave,²⁸ the range of Q values was 0.7 to 2.6. This range was used as a guide by the investigator to select statements for the final attitude scale in this study. The Q values for the Biological Science Attitude Scale ranged from 0.5 to 2.4.

The Q value was computed by taking the difference between the 75th and the 25th centile.²⁹ Thus:

$$Q = C_{75} - C_{25}$$

where Q = the interquartile range

C_{75} = the 75th centile computed from the formula

$$C_{75} = 1 + \left(\frac{.75 - \sum P_b}{P_w} \right) i$$

²⁷ Edwards, op. cit., p. 89.

²⁸ Thurstone and Chave, op. cit., pp. 33-34.

²⁹ Edwards, loc. cit.

C_{25} = the 25th centile computed from the formula

$$C_{25} = l + \left(\frac{.25 - \sum p_b}{p_w} \right) i$$

where l = the lower limit of the interval in which the centile falls

$\sum p_b$ = the sum of the proportions below the interval in which the centile falls

p_w = the proportion within the interval in which the centile falls

i = the width of the interval and is assumed to be equal to 1.0

The data obtained from the judgment process were recorded in a summary table like the one shown in Table 4 on page 83. The actual computation of Q for item 1 in Table 4 follows:

for C_{75}

$$l = 10.5; \sum p_b = 0.24; p_w = 0.76; i = 1.0$$

and substituting into the above formula

$$C_{75} = 10.5 + \left(\frac{.75 - .24}{.76} \right) 1.0$$

$$C_{75} = 11.17$$

and for C_{25}

$$I = 10.5; \leq p_b = 0.24; p_w = 0.76; i = 1.0$$

$$C_{25} = 10.5 + \left(\frac{.25 - .24}{.76} \right) 1.0$$

$$C_{25} = 10.51$$

$$Q = 11.17 - 10.51$$

$$Q = 0.66$$

Selection of statements for the Biological Science

Attitude Scale. When selecting statements for an attitude scale, Shaw and Wright³⁰ suggested picking a small number of items that would be spread more or less evenly along the attitude continuum. For the instrument used in this study, 32 statements were picked with S values which were spread as evenly as possible along the attitude continuum from one to eleven. Selection of statements for the attitude scale was also based upon Q values. Edwards³¹ suggested selecting statements with low Q values, but did not specify what a maximum value might be. As noted in the previous section, the attitude scale produced by Thurstone and Chave had a range of Q values from 0.7 to 2.6. With this range as a guide, statements were first selected for the attitude scale

³⁰Shaw and Wright, op. cit., p. 22.

³¹Edwards, op. cit., pp. 92-93.

in this study with the largest Q value being 2.8. However, due to further judgments and Q value computations, the Q value maximum was reduced to a value of 2.4.

The 32 statements which met the established criteria constituted a working form of the Biological Science Attitude Scale. In building the scale the statements were randomized and then numbered 1 through 32. There were instructions at the top of the instrument giving the respondent directions to either agree or disagree with each of the statements. A sample of the Biological Science Attitude Scale is included in Appendix B. The method by which a respondent's score was computed is described in a later section of this chapter.

A repetition of the process of judging the attitude statements. Oppenheim³² warned against using subjects for the judging procedure which differed appreciably from the group to which the final instrument was to be administered. The population used in this study, elementary education majors, were considered by the investigator to be appreciably different from the judges obtained from the Science and Mathematics Teaching Center. Consequently, the attitude statements were judged by elementary education majors during the winter term and also during the spring term before the final S and Q values were established for use in statistical computations in the study.

³²Oppenheim, op. cit., p. 133.

During winter term, 1970, 25 elementary education majors enrolled in Biological Science 202 were randomly selected to serve as judges for categorizing the attitude statements. Rather than the original 100 statements only the 32 items which had been selected as a result of the first judging were given to these student judges. With each of the 32 statements typed on a separate card they were sorted onto a scale ranging from one to eleven using the same procedure as the one described for the faculty and graduate assistants from the Science and Mathematics Teaching Center. Using the data obtained from the student judges, S and Q values were again computed. Large Q values were found for several of the statements, so the investigator repeated the judging process during the spring term, 1970.

During the spring term, 25 elementary education majors enrolled in Biological Science 202 were randomly selected to serve as judges for categorizing the attitude statements. The investigator suspected the large Q values which had occurred as a result of the winter term judging could be due to inaccurate sorting by the student judges selected. This problem could have been a result of the judges' inexperience or to a misunderstanding of the directions. Therefore, a short training session was added to the sorting procedure. In addition to the original 32 statements used on the Biological Science Attitude Scale, ten statements were

written on separate cards and added to the deck of cards containing the 32 statements. These cards were numbered from I to X in Roman numerals so they could be easily distinguished from the other cards by the investigator. The deck of the original 32 cards were shuffled as before so they were in random order. The ten supplemental cards were then placed at the front of the deck in sequential order from I to X. As each of the 25 judges sorted the cards and placed them in a particular pile, the investigator observed whether the student appeared to understand the directions. For example, if the student placed an obviously negative statement in the number eleven pile the investigator intervened and quizzed the person as to whether or not he understood the directions. This coaching procedure was repeated for the first ten cards only. As it usually turned out, the student either had forgotten which numbers indicated positive or negative attitudes, had misread the statement, or had not understood he was not to agree or disagree with the statement, but simply decide whether it was a favorable or unfavorable statement about biological science. None of the original 32 statements were discussed with the student during the judging process. The assumption was made that the coaching by the investigator of the students on the ten supplemental statements did not bias the resulting S or Q values of the 32 statements. However, values different

from the previous judgments were obtained, and it was assumed by the investigator that these differences were a result of increased precision in the final judging procedure. The objective of the training procedure was to increase the probability that the student would do a conscientious job of sorting the statements.

After the statements had been subjected to this final judging, the data were transferred from the backs of the cards containing the statements to a judgment summary table, described by Edwards.³³ These data are presented in Table 4 which includes the S and Q values for each statement. The Table shows that the S values actually used for final computation of attitude scores ranged from 1.1 to 10.9, and Q values ranged from 0.5 to 2.4. Since it was assumed that the spring term judgments of the attitude statements were the most accurate, only the data obtained during that term are included in Table 4 and consequently only those data were used in the study for the final computations of attitude scores for experimental and control groups. As was pointed out earlier, the investigator set a maximum acceptable Q value of 2.6 based on the Thurstone and Chave instrument. All attitude statements which exceeded a Q value of 2.6 were omitted from the final attitude score computations. Of the

³³Edwards, op. cit., p. 87.

32 items, 4 had Q values greater than 2.6. The maximum Q value for the final 28 items* was 2.4.

Appendix A contains the original 100 attitude statements with accompanying S and Q values. These values are based on computations resulting from data collected from judgments obtained from the original group of judges from the Science and Mathematics Teaching Center. It should be noted that in a few cases the wording of a statement used in the final scale was changed slightly from the way it appeared in the original list. For example, the statement numbered 23 in the original list which reads: "Keeping children's pets, such as mice, hamsters, or turtles, in the elementary classroom is just too much bother," was altered to read as number 4 in the final instrument: "Allowing children to keep pets such as mice, hamsters, or turtles in the elementary classroom is just too much bother." In all cases where a change was made in the wording of a statement it was done prior to the final judging process; no changes were made after the final judging.

Table 5 contains a list of the 32 statements used on the Biological Science Attitude Scale and shows the S and Q

*Statement 32 was omitted accidentally during machine scoring of the answer sheets, so the final analyses were based on 27 items.

TABLE 4

SUMMARY TABLE SHOWING JUDGMENTS OF STATEMENTS OBTAINED FROM TWENTY-FIVE
ELEMENTARY EDUCATION STUDENTS, SPRING TERM, 1970

Statement		Sorting Categories										
		1	2	3	4	5	6	7	8	9	10	11
1	f							1		1	4	19
	p							.04		.04	.16	.76
	cp							.04		.08	.24	1.00
2	f	1	1				7	7	3	2	2	2
	p	.04	.04				.28	.28	.12	.08	.08	.08
	cp	.04	.08				.36	.64	.76	.84	.92	1.00
3	f						10	6	3	1	3	2
	p						.40	.24	.12	.04	.12	.08
	cp						.40	.64	.76	.80	.92	1.00
4	f	8	6	7	4							
	p	.32	.24	.28	.16							
	cp	.32	.56	.84	1.00							
5	f							1		2	2	20
	p							.04		.08	.08	.80
	cp							.04		.12	.20	1.00
6	f	22	2	1								
	p	.88	.08	.04								
	cp	.88	.96	1.00								
7	f	3	4	9	2	4	3					
	p	.12	.16	.36	.08	.16	.12					
	cp	.12	.28	.64	.72	.88	1.00					
8	f						1	3	6	9	2	4
	p						.04	.12	.24	.36	.08	.16
	cp						.04	.16	.40	.76	.84	1.00

f = frequency with which a statement was placed in each of the 11 sorting categories.
p = frequencies as proportions
cp = cumulative proportions

TABLE 4 (continued)

Statement	1	2	3	4	Sorting Categories											S	Q
					5	6	7	8	9	10	11						
9	f	10	9	4	2												
	p	.40	.36	.16	.08											1.8	1.4
	cp	.40	.76	.92	1.00												
10	f					1	1	5	4	8	6						
	p					.04	.04	.20	.16	.32	.24					9.7	2.1
	cp					.04	.08	.28	.44	.76	1.00						
11*	f					11	3	3	3	1	4						
	p					.44	.12	.12	.12	.04	.16					7.0	3.0
	cp					.44	.56	.68	.80	.84	1.00						
12*	f	3	2	3	2	14	1										
	p	.12	.08	.12	.08	.56	.04									5.7	3.2
	cp	.12	.20	.32	.40	.96	1.00										
13	f	14	6	4	1												
	p	.56	.24	.16	.04											1.4	1.4
	cp	.56	.80	.96	1.00												
14	f	12	3	4	3	1											
	p	.48	.12	.16	.08	.12	.04									1.7	2.4
	cp	.48	.60	.76	.84	.96	1.00										
15	f							2	6	8	9						
	p							.08	.24	.32	.36					10.1	1.6
	cp							.08	.32	.64	1.00						
16	f					3	9	4	7	2							
	p					.12	.36	.16	.28	.08						7.6	2.0
	cp					.12	.48	.64	.92	1.00							
17*	f					2	3	5	6	2	7						
	p					.08	.12	.20	.24	.08	.28					8.9	2.8
	cp					.08	.20	.40	.64	.72	1.00						
18	f	8	8	6	3											2.1	1.6
	p	.32	.32	.24	.12												
	cp	.32	.64	.88	1.00												

TABLE 4 (continued)

Statement		Sorting Categories										
		1	2	3	4	5	6	7	8	9	10	11
19	f							4	4	11	3	3
	p							.16	.16	.44	.12	.12
	cp							.16	.32	.76	.88	1.00
20	f					1		1	3	2	7	11
	p					.04		.04	.12	.08	.28	.44
	cp					.04		.08	.20	.28	.56	1.00
21	f	4	6	6	7	2						
	p	.16	.24	.24	.28	.08						
	cp	.16	.40	.64	.92	1.00						
22	f								4	5	9	7
	p								.16	.20	.36	.28
	cp								.16	.36	.72	1.00
23	f							1	5	7	7	5
	p							.04	.20	.28	.28	.20
	cp							.04	.24	.52	.80	1.00
24	f	16	2	6	1							
	p	.64	.72	.96	1.00							
	cp	.64	.72	.96	1.00							
25*	f	9	5	3	3	2	3					
	p	.36	.20	.12	.12	.08	.12					
	cp	.36	.56	.68	.80	.88	1.00					
26	f	10	9	4	1		1					
	p	.40	.36	.16	.04		.04					
	cp	.40	.76	.92	.96		1.00					
27	f							1	2	4	7	11
	p							.04	.08	.16	.28	.44
	cp							.04	.12	.28	.56	1.00
28	f	6	10	4	1	2	2					
	p	.24	.40	.16	.04	.08	.08					
	cp	.24	.64	.80	.84	.92	1.00					

TABLE 4 (continued)

Statement	1	2	3	4	Sorting Categories							11	S	Q
					5	6	7	8	9	10				
29	f	2	2	1	4	13		1						
	p	.08	.08	.04	.16	.52		.04					5.6	2.3
	cp	.08	.16	.24	.28	.44	.96	1.00						
30	f	1	2	1	3	12	5	1						
	p	.04	.08	.04	.12	.48	.20	.04					6.0	1.2
	cp	.04	.12	.16	.28	.76	.96	1.00						
31	f	2	7	7	4	1								
	p	.08	.28	.28	.16	.04							3.4	1.8
	cp	.08	.24	.52	.80	.96	1.00							
32**	f						4	4	4	8	5			
	p						.16	.16	.16	.32	.20		9.6	2.2
	cp						.16	.32	.48	.80	1.00			

*Those statements marked with an asterisk were omitted from the final attitude scale due to large Q values.

**Statement 32 was omitted accidentally during the machine scoring of the answer sheets for the Spring term experimental group posttest and the Spring term control group posttest. Consequently, it was not used in computing the students' attitude scores.

TABLE 5
LIST OF 32 STATEMENTS SHOWING
S AND Q VALUES

S	Q	Statement
10.8	0.7	1. The future destiny of man depends on how well he comprehends the biology of nature.
7.0	2.4	2. A biologist's laboratory is usually clean.
6.5	2.3	3. Biologists are usually nice to animals.
2.3	1.9	4. Allowing children to keep pets such as mice, hamsters, or turtles in the elementary classroom is just too much bother.
10.9	0.6	5. The pursuit of biological science is one of the most worthwhile endeavors of mankind.
1.1	0.5	6. The contributions biological science has made to society are few and far between.
3.1	2.4	7. More college students dislike biological science than like it.
8.8	1.6	8. Learning about amoebas is fascinating.
1.8	1.4	9. There is no useful purpose in having elementary school children collect pond "scum" and bring it to class in a jar even if it were interesting to them.
9.7	2.1	10. Dissecting animal specimens is informative and interesting.
*7.0	3.0	11. Biologists don't seem any different than anyone else I know.
*5.7	3.2	12. A required course in biological science for prospective elementary school teachers probably won't do them any good or harm.
1.4	1.4	13. The thought of carrying out biological experiments is repugnant.

TABLE 5 (continued)

S	Q	Statement
1.7	2.4	14. I'm not too convinced of the need for biological science in the elementary school curriculum.
10.1	1.6	15. Elementary school teachers should encourage their students to bring various kinds of living things, such as snakes, frogs, bugs, or caterpillars, to school for study.
7.6	2.0	16. Knowing the names of living things helps one understand them better.
*8.9	2.8	17. Biological science is as much for the average person as it is for the real intelligent person.
2.3	1.6	18. There is something wrong with anyone who would enjoy collecting insects.
8.9	1.4	19. Observing microscopic living things under the microscope is fun.
10.3	1.8	20. I would like to learn more about biological science.
2.9	2.0	21. Having elementary school children maintain a terrarium in the classroom might serve as a teaching aid but is not worth the mess and time required.
9.9	1.6	22. Everyone should have a knowledge of biological science in order to understand his own bodily processes.
9.4	1.8	23. Elementary school children should be encouraged to prepare biology projects for a science fair.
1.3	1.7	24. Taking a college course in biological science is a waste of time.
*2.2	2.9	25. Learning by discovery doesn't apply to biological science courses.

TABLE 5 (continued)

S	Q	Statement
1.8	1.4	26. The thought of keeping a living garter snake in an elementary classroom is repulsive.
10.3	1.6	27. The study of biological science is intellectually stimulating.
2.2	1.7	28. About the most boring thing I can think of would be a field trip to a laboratory conducting biological research.
5.6	2.3	29. It probably wouldn't make a difference whether or not some legislators were biologists.
6.0	1.2	30. I believe reading about biological science has value, but I seldom do so.
3.4	1.8	31. Most elementary education majors don't feel too happy about being required to take a course in biological science.
**9.6	2.2	32. Studying about the history of biological science is very interesting.

*Those items marked with an asterisk were omitted from the final attitude scale due to Q values in excess of 2.6.

**Item 32 was omitted accidentally during machine scoring of the answer sheets and was not used in computing students' attitude scores.

values for each statement. The statements marked with an asterisk were the ones omitted due to having Q values in excess of 2.6.

Computation of attitude scores for respondents. Each respondent's attitude score was calculated, as suggested by Edwards,³⁴ by taking only the statements with which he agreed and using the arithmetic mean of the S values of these statements as the score. For example, if a student agreed only with statements 1, 5, and 8 his attitude score was computed thusly: $10.8 + 10.9 + 8.8 = 30.5$; $30.5/3 = 10.2$. Thus, the student's hypothetical score was 10.2 and indicated a highly favorable attitude toward biological science. According to Edwards,³⁵ "Taking only the statements with which the subject has agreed, an attitude score is obtained from the scale values of these statements that is regarded as an indication of the location of the subject on the psychological continuum on which the statements have been scaled."

The actual computation of attitude scores for this study was carried out on the 3600 Computer in the Computer Laboratory, Michigan State University. A list of pretest and posttest attitude scores for all experimental and control groups is listed in Appendix D.

³⁴Edwards, op. cit., p. 93.

³⁵Ibid.

Test-retest reliability. One method of computing instrument reliability consists of correlating pretest scores with posttest scores using the Pearson product-moment correlation coefficient (r).³⁶ However, in the present study it would not have been appropriate to calculate a single r for all 382 subjects since the experimental group had received the treatment and the control group had not. Further, the investigator did not feel it was of value to report four separate r 's for the two experimental groups and the two control groups.

In order to report a single r for external test reliability, the investigator made use of the Fisher r to Z transformation.³⁷ Through this technique it was possible to obtain an average r for all four groups. Briefly, the procedure consisted of converting all four r 's to a Z value³⁸ and then computing an average value³⁹ for Z via the formula reported by Hays.⁴⁰ This average Z , or U according to Hays,⁴¹

³⁶N. M. Downie and R. W. Heath, Basic Statistical Methods (New York: Harper and Row, Publishers, 1965), p. 85.

³⁷William L. Hays, Statistics (New York: Holt, Rinehart and Winston, 1963), p. 530.

³⁸Ibid., p. 531.

³⁹George W. Snedecor, Statistical Methods (5th ed., Ames, Iowa: The Iowa State University Press, 1962), p. 179.

⁴⁰Hays, op. cit., p. 532.

⁴¹Ibid.

was then converted back to an r value which represented an average r for all experimental and control groups. The transformations of r to Z and the average Z conversion to an average r was done using Table V in Hays.⁴²

TABLE 6 (adapted from Snedecor⁴³)

ESTIMATE OF AN AVERAGE r FOR EXPERIMENTAL AND CONTROL GROUPS USING A FISHER r TO Z TRANSFORMATION

Samples	n	n - 3	r	Z	(n - 3) Z
Experimental Group Winter Term	196	193	0.606	0.7026	135.6018
Control Group Winter Term	29	26	0.676	0.8217	21.3642
Experimental Group Spring Term	141	138	0.586	0.6716	92.6808
Control Group Spring Term	16	13	0.966	2.029	26.3770
(n - 3) = 370		(n - 3)Z = 276.0238			
Average Z = $\frac{276.0238}{370}$ = 0.746					

⁴²Hays, op. cit., pp. 680-681.

⁴³Snedecor, op. cit., p. 179.

The individual r 's for each experimental and control group were computed using the raw score formula:⁴⁴

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{\sqrt{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]}}$$

These values are shown in Table 6 along with the transformations for r to Z . The table also shows the computed value for the average Z . In order to convert the average Z of 0.746 to an average r , Table V in Hays⁴⁵ was consulted. The reliability coefficient, then, for the Biological Science Attitude Scale was $r = 0.633$.

Split-half reliability. When applying the split-half reliability method to attitude scales, Thurstone and Chave explained:

... the usual procedure of assigning alternate items to the two forms A and B was slightly modified because that procedure would give one of the two parallel forms a slightly higher mean scale-value than the other. In order to make the two forms truly parallel,... we arranged all the opinions of the scale in rank order according to their scale-values. Successive pairs were then marked off. The first opinion in each pair had ... a slightly lower scale-value than the second. In the odd numbered pairs the first opinion with the lower scale-value was assigned to form A of the scale, and in the even numbered pairs the second opinion with the higher scale-value was assigned to form A of the test. The others were

⁴⁴Downie and Heath, op. cit., p. 85.

⁴⁵Hays, op. cit., pp. 680-681.

assigned to form B. In this manner we obtained two forms, A and B, each half as long as the experimental scale, and so prepared that the average scale-values of the two forms were practically identical. The odd statement scaled at 11.8 [11.0] was included in both forms, A and B.⁴⁶

Following this technique the investigator divided the Biological Science Attitude Scale into two halves consisting of forms A and B. Since there were an odd number of statements used in computing the students' scores, 27 in all, the scale value 10.9 was used in both halves the same way. Thurstone and Chave used the item scaled at 11.0 in both forms, A and B.

Since the attitude scores for the respondents on forms A and B had to be computed by hand the task was very time consuming. Consequently, the investigator selected a representative sample of the experimental groups by randomly selecting 54 elementary education majors from the spring term students enrolled in Biological Science 202. Their pretest scores were used for calculating reliability coefficients. Each answer sheet was given two scores, one score for the statements agreed with corresponding to the form A half of the instrument and the second score for the statements agreed with corresponding to the form B half of the instrument. A Pearson product-moment correlation coefficient was calculated for the two halves. With $N = 54$, $r_{ab} = 0.76$.

⁴⁶Thurstone and Chave, op. cit., p. 65.

Use of the split-half method had the effect, on the correlation coefficient, of shortening the instrument by one-half. The Spearman-Brown formula was used to correct for this effect. The formula used was:⁴⁷

$$r_{tt} = \frac{2r_{ab}}{1 + r_{ab}}$$

where r_{tt} = the reliability of the original test

r_{ab} = the reliability coefficient obtained by correlating the scores on the odd items with the scores of the even item.

After correcting the correlation coefficient, using the Spearman-Brown formula, with $N = 54$, $r_{tt} = 0.86$.

Validity of the instrument. The Biological Science Attitude Scale was assumed to be valid. One qualification for making this assumption was the fact that all the items on the instrument had been subjected to a judgment of faculty and graduate assistants in the Science and Mathematics Teaching Center, Michigan State University, and judgment of elementary education majors selected from the population under study.

⁴⁷Downie and Heath, op. cit., p. 218.

SUMMARY

For the purposes of this study an attitude scale, the Biological Science Attitude Scale, was constructed according to the equal-appearing intervals technique. Once a preliminary working form of the instrument had been produced, the attitude statements were subjected to further judgments by a panel consisting of a sample of subjects selected from the population under study. Test-retest reliability was computed and found to be $r = 0.633$. Split-half test reliability was calculated and was found to be $r_{tt} = 0.86$ after a correction using the Spearman-Brown formula. Validity was assumed for the instrument as a consequence of the process by which the attitude statements were subjected to judgment by a panel of staff members and graduate assistants and a sample of elementary education majors.

CHAPTER V

FINDINGS OF THE STUDY

As stated in Chapter I, the main purposes of this study were: (1) to determine whether or not the taking of Biological Science 202 produced any change in attitudes of the elementary education majors toward biological science; and, (2) to develop an instrument for measuring attitude toward biological science as a psychological object. The findings of the investigation are presented as they relate to the experimental hypotheses tested. The analysis of data was based on information obtained from the Biological Science Attitude Scale developed by the investigator. The instrument was administered to 382 elementary education majors during winter and spring terms, 1970, who were enrolled in Biological Science 202 and Mathematics 201. The pretest and posttest attitude scores for each respondent are contained in Appendix D.

The data were prepared for treatment on the 3600 Computer at the Computer Laboratory, Michigan State University. A one-way analysis of covariance was computed for the data collected for winter term and for spring term, with pretest scores serving as covariables. The computer program used included adjustments for unequal cell

frequencies. In presenting the results of the analysis of the data, a 0.05 level of confidence was used as the criterion of significance of the stated hypotheses.

Information about the numbers of subjects in each experimental group and each control group, means of pretest and posttest scores, and standard deviations are contained in Table 7.

TABLE 7
NUMBER OF SUBJECTS, MEANS, AND STANDARD DEVIATIONS
FOR EACH EXPERIMENTAL AND CONTROL GROUP

		N	Mean ($\bar{X}$)	Standard Deviation
Winter Term				
Experimental Group I:	Pretest	196	8.2	0.8
	Posttest	196	8.2	0.9
Control Group I:	Pretest	29	8.1	1.0
	Posttest	29	8.2	0.7
Spring Term				
Experimental Group II:	Pretest	141	8.2	0.9
	Posttest	141	8.2	0.9
Control Group II:	Pretest	16	8.1	1.1
	Posttest	16	7.8	1.1

Each of the experimental hypotheses, with relevant analyses of the data collected to test the hypotheses, is presented in the following sections.

Hypothesis 1. There is no significant difference in attitudes of elementary education majors enrolled in

Biological Science 202 during winter term, 1970, and a control group of elementary education majors enrolled in Mathematics 201 during winter term, 1970.

To determine whether or not attitudes, toward biological science, of experimental group I were significantly different from control group I at the end of winter term, 1970, a one-way analysis of covariance on posttest scores was performed with pretest scores as covariables.

TABLE 8

ANALYSIS OF COVARIANCE FOR POSTTEST SCORES ON THE
BIOLOGICAL SCIENCE ATTITUDE SCALE FOR
EXPERIMENTAL GROUP I AND CONTROL
GROUP I, WINTER TERM

Source of Variance	Sum of Squares	df	Mean Square	F
Between Groups	0.1097	1	0.1097	0.2131
Within Groups	114.2172	222	0.5145	

The value¹ required to reject the null hypothesis with $F_{1,222; \alpha=0.05}$ was 3.84. Since the F ratio obtained for the data in this study was 0.2131 the null hypothesis was

¹William L. Hays, Statistics (New York: Holt, Rinehart, and Winston, 1963), p. 677.

not rejected. Based upon these data, having enrolled in the Biological Science 202 course during winter term, 1970, did not significantly change prospective elementary school teachers' attitudes toward biological science when compared with a control group of prospective elementary school teachers who were not exposed to the Biological Science 202 course.

Hypothesis 2. There is no significant difference in attitudes of elementary education majors enrolled in Biological Science 202 during spring term, 1970, and a control group of elementary education majors enrolled in Mathematics 201 during spring term, 1970.

To determine whether or not attitudes, toward biological science, of experimental group II were significantly different from control group II at the end of spring term, 1970, a one-way analysis of covariance on posttest scores was performed with pretest scores serving as covariables.

TABLE 9

ANALYSIS OF COVARIANCE FOR POSTTEST SCORES ON THE
BIOLOGICAL SCIENCE ATTITUDE SCALE FOR
EXPERIMENTAL GROUP II AND CONTROL
GROUP II, SPRING TERM

Source of Variance	Sum of Squares	df	Mean Square	F
Between Groups	1.7733	1	1.7733	3.5699
Within Groups	76.4983	154	0.4967	

The value² required to reject the null hypothesis with $F_{1,154}; \alpha=0.05$ was 3.84. Since the F ratio obtained for the data in this study was 3.5699 the null hypothesis was not rejected. Based upon these data, having enrolled in the Biological Science 202 course during spring term, 1970, did not significantly change prospective elementary school teachers' attitudes toward biological science when compared with a control group of prospective elementary school teachers who were not exposed to the Biological Science 202 course.

Hypothesis 3. There is no significant difference in attitudes of elementary education majors enrolled in

²Ibid.

Biological Science 202 during winter term, 1970, and elementary education majors enrolled in Biological Science 202 during spring term, 1970.

To determine whether or not attitudes, toward biological science, of experimental group I were significantly different from experimental group II after exposure to the Biological Science 202 course during two different terms, winter and spring respectively, a one-way analysis of covariance on posttest scores was performed with pretest scores serving as covariables.

TABLE 10

ANALYSIS OF COVARIANCE FOR POSTTEST SCORES ON THE
BIOLOGICAL SCIENCE ATTITUDE SCALE FOR
EXPERIMENTAL GROUP I AND
EXPERIMENTAL GROUP II

Source of Variance	Sum of Squares	df	Mean Square	F
Between Groups	0.0424	1	0.0424	0.0794
Within Groups	178.2735	334	0.5338	

The value³ required to reject the null hypothesis with $F_{1,334}; \alpha=0.05$ was 3.84. Since the F ratio obtained for the data in this study was 0.0794 the null hypothesis was

³Ibid.

not rejected. Based upon these data, there was no difference in the effect the Biological Science 202 course had on prospective elementary school teachers' attitudes toward biological science during winter or spring terms, 1970.

Summary. The first two experimental hypotheses in this investigation were designed to determine whether or not there was a significant difference in prospective elementary school teachers' attitudes toward biological science between those subjects who were exposed for a term to the Biological Science 202 course and those subjects in the control groups who were not. The third experimental hypothesis was designed to determine whether or not there was a difference in prospective elementary teachers' attitudes between those subjects who took Biological Science 202 winter term and those subjects who took it spring term. The standard for rejecting an hypothesis was the 0.05 level of confidence. The dependent variable was measured by the Biological Science Attitude Scale.

Based upon the data of this study it was found there was no significant difference between the experimental groups and the control groups at the end of winter term and spring term with respect to attitudes toward biological science, as measured by the Biological Science Attitude Scale. Further, it was discovered there was no significant difference in the attitudes of the experimental group at

the end of winter term and the attitudes of the experimental group at the end of spring term.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Included in this summary chapter is a brief review of the purposes, design, treatment, and the experimental hypotheses tested in the study. Conclusions based on the analysis of the data described in Chapter V are stated. Implications of the study to the field of science education and suggestions for further research are also presented.

Summary. The purposes of this study were: (1) to determine the effect a combination lecture and auto-tutorial biological science course had on the attitudes of prospective elementary school teachers toward biological science, and (2) to develop a Biological Science Attitude Scale designed specifically to measure prospective elementary school teachers' attitudes toward biological science.

The study was carried out during winter and spring terms, 1970, in the Science and Mathematics Teaching Center, Michigan State University. The data gained from administering the Biological Science Attitude Scale as a pretest and posttest to two experimental groups and two control groups were used to test three experimental hypotheses dealing with: (1) a comparison of attitudes

at the end of winter term between the experimental and control groups; (2) a comparison of attitudes between experimental and control groups at the end of spring term; and (3) a comparison of attitudes between experimental group I at the end of winter term and experimental group II at the end of spring term.

Analysis of covariance procedures, with pretests serving as covariables, were used to treat the data. Attitude scores obtained from administering the Biological Science Attitude Scale to the subjects in the study were used as the dependent variable. The independent variables consisted of the treatment of major interest, the Biological Science 202 course during winter and spring terms, 1970. Selected students from the Mathematics 201 course who were not exposed to the treatment served as the control groups.

The method used for constructing the Biological Science Attitude Scale was the equal-appearing intervals technique. Test-retest reliability was computed and found to be $r = 0.633$. Split-half reliability was found to be $r = 0.86$. The attitude scale was assumed to be valid because the items, consisting of attitude statements, were subjected to a judging procedure as part of the equal-appearing intervals technique. The judges were comprised of faculty and graduate assistants in the Science and Mathematics Teaching Center and elementary education majors selected from the population under study.

Conclusions. None of the obtained F ratios computed to test the experimental hypotheses were significant at the 0.05 level, so none of the null hypotheses were rejected. Based on these data it was concluded that enrollment in Biological Science 202, by elementary education majors, did not change attitudes toward biological science as measured by the instrument used in this study.

It can be noted from Table 7 that the mean attitude scores for all groups were high. When one considers the maximum possible score on the attitude scale was 10.9, which could be obtained by agreeing with one statement only on the instrument and disagreeing with all the rest,* it is apparent a score of 8.0 or higher is quite high. Out of all the pretest and posttest responses for 382 students the highest single attitude score obtained was 9.91 and that occurred only once. This indicated students entered the course with positive attitudes toward biological science as measured by the Biological Science Attitude Scale. Although the students' attitudes were not significantly increased, neither were they significantly decreased. Thus, the treatment in the course met Mager's¹ thesis that

*A phenomenon which did not occur in practice but was hypothetically possible.

¹Robert F. Mager, Developing Attitude Toward Learning (Palo Alto: Fearon Publishers, 1968), p. 10.

"Whatever else we do in the way of influencing the student, the least we must strive to achieve is to send him away with favorable rather than unfavorable feelings about the subject or activity we teach. This might well be our minimum, and universal goal in teaching." One may infer from this finding that these future teachers will have positive attitudes toward setting learning situations for elementary pupils which stress biological phenomena.

Implications of the Study. The raw scores, as shown in Appendix D, revealed there were subjects which scored low on the instrument, but inspection of Table 7 shows the experimental and control groups' mean scores were quite similar. This phenomenon raises at least one question, which is discussed further in recommendations for further study, and that is: Does the Biological Science Attitude Scale discriminate between students with positive and students with negative attitudes toward biological science? The instrument will have to undergo further testing before this question can be answered.

On the other hand, if it is assumed the instrument does discriminate, interesting comparisons can be made with past attitude research. Typically, research has shown that preservice elementary teachers' attitudes toward science teaching and science courses are not very high. However, the Biological Science Attitude Scale was designed to

measure attitude toward the science of biology. The positive attitude scores obtained in the present study implies that an attitude toward science teaching, an attitude toward a science course, and an attitude toward the science of biology are independent variables. That is, a student could hold negative attitudes toward teaching biology and toward a biological science course but have positive attitudes toward the science of biology. It is suggested by the investigator that this implication be subjected to experimental verification.

Since the Biological Science 202 course was taught to a fairly large number of students using a combined lecture and auto-tutorial method, the implication may be made that the auto-tutorial method will not decrease student attitude toward biological science. This finding may be of interest to those contemplating the use of an auto-tutorial method of instruction.

Since the direct teaching for developing positive attitudes toward biological science was not included in the objectives for Biological Science 202, the implication may be made that in order to achieve a more comprehensive increase in positive attitudes it may be necessary to specify behavioral objectives to that end. The implication could also be made that, in addition to instruments designed to measure such objectives, techniques such as instructor-

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student interviews, tape recordings of student reactions, and student autobiographical reports of magazine articles read, books checked out from the library, visits to a museum of natural history or television programs viewed dealing with the psychological object of interest may be used for evaluation. It is suggested such techniques be used by teachers for evaluating themselves and their course rather than for determining a student's grade. If a student knows a visit to a museum will increase his chances of obtaining a higher grade he will probably do so even if he has a negative attitude toward such an activity.

Recommendations for further study. The following recommendations are made relative to ascertaining attitude toward biological science and to Biological Science 202.

1. Attitude scales should be developed which would measure attitude toward major conceptual subdivisions of biological science. Examples of such concepts are ecology, genetics, evolution, and homeostasis. Such instruments would be of value to the biology instructor interested in assessing the extent to which affective behavioral objectives have been achieved in his course. Such instruments would be valuable research tools for determining the effect a course such as Biological Science 202 has on students' attitudes toward each of these psychological objects.

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2. The Biological Science Attitude Scale as developed by the writer needs to be subjected to further scrutiny. The lack of a significant difference between experimental and control group posttest scores and the high pretest scores obtained might have been due to the instrument's inability to discriminate between students with positive and students with negative attitudes. The instrument may not have been measuring attitudes toward biological science. Observations made by the investigator during the terms he was a graduate assistant were not consistent with the high attitude scores obtained. However, it should be kept in mind the Biological Science Attitude Scale was designed to measure an attitude toward the science of biology and not attitudes toward a biology course. There have been studies reported in the literature which indicated that elementary school teachers had fairly low attitudes toward science and toward science teaching. This also seems inconsistent with the high pretest scores on the Biological Science Attitude Scale. It is recommended that elementary education majors be studied through other methods of observations, such as personal interviews, in order to learn why they score so high on attitudes toward biological science. Also, the Biological Science Attitude Scale and an attitude scale which measures attitude toward the course could be administered to determine if preservice elementary

teachers might have different attitudes toward biological science than toward the biological science course. It is recommended that a group of individuals with negative attitudes and a group of individuals with positive attitudes toward biological science be administered the instrument to see if the groups' attitudes are reflected in their scores. Such groups could be identified through personal interviews. It is further recommended that a longer version of the instrument be constructed and compared with the present version on reliability and validity criteria. It may be that a longer version of the attitude scale would show a greater ability to discriminate between subjects with negative and subjects with positive attitudes.

3. An increase in attitudes toward biological science should be incorporated as one of the behavioral objectives of the Biological Science 202 course. The effect of directly teaching for an increase in positive attitudes could be studied using the Biological Science Attitude Scale. It is also suggested that objectives dealing with attitudes toward science in general, toward the course, and toward scientific attitudes be included in the course objectives and that the extent to which these objectives are achieved be measured by available instruments.

4. It is recommended that a study similar to the present one be replicated using random assignment of

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subjects to treatment categories. This design would control for possible confounding variables and would allow for a larger number of subjects in the control groups. It would also be of interest to study the effect of specific factors within the course such as oral quizzes, discussion sessions, specific laboratory exercises, and lectures. If subjects could be randomly assigned to each of these experimental treatments and appropriate control treatments, the effect these factors have on attitudes could be studied more specifically.

5. Further research needs to be done on the technique by which the Biological Science Attitude Scale was constructed. It was pointed out in the literature review that there have been other methods developed which are different from Thurstone's equal-appearing intervals technique. Research has also been reported which studied the effect of varying the Thurstone technique itself. More research needs to be done in this area. For example, it was suggested to the investigator that during the judging process the cards with the attitude statements printed on them be placed in numbered boxes with slits in the top rather than on numbered cards. Then the judges would not be aware of how many cards were placed in each category. If this procedure were used with the attitude statements on the Biological Science Attitude Scale, S and Q values could be used as criteria for comparing the two techniques.

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APPENDIX A

LIST OF ORIGINAL 100 ATTITUDE STATEMENTS WITH
S AND Q VALUES COMPUTED FROM JUDGMENTS
BY JUDGES FROM THE SCIENCE AND
MATHEMATICS TEACHING CENTER

1. Elementary school teachers should feel some responsibility to include biological science in their weekly lesson plans.
S = 9.7; Q = 2.6
2. The pursuit of biological science is one of the most worthwhile endeavors of mankind.
S = 10.6; Q = 1.8
3. There probably is a logical explanation for every observable phenomenon related to living things.
S = 9.0; Q = 3.5
4. Learning about amoebas is fascinating.
S = 8.4; Q = 2.7
5. Elementary school teachers should encourage their students to bring to school various kinds of living creatures such as snakes, frogs, and bugs, or caterpillars.
S = 9.3; Q = 2.7
6. Knowing the names of living things helps one understand them better.
S = 8.4; Q = 3.3
7. Using a microscope is enjoyable.
S = 7.9; Q = 2.1
8. Bird watching is an interesting hobby.
S = 7.2; Q = 1.9
9. Elementary school children should be encouraged to read about famous biologists.
S = 8.0; Q = 2.1
10. Dissecting preserved animal specimens is informative and interesting.
S = 9.1; Q = 2.2
11. A biologist is likely to be unbiased and objective in his own work and in other areas as well.
S = 8.3; Q = 2.9
12. Taking elementary school children on nature study field trips is well worth the effort.
S = 9.0; Q = 1.5

13. It would be a good idea if at least some lawmakers were biologists.'
- S = 7.4; Q = 2.7
14. Being able to classify plants and animals is a useful skill.
- S = 8.8; Q = 1.3
15. Studying about green plants causes people to appreciate them more.
- S = 8.6; Q = 2.4
16. A biologist would make an interesting and worthwhile guest speaker for an elementary school classroom.
- S = 8.6; Q = 2.1
17. An elementary education major should take at least one course in biological science.
- S = 8.9; Q = 1.7
18. The real contributions biological science has made to society are few and far between.
- S = 1.3; Q = 1.7
19. Studying about the history of biological science is about the most uninteresting thing I can think of.
- S = 1.8; Q = 4.3
20. Taking a college biology course is a waste of time.
- S = 1.3; Q = 1.3
21. There is no reason for teaching elementary school children about the problems of water and air pollution.
- S = 1.7; Q = 2.2
22. Anyone who accepts the theory of evolution is not very religious.
- S = 2.7; Q = 2.3
23. Keeping children's pets, such as mice, hamsters, or turtles, in the elementary classroom is just too much bother.
- S = 2.3; Q = 1.3
24. Biological science is definitely not for the average person.
- S = 3.7; Q = 3.5
25. More college students dislike biological science than like it.
- S = 4.3; Q = 2.5

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26. Elementary school children should be encouraged to prepare biology projects for a science fair.
S = 8.8; Q = 1.9
27. The thought of keeping a living garter snake in an elementary classroom is repulsive.
S = 3.3; Q = 3.2
28. About the most boring thing I can think of would be a field trip to a laboratory conducting biological research.
S = 1.9; Q = 2.3
29. A study of biological science contributes to one's common sense view of the world.
S = 8.9; Q = 1.8
30. A knowledge of biological science has little relevance to everyday living.
S = 1.7; Q = 2.6
31. Biology really shouldn't be classed as a science along with physics.
S = 2.4; Q = 3.4
32. Biologists don't care whether their discoveries are used for good or evil.
S = 2.1; Q = 2.3
33. Biological science is a difficult subject and can be pursued profitably only by those of better than average ability.
S = 3.6; Q = 3.2
34. The teaching of biological science should receive little emphasis until junior high school at the earliest.
S = 3.9; Q = 3.8
35. The thought of handling living animals such as mice, earthworms, bugs, or frogs is repulsive.
S = 2.4; Q = 1.9
36. Trying to "sprout" acorns, walnuts, chestnuts, or other seeds in an elementary classroom is a waste of time.
S = 1.4; Q = 1.7
37. I would like to be a biologist.
S = 10.6; Q = 1.4

38. The future destiny of man depends on how well he comprehends ecology.
S = 10.1; Q = 2.0
39. Biologists place too much emphasis on requiring theories to be supported by factual evidence.
S = 3.6; Q = 2.7
40. The journal, The American Biology Teacher, probably contains articles of interest to the elementary school teacher.
S = 7.8; Q = 1.9
41. Studying biological science increases one's own appreciation of their environment.
S = 9.4; Q = 1.6
42. I would like to learn more about biology.
S = 8.2; Q = 1.8
43. The thought of carrying out biological experiments is repugnant.
S = 1.3; Q = 1.8
44. Having elementary school children maintain an aquarium in the classroom would make an excellent teaching aid.
S = 9.9; Q = 1.4
45. Having elementary school children maintain a terrarium in the classroom is not worth the mess and time.
S = 2.1; Q = 2.0
46. A large number of the theories of biological science are just plain unacceptable.
S = 2.6; Q = 2.1
47. There is no useful purpose in having elementary school children collect pond "scum" and bring it to class in a jar.
S = 2.9; Q = 2.5
48. Biological science is not a suitable vocation for women.
S = 2.4; Q = 1.9
49. One's appreciation of a tree really isn't increased by knowing the tree is made up of cells and tissues.
S = 3.8; Q = 2.3

50. The study of biological science is intellectually stimulating.
S = 10.4; Q = 1.7
51. Everyone should have a fair amount of biological knowledge in order to understand their own bodily processes.
S = 8.7; Q = 1.9
52. Biologists worry too much about giving everything a big name.
S = 4.1; Q = 2.2
53. An elementary school teacher is certainly justified in spending a major portion of his/her budget on instructional materials related to biology.
S = 9.6; Q = 1.9
54. Observing biological specimens under the microscope is enjoyable.
S = 8.9; Q = 1.7
55. There is something wrong with anyone who would enjoy collecting insects.
S = 1.9; Q = 2.3
56. A lot of biological science can be taught by having children maintain an aquarium in the elementary classroom.
S = 9.3; Q = 1.9
57. Being able to study about green plants in the laboratory causes people to appreciate them more.
S = 8.7; Q = 1.7
58. Having children discover facts about animals by keeping pets in the classroom is well worth the effort.
S = 9.2; Q = 1.7
59. Trying to "sprout" acorns, walnuts, chestnuts, or other seeds in an elementary classroom would be fun for the teacher and students.
S = 8.7; Q = 1.3
60. Nature study makes a good hobby.
S = 8.8; Q = 1.1
61. A study of biological science contributes to one's common sense view of the world.
S = 8.6; Q = 1.6

62. The elementary school teacher should provide an opportunity for his students to discover some fundamental biological principles.
S = 9.0; Q = 1.7
63. Being able to classify living things is a useful skill.
S = 8.8; Q = 1.0
64. A teacher would find it well worth the effort to allow an experienced biologist to take their elementary classroom on a field trip.
S = 9.6; Q = 2.0
65. Certain facts about biological science must be taught directly, but students should be provided an opportunity to discover some basic biological concepts on their own.
S = 8.1; Q = 1.8
66. A student majoring in elementary education should take at least one course in biological science.
S = 8.4; Q = 1.6
67. Elementary school teachers could profit by reading the journal, The American Biology Teacher.
S = 8.4; Q = 1.5
68. It's just as reasonable for women to enter biological science as a vocation as it is for men.
S = 8.2; Q = 2.6
69. A biologist is likely to be unbiased and objective in his work.
S = 8.4; Q = 2.0
70. One's appreciation of a tree is increased by knowing the tree is made up of cells and tissues.
S = 8.3; Q = 2.2
71. Most students majoring in elementary education enjoy taking a course in biological science.
S = 8.2; Q = 4.4
72. If I weren't majoring in my present area I really wouldn't mind being a biologist.
S = 8.1; Q = 1.9
73. I wouldn't mind taking a course in the study of birds sometime.
S = 8.2; Q = 1.9

74. Carrying out biological experiments would be sort of fun if I had the time.
S = 7.7; Q = 1.2
75. Elementary school children should be encouraged to read about famous biologists such as Darwin.
S = 7.7; Q = 1.5
76. Biologists are usually nice people.
S = 7.0; Q = 1.8
77. Biological science isn't such a bad course to take in college.
S = 7.1; Q = 1.4
78. Biologists really aren't being mean to animals when they conduct experiments upon them.
S = 7.2; Q = 1.3
79. Biological science is really not too bad.
S = 7.1; Q = 1.6
80. Biologists are usually in good health.
S = 6.1; Q = 0.7
81. I have no strong interest in reading magazine articles about biological science.
S = 4.1; Q = 1.2
82. Biological science, as a subject, should receive little emphasis in school before the 7th or 8th grade.
S = 2.7; Q = 2.4
83. Having elementary school children maintain a terrarium in the classroom is not worth the mess and time even if it could serve as a teaching aid.
S = 2.6; Q = 1.9
84. A required course in biological science for preservice elementary school teachers probably won't do them any good.
S = 2.4; Q = 2.0
85. Learning more about biological science is not going to have too much of an effect on me.
S = 4.0; Q = 2.2
86. It probably wouldn't make much difference if some legislators were biologists or not.
S = 4.3; Q = 2.5

87. A biologist's laboratory is usually clean.
S = 7.0; Q = 2.4
88. The future destiny of man depends on how well he
comprehends the biology of nature.
S = 10.8; Q = 0.7
89. Biologists are usually nice to animals.
S = 6.5; Q = 2.3
90. Biologists don't seem any different than anyone
else I know.
S = 6.5; Q = 2.5
91. A required course in biological science for prospec-
tive elementary school teachers probably won't do
them any good or harm.
S = 6.0; Q = 2.7
92. I'm not too convinced of the need for biological
science in the elementary school curriculum.
S = 1.9; Q = 2.8
93. Biological science is as much for the average person
as it is for the real intelligent person.
S = 8.0; Q = 2.5
94. Observing microscopic living things under the
microscope is fun.
S = 8.9; Q = 1.4
95. Learning by discovery doesn't apply to biological
science courses.
S = 2.2; Q = 3.1
96. I believe reading about biological science has
value, but I seldom do so.
S = 6.0; Q = 2.3
97. Most elementary education majors don't feel too
happy about being required to take a course in
biological science.
S = 4.1; Q = 2.1
98. Studying about the history of biological science is
very interesting.
S = 9.6; Q = 2.2

99. The study of biological science really won't hurt
anyone.

S = 6.6; Q = 2.1

100. Biologists like to drive nice automobiles.

S = 6.0; Q = 0.6

APPENDIX B

THE BIOLOGICAL SCIENCE ATTITUDE SCALE

AS ADMINISTERED TO THE BIOLOGICAL

SCIENCE 202 STUDENTS WINTER

AND SPRING TERMS, 1970

Instructions

Do not place your name on the answer sheet. I am interested only in your honest reaction to the following statements. Your responses will in no way be used to determine your grade in this course. I do need your student number for statistical purposes, so please fill in the spaces indicated for student number on the answer sheet. Your name will remain anonymous.

Read each statement carefully. If you agree with the statement mark true on the answer sheet. If you disagree with the statement mark false on the answer sheet. Please respond to all statements.

1. The future destiny of man depends on how well he comprehends the biology of nature.
2. A biologist's laboratory is usually clean.
3. Biologists are usually nice to animals.
4. Allowing children to keep pets such as mice, hamsters, or turtles in the elementary classroom is just too much bother.
5. The pursuit of biological science is one of the most worthwhile endeavors of mankind.
6. The contributions biological science has made to society are few and far between.
7. More college students dislike biological science than like it.
8. Learning about amoebas is fascinating.
9. There is no useful purpose in having elementary school children collect pond "scum" and bring it to class in a jar even if it were interesting to them.
10. Dissecting animal specimens is informative and interesting.
- *11. Biologists don't seem any different than anyone else I know.
- *12. A required course in biological science for prospective elementary school teachers probably won't do them any good or harm.

13. The thought of carrying out biological experiments is repugnant.
14. I'm not too convinced of the need for biological science in the elementary school curriculum.
15. Elementary school teachers should encourage their students to bring various kinds of living things, such as snakes, frogs, bugs, or caterpillars, to school for study.
16. Knowing the names of living things helps one understand them better.
- *17. Biological science is as much for the average person as it is for the real intelligent person.
18. There is something wrong with anyone who would enjoy collecting insects.
19. Observing microscopic living things under the microscope is fun.
20. I would like to learn more about biological science.
21. Having elementary school children maintain a terrarium in the classroom might serve as a teaching aid but is not worth the mess and time required.
22. Everyone should have a knowledge of biological science in order to understand his own bodily processes.
23. Elementary school children should be encouraged to prepare biology projects for a science fair.
24. Taking a college course in biological science is a waste of time.
- *25. Learning by discovery doesn't apply to biological science courses.
26. The thought of keeping a living garter snake in an elementary classroom is repulsive.
27. The study of biological science is intellectually stimulating.
28. About the most boring thing I can think of would be a field trip to a laboratory conducting biological research.

29. It probably wouldn't make a difference whether or not some legislators were biologists.
30. I believe reading about biological science has value, but I seldom do so.
31. Most elementary education majors don't feel too happy about being required to take a course in biological science.
- *32. Studying about the history of biological science is very interesting.

*Those statements marked with an asterisk were omitted from the final calculation of students' attitude scores as explained in the text of Chapter IV.

APPENDIX C

THE BIOLOGICAL SCIENCE ATTITUDE SCALE

AS ADMINISTERED TO THE

MATHEMATICS 201 STUDENTS

DURING SPRING TERM, 1970

Directions

Please, do not put your name on the answer sheet. I am interested only in your honest reaction to the following statements. Your response will in no way be used to determine your grade in this or any course. I do need your student number for statistical purposes. Your name will remain anonymous. Fill in the spaces on the answer sheet which correspond to your student number. Be sure to use an electrographic pencil.

PART A

Please, read the following questions and then do as directed.

- I. Are you now taking or have you ever taken Biological Science 202 at Michigan State University?

_____ Yes -- Stop here. Do not answer any further questions!

Hand in this questionnaire and answer sheet when requested by your instructor.

_____ No -- Go to part II.

- II. To the best of your knowledge, will you be taking Biological Science 202 during Fall term, 1970, at Michigan State University?
(Or summer term, 1970)

_____ Yes -- Go to PART B.

_____ No -- Stop here. Do not answer any further questions!

Hand in this questionnaire and answer sheet when requested by your instructor.

PART B

Answer all of the following according to your agreement or disagreement with each statement. Place your responses on the answer sheet using an electrographic pencil.

1. The future destiny of man depends on how well he comprehends the biology of nature.
2. A biologist's laboratory is usually clean.
3. Biologists are usually nice to animals.
4. Allowing children to keep pets such as mice, hamsters, or turtles in the elementary classroom is just too much bother.
5. The pursuit of biological science is one of the most worthwhile endeavors of mankind.
6. The contributions biological science has made to society are few and far between.
7. More college students dislike biological science than like it.
8. Learning about amoebas is fascinating.
9. There is no useful purpose in having elementary school children collect pond "scum" and bring it to class in a jar even if it were interesting to them.
10. Dissecting animal specimens is informative and interesting.
11. Biologists don't seem any different than anyone else I know.
12. A required course in biological science for prospective elementary school teachers probably won't do them any good or harm.
13. The thought of carrying out biological experiments is repugnant.
14. I'm not too convinced of the need for biological science in the elementary school curriculum.
15. Elementary school teachers should encourage their students to bring various kinds of living things, such as snakes, frogs, bugs, or caterpillars, to school for study.

16. Knowing the names of living things helps one understand them better.
17. Biological science is as much for the average person as it is for the real intelligent person.
18. There is something wrong with anyone who would enjoy collecting insects.
19. Observing microscopic living things under the microscope is fun.
20. I would like to learn more about biological science.
21. Having elementary school children maintain a terrarium in the classroom might serve as a teaching aid but is not worth the mess and time required.
22. Everyone should have a knowledge of biological science in order to understand his own bodily processes.
23. Elementary school children should be encouraged to prepare biology projects for a science fair.
24. Taking a college course in biological science is a waste of time.
25. Learning by discovery doesn't apply to biological science courses.
26. The thought of keeping a living garter snake in an elementary classroom is repulsive.
27. The study of biological science is intellectually stimulating.
28. About the most boring thing I can think of would be a field trip to a laboratory conducting biological research.
29. It probably wouldn't make a difference whether or not some legislators were biologists.
30. I believe reading about biological science has value, but I seldom do so.
31. Most elementary education majors don't feel too happy about being required to take a course in biological science.

32. Studying about the history of biological science is very interesting.

APPENDIX D

RAW SCORES FOR PRETEST AND POSTTEST
FOR ALL EXPERIMENTAL AND CONTROL
GROUPS DURING WINTER AND
SPRING TERMS

TABLE 11

RAW SCORES* FOR PRETEST AND POSTTEST OF THE
WINTER TERM EXPERIMENTAL GROUP ON THE
BIOLOGICAL SCIENCE ATTITUDE SCALE

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
7.3312	8.6400	8.3818	7.0000	7.8312	8.6400
8.4556	8.6400	7.9118	8.2937	9.1273	9.1231
8.6286	8.3500	6.8636	7.1333	8.9900	8.6769
8.3500	8.3077	7.6900	7.6636	8.3923	8.8077
7.0769	8.3000	7.1833	8.6100	8.0385	8.4714
9.3909	8.3857	7.5875	7.8562	8.2937	9.1583
7.8933	7.2545	6.9400	7.5545	7.5455	7.5100
7.2214	7.5308	8.4462	8.1154	8.2385	8.3500
8.3600	7.9294	8.6000	8.5750	9.4333	9.4333
6.3000	6.3091	8.4923	8.4091	8.8286	8.1000
8.3923	9.1250	8.4833	6.3889	5.6154	6.5692
8.5857	7.4071	9.2636	8.4077	8.2750	8.3857
6.6583	7.7727	8.3071	8.2600	8.8917	9.4857
6.1059	6.3000	9.1692	8.4357	8.3800	8.5143
8.8286	8.5000	7.7429	7.9286	8.3923	8.9417
7.9933	7.8786	8.3857	8.6636	7.6300	5.6750
8.8846	9.2462	8.2000	8.3500	8.9231	9.3833
8.2000	9.3917	6.6714	6.8286	9.0222	7.9385
9.1700	8.6500	7.3167	7.5833	8.0417	8.1250
9.6300	8.4923	8.0429	7.5200	8.2062	8.4214
9.4800	9.4909	8.7000	6.0538	7.7417	7.4933
8.7929	8.6143	8.0375	8.3385	7.6867	8.1750
7.6000	5.0412	8.6286	8.6400	7.9455	7.4643
9.3909	8.4462	8.1500	8.2937	9.2077	8.5692
8.4267	8.8800	7.9500	8.3417	6.7533	8.5750
9.6700	5.3687	9.3182	8.6400	8.9889	8.7000
7.8500	7.2500	8.9091	7.1385	8.4571	8.2937
8.1467	8.6400	8.0062	8.4308	9.5182	8.5067
8.9455	8.6286	8.8000	9.8000	8.6400	8.7571
8.3800	8.1250	9.1000	8.6692	5.9786	7.4091

TABLE 11 (continued)

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
8.3923	8.6929	7.8667	7.9500	9.6000	8.9636
8.2500	6.9000	8.9154	8.1500	8.6929	8.7143
8.4923	9.1385	7.1636	7.7417	7.5091	6.5875
7.8636	9.4100	7.8143	7.7667	8.4500	8.2571
8.8455	8.8000	8.3000	9.0636	7.3250	8.1846
8.1143	8.5357	7.9182	7.7571	8.9000	6.5462
9.9143	9.0143	9.0417	8.1687	8.7667	8.3071
7.2077	8.4833	7.8562	8.6286	7.8214	8.5615
8.2937	8.1600	8.4769	9.5545	8.6692	8.7833
7.9133	7.2133	8.1538	8.2600	9.1273	9.7000
8.2692	8.1143	8.4583	8.5143	8.9667	9.1231
8.7308	8.8308	8.2583	8.2600	8.0364	7.6923
7.8213	7.1714	8.7818	8.2125	8.9455	8.0556
8.4500	8.7077	7.7500	8.9692	7.3000	8.7714
7.2500	8.2125	9.3417	9.1000	7.5100	8.6500
8.2600	8.2600	9.2417	8.8500	6.2813	7.2917
7.8300	7.8833	9.9250	8.5286	7.9154	7.0933
5.8300	6.8111	8.9500	8.6400	9.0143	9.4333
5.8067	4.6500	8.2200	8.6400	8.7300	7.6500
8.9833	9.1692	8.8286	8.4467	7.7062	7.5929
7.2222	7.5500	7.7625	8.2125	7.5187	8.5071
6.3889	6.8600	7.4000	7.0929	7.8786	7.9091
8.5000	8.9750	9.6300	9.2636	7.2167	8.1600
7.6733	8.4923	8.6615	8.4615	7.6333	5.7000
8.9500	8.9308	8.6200	8.2937	9.4455	8.9800
7.7167	8.8077	7.7235	7.8357	8.1133	7.9000
9.3833	8.3267	8.2600	7.6733	9.2545	8.0769
8.0714	8.0500	8.4267	8.2600	7.9867	8.0938
8.3600	9.1692	8.8286	9.0143	8.9143	8.2333
9.1500	8.7538	8.9231	8.1909	7.9333	8.1214
8.4923	8.7833	8.4400	9.4333	8.0000	9.0000
7.5214	8.2600	7.5400	8.1786	8.7692	8.7583
8.4133	8.5143	7.1687	6.8077	9.9100	9.3400

TABLE 11 (continued)

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
9.0308	9.2000	8.3917	7.6923	8.5143	9.0417
7.8556	8.2917	8.8846	8.7920	8.6268	8.3833
7.9750	9.2077				

*Computed on the 3600 Computer, Michigan State University.

TABLE 12
RAW SCORES FOR PRETEST AND POSTTEST OF THE
WINTER TERM CONTROL GROUP ON THE
BIOLOGICAL SCIENCE ATTITUDE SCALE

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
9.2000	8.8462	7.4143	8.4923	7.6875	7.3056
8.3400	8.2937	8.3690	8.6400	9.4750	9.2462
9.1700	8.7571	8.4200	9.3333	8.6083	8.0643
8.5846	8.8000	7.8786	8.4833	8.0154	8.4400
7.2687	8.7667	8.7929	8.2937	8.4500	7.5500
8.5143	8.2600	7.2400	7.7200	8.6667	7.8308
5.9200	6.0583	9.1091	8.7167	9.1091	9.0143
7.1500	8.2556	9.4750	8.5071	8.3250	8.2600
6.8444	7.8500	4.9182	6.4786	8.1154	7.0333
7.7167	8.3583	8.0692	8.1333		

TABLE 13

RAW SCORES FOR PRETEST AND POSTTEST OF THE
 SPRING TERM EXPERIMENTAL GROUP ON THE
 BIOLOGICAL SCIENCE ATTITUDE SCALE

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
9.1231	9.3833	8.1889	5.7824	7.5077	7.7267
9.7900	8.7077	8.1846	8.4091	8.3800	8.3800
7.2312	7.3667	8.7846	8.1833	8.5429	8.1533
8.0818	8.4000	8.6000	8.4857	6.9688	5.6455
5.5364	8.5364	8.6400	8.1143	4.1333	7.1000
7.6600	7.2100	6.8786	6.1267	9.4100	8.3071
7.7462	6.8182	8.7929	8.7867	8.7538	8.5000
8.0857	7.2800	8.4500	8.0267	8.4571	8.9500
8.5400	8.8000	8.6286	8.6400	7.9357	7.4077
9.0000	9.0333	8.3400	8.8500	6.7917	5.1214
8.1267	7.8250	8.2417	8.3071	9.0308	9.0308
8.8462	9.1692	8.5071	8.2714	8.1273	8.4462
8.8455	9.0818	7.3714	7.0231	7.7385	8.1143
8.3786	9.1900	8.3071	8.5750	8.5286	8.2917
3.8083	5.3071	8.4364	8.4133	8.4308	8.9417
8.7929	8.7462	8.2385	8.1917	8.7143	8.9692
8.1250	8.5769	8.5571	8.2937	8.1875	8.1250
7.9688	8.0000	8.6143	8.9308	7.6412	8.0800
8.4467	8.4467	8.0400	8.1538	8.0923	7.4000
7.6933	8.0071	8.9692	8.9308	7.8857	7.6308
8.2375	7.0067	9.6000	9.2833	9.1750	8.9077
8.2571	8.8182	8.9077	9.1750	8.9750	8.9154
7.7500	6.5000	8.1571	8.0455	8.2062	8.3231
8.2937	7.9500	8.1353	5.6647	7.2294	7.6000
9.0364	8.5308	8.1353	5.8842	8.3200	8.2786
9.1167	9.3500	7.8000	8.0154	7.8588	8.1500
7.8786	7.8562	9.4909	9.4909	8.5231	8.5857
8.6769	8.1750	7.9333	8.6400	6.6000	7.9917
7.2909	6.7417	7.7750	8.2600	9.0818	8.3500
9.0143	8.6400	8.9083	8.4923	8.0429	8.6357

TABLE 13 (continued)

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
8.5500	8.2300	7.1571	8.6071	7.1923	6.9000
8.1353	6.6571	7.7000	8.0846	8.3583	8.8167
9.0143	9.0308	7.1000	8.3500	8.4700	8.2286
9.1300	8.6077	9.0143	9.0143	7.1286	8.0200
7.0364	8.8000	8.8077	8.5143	8.4077	8.4000
6.6357	7.8000	8.3417	8.5667	8.2462	8.2727
9.3455	7.8933	8.5286	8.9143	8.4467	8.5214
8.3533	9.0308	8.8615	8.7714	8.4083	8.9083
8.2800	7.8222	9.1385	8.8071	9.0143	9.0143
7.6357	7.9364	8.2909	8.5364	8.7923	8.2600
6.6818	7.3917	7.6133	9.2077	8.566	8.3733
7.8692	7.3385	7.8562	7.9538	8.4467	9.3917
6.0625	7.7625	8.6429	9.2462	8.7923	8.4923
9.1231	9.1231	8.4917	9.3600	9.2462	9.2462
7.2100	6.2778	7.2000	6.3692	8.3857	9.3917
8.2533	8.6200	8.9167	8.5769	8.2125	8.2937
8.7769	8.2937	9.2077	8.7357	9.2462	9.2462

Pret

4.2

8.5

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8.4

TABLE 14
 RAW SCORES FOR PRETEST AND POSTTEST OF THE
 SPRING TERM CONTROL GROUP ON THE
 BIOLOGICAL SCIENCE ATTITUDE SCALE

Pretest	Posttest	Pretest	Posttest	Pretest	Posttest
4.2786	4.4222	9.2462	8.3400	8.5143	8.3429
8.5500	7.1000	7.5200	6.7778	7.7867	7.7867
7.7533	7.0357	8.5846	8.1214	8.5143	8.0867
9.3917	8.4857	7.8667	8.1833	8.3071	8.3071
8.2937	8.5500	8.3400	7.9312		
8.4700	8.7571	8.1267	8.4615		

APPENDIX E

OBJECTIVES FOR THE WEEKLY UNITS 1-9
IN THE BIOLOGICAL SCIENCE 202 COURSE

310

A.C.

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK ONE

At the conclusion of the week you should be able to:

1. Support or refute the statement "scientific endeavor is restricted to the laboratory" and list several aspects of scientific methodology brought out in the "black box" experience.
2. Point out the various parts of the compound microscope--giving the functions of the parts.
3. Prepare a wet mount of organisms provided and measure the organism using your microscope.
4. Measure the length, weight, volume and temperature of objects using the metric and Celsius scales and relate these measurements English and Fahrenheit scales.
5. Define the term biosphere using the words atmosphere, hydrosphere and lithosphere.
6. Trace the path of energy flow through the biosphere and give examples of the cycling of matter within the biosphere.
7. Outline the concept of "levels of biological organization" from atom to Biosphere.
8. Point out the basic attributes of life as exhibited by Physarum polycephalum.
9. Relate living and non-living objects as to their longevity.
10. Define taxonomy and compare artificial and natural classification systems.
11. List the seven major categories used by taxonomists in classifying organisms and define the category species.
12. Identify amoeba, paramecium, euglena and describe their movement.
13. Compare the general body plan and complexity of the Porifera, Protozoa, and Coelenterata.

14. Prepare a hydra for microscopic observation--point out the mouth, tentacles, body and asexual bud (if present).
15. Compare the general body plan and complexity of the flatworms and roundworms and relate them to the previous phyla.
16. Given an unknown lower form organism, be able to classify it into its proper phylum on the basis of its structure.

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BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK TWO

At the conclusion of the weeks study you should be able to:

A. Taxonomy

1. State the basic body plan of mollusks and classify unknown mollusks as bivalve, univalve, or atypical.
2. Point out the following organs of a fresh water clam: adductor muscles, foot, mantle, visceral mass, gills, excurrent and incurrent siphons.
3. Point out the major characteristics of annelids, and compare Nereis and the earthworm as to similarities and differences.
4. Identify the external anatomical structures of the earthworm and describe its locomotion.
5. List the distinguishing characteristics of echinoderms.
6. Identify on sight an organism as being a mollusk, annelid, or echinoderm and specify the habitat(s) of each phylum - land, fresh water or marine.

B. Cells

7. List several postulates of the cell theory and compare it as a theory with the atomic molecular theory.
8. Prepare cells of onion for microscopic observations and point out the visible structures.
9. Contrast "the cell" as seen with the light microscope and with the electron microscope.
10. State the function of the organelles seen with an electron microscope.
11. Differentiate between plant and animal cells and compare the structure of cells from unicellular and multicellular organisms.
12. Prepare a paramecium for microscopic observation and give the function of the cilia, oral groove, food vacuole and contractile vacuole.

C. Physical Aspects of Life

13. State the primary physical phenomenon underlying Brownian movement, diffusion and osmosis and illustrate the importance of these processes.
14. Define a semipermeable membrane and predict the equilibrium condition of a bag filled with a known, osmotically active solution resting in a dish of another known, osmotically active solution.
15. Contrast active transport and passive transport.

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BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK THREE

At the end of the study you should be able to:

A. Taxonomy

1. Give the basic body plan of arthropods and their distinguishing characteristics.
2. Specify the modifications of the arthropod body plan and other special features exhibited by each of the five classes studied.
3. Place each of the representative organisms studied in its class and give its common name.
4. Identify the major habitat(s) -- land, fresh water, or marine -- of each class of arthropods.

B. Plant Structure

5. Describe the four basic tissues of plants giving examples of each.
6. List and give the functions of the four organs of flowering plants.
7. Prepare an epidermal peel and relate the external and internal structure of a leaf to its function.
8. Prepare a wet mount of a stem cross section and compare the structure of the monocot, herbaceous dicot and woody dicot stems.
9. Trace the path of water and minerals from the soil to the chloroplast and explain the effects of the environment on transpiration.
10. Explain how a plant grows in height and diameter identifying the tissues responsible for their growth.

C. Photosynthesis

11. Present the problems, hypotheses, experiments and conclusions of investigation of photosynthesis from Van Helmont to Blackman.

12. Support with experimental evidence the hypotheses that light, CO_2 and chlorophyll are necessary for photosynthesis.
13. Using the diagram on page 16 describe the role of chlorophyll, TPNH_2 , and H_2O in the Light Reaction of photosynthesis.
14. With the diagram describe the events of the Dark Reaction.
15. Give the source in the biosphere of the carbon, hydrogen and oxygen that make up the sugar molecules produced in photosynthesis.

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK FOUR

A. Taxonomy

1. Discuss the diagnostic characteristics of the phylum chordata using as examples both invertebrate and vertebrate chordates.
2. Contrast the three major groups of fishes giving examples of each group.
3. Compare amphibians and reptiles, and relate their characteristics to their requirements for water.
4. Contrast birds with fishes, amphibians, and reptiles; and specify adaptations for flight seen in birds.

B. Anatomy of Heterotrophs

5. Present the general pattern of animal nutrition by interrelating the digestive, circulatory, excretory, and gas exchange systems.
6. Point out on the pig, the external features of the male or female fetal pig using the accepted directional terms.
7. Point out on the pig, the organs of the thorax, abdomen and head as identified in figures 4, 5 and 6 in the study guide.
8. Trace the path of food from mouth to anus through the digestive tract using the human torso model.
9. Trace the path of air through the respiratory system using the human torso model.
10. Using the plastic models trace the flow of blood through the heart and lung from the vena cava to the aorta.
11. Relate the general pattern of systemic circulation pointing out on the pig the veins and arteries shown in figures 8 and 9.

12. Draw the organs of the female and male reproductive system of the pig (figures 10 and 12) and explain their functioning.

*Don't forget the assigned reading - p - 111 to 120
129 to 134
148 to 162
168 to 172

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK FIVE

You should be able to:

A. Taxonomy

1. List the diagnostic characteristics of mammals and point out relevant examples.
2. Distinguish the three major groups of mammals giving examples of each group.
3. Use a key to identify to order level unknown mammals.
4. Identify on sight common mammals by common name.

B. Respiration

5. Discuss the demonstration of anaerobic respiration; Include organisms, products, commercial uses and equation.
6. With one sentence each, specify the events during glycolysis, krebs citric acid cycle and terminal hydrogen transport, and tell where they occur in a cell.
7. List and compare raw materials and products of anaerobic and aerobic respiration in human cells.
8. Discuss the "thermos bottle" experiment including an interpretation of the graphs and the significance of the heat given off.
9. Compare photosynthesis and respiration as to utilization of O_2 , CO_2 , sugar, water and energy.

C. Control

10. List and give examples of control mechanisms at the cellular, organismal, and ecosystem levels.
11. Define "enzyme" and relate the importance of its 3 dimensional structure.
12. Describe the reaction of starch and diastase and recognize positive and negative tests for starch.

13. Present experimental evidence and your conclusions concerning the effects of temperature and pH on enzyme activity.
14. Draw a nerve cell; give the parts and direction of nerve impulse through the neuron.
15. Explain the reflex arc including the path of an impulse from receptor to effector and experimental evidence for the arc.
16. Using the models and specimens provided discuss the functioning of the eye and ear.
17. Point out on a model or specimen the three major parts of the brain and give their functions.

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK SIX

You should be able to:

A. Taxonomy

1. Compare the "two kingdom" classification system with the "four kingdom" system and present the merits of each. (Know the kingdom names.)
2. Recognize and describe examples of both autotrophic and heterotrophic phyla of monerans.
3. Present a method for starting and maintaining a culture of bacteria with sterile technique.
4. Give your conclusions from the data collected concerning the effectiveness of various antibiotics and antiseptics.
5. Recognize and describe several members of the phylum Mycophyta and define mutualism giving a specific example.

B. Cellular and Molecular Reproduction

6. Draw a representation of the life cycle of all sexually reproducing organisms and show the condition of the nucleus (haploid, diploid) during the cycle.
7. Compare sexual and asexual reproduction giving examples of each and relate them to the life cycle chart.
8. Describe the events that occur during interphase, prophase, metaphase, anaphase, and telophase of mitosis.
9. Identify the 5 phases of mitosis in the onion root tip or white fish blastula.
10. Explain the events occurring during replication of the DNA molecule.
11. Give the role of DNA, m-RNA, t-RNA and ribosomes in protein synthesis.

12. Explain how your hereditary make-up is determined by your proteins and how your proteins are determined by your DNA.

C. Organismal Reproduction and Development - Plants

13. Dissect a flower and identify the following parts: pedicel, receptacle, sepals, petals, stamen, filament, anther, pistil, ovary, style, stigma.
14. Relate the generalized life cycle chart to flowering plants and the slides of male and female gametogenesis in Lily.
15. Point out the parts of corn or bean seeds and give the destiny of each part.
16. Draw a typical growth curve and explain the three phases of the curve.
17. Describe the experiments which demonstrate the effect and origin of the plant hormone auxin.
18. Demonstrate the phototropic response and present evidence that auxin mediates this response.
19. Describe and explain the mechanism of thigmotropism.

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK SEVEN

You should be able to:

A. Taxonomy

1. Give the characteristics of algae and differentiate the four major groups giving examples of each.
2. Show how the mosses and ferns fit into the generalized life cycle of sexually reproducing organisms.
3. Define "tracheophyte" and distinguish the three major groups of tracheophytes.
4. Identify common gymnosperms of Michigan by common name.

B. Reproduction and Development of Animals

5. Present the procedure for obtaining fertile frog eggs; describe the unfertilized frog egg and the events that occur on fertilization.
6. Describe and compare the events of cleavage in eggs of invertebrates, amphibians, avians, and mammals.
7. Describe the process of gastrulation in frogs, name the 3 germ layers and describe the development of the dorsal nerve cord in vertebrates.
8. Relate the 3 germ layers to the systems into which they develop.
9. Describe a hen egg and tell how it is produced and fertilized in the reproductive tract of a hen.
10. Describe the 33 hour chick embryo and compare it to the primitive streak stage.
11. Describe the 72 hour chick embryo and compare it to the 33 hour stage.
12. Present evidence for environmental effects on development of a zygote.
13. Describe fertilization and the development of the human embryo and fetus.

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK EIGHT

You should be able to:

A. Taxonomy

1. Present five differences between dicots and monocots giving examples of each group.
2. Recognize adaptations of flowers and fruit for various types of pollination and seed dispersal.
3. Compare the flower and fruit structure of four different plants.
4. Describe the pollination and fruit production of corn.

B. Ecology

5. Define population, community, ecosystem and biosphere.
6. Define ecology giving examples of the types of studies made by ecologists.
7. Recognize and point out maple and beech trees and leaves.
8. Demonstrate the procedure for using the soil test kit, maximum-minimum thermometer, light meter, and hygrometer and describe how they are used by ecologists.
9. Define and develop the concept of habitat, niche and microclimate.
10. Define and give examples of food chains, food webs, and trophic levels.
11. Describe the pyramid of numbers and biomass.
12. Given the diagram from the study guide, discuss the efficiency of energy flow through an ecosystem.
13. Trace the cycling of carbon and nitrogen in the biosphere.
14. Relate nitrogen and phosphorus to water pollution.

15. Describe the effects of temperature, light periodicity, rainfall, and elevation on biogeography.
16. Characterize the major biomes of the United States.
17. Define succession and give three examples.

BIOLOGICAL SCIENCE 202

OBJECTIVES FOR WEEK NINE

You should be able to:

1. Define taxonomy and compare artificial and natural classification systems.
2. List the seven major categories used by taxonomists in classifying organisms and define the category "species."
3. Compare the two Kingdom and four Kingdom approaches to biological classifications.
4. Use a dichotomous key for classifying objects.
5. Point out on given organisms the characteristics that are useful in classification and specify which group it belongs with.
6. Draw and compare a growth curve for yeast in a closed system over a short time period and a growth rate curve for the yeast.
7. Define and show the relationships between biotic potential, environmental resistance, and carrying capacity.
8. Differentiate and discuss the non-density dependent and density dependent effects on population growth.
9. Discuss the relationship of the snowhare and lynx and relate it to population growth.
10. Relate the results of over production in rat populations.
11. Present data and a curve which represents the growth of the human population.
12. Present the present situation and predictions concerning human population. What is your reaction to the data and predictions presented.
13. Discuss the path of pesticides and radiation in ecosystems.

14. Recalling the water cycle (week one) present the problem of water pollution listing the seven major types of pollutants and relating them to eutrophication and the oxygen content of water.
15. List six types of air pollution, its three major sources and possible solutions by government, industry and individuals.
16. Discuss the statement: The basis of all the pollution problems is the population increase; we must give it the highest priority.
17. List five things you will do to retard the deterioration of the environment.
18. Outline the course presenting the major points and the conceptual scheme that bound them together.

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