AN ANALYSIS OF THE PATTERNS OF ACADEMIC PREPARATION OF HIGH SCHOOL BIOLOGY TEACHERS IN RELATION TO THEIR ATTITUDES TOWARD THE BSCS BIOLOGY PROGRAM

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PREFACE

The primary objective of this study was to analyze the undergraduate and graduate patterns of academic preparation of high school biology teachers in relation to their attitudes toward the BSCS Biology Program. The data used in the investigation were collected in connection with the Science Teachers' Characteristics Study which was financed, in part, by the Oklahoma State University Research Foundation.

I wish to thank Dr. James K. St.Clair, Head of the Education Department and Dr. L. Herbert Bruneau of the Zoology Department for their assistance by serving on my thesis advisory committee. I especially wish to thank Dr. Kenneth E. Wiggins, Director of Student Teaching and chairman of my thesis advisory committee, and Dr. Jacob W. Blankenship of the Education Department for their helpful advice and continued encouragement throughout the execution of this study.

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CHAPTER I

INTRODUCTION

One of the most distinguishing characteristics of our modern society is that it is scientifically oriented. Science and technology are becoming more important in the consideration of problems basic to our social, economic, and political welfare. As participants in the decision making process concerning our society, it, then becomes imperative that our citizens become scientifically literate. However, the accomplishment of a scientifically educated citizenry has become increasingly complex.

Within the past quarter of a century the accumulation of scientific knowledge has been phenomenal and the rate at which new knowledge is being added is increasing daily. This explosive growth of science knowledge has made it necessary for science educators to search for new ways of imparting this knowledge to youth. It has become apparent that a coverage of the "facts" is impossible and that factual knowledge alone is not sufficient for an understanding of the nature of science.

To provide new methods of educating youth in the sciences, several national curriculum groups have developed new curricular materials for use in the secondary schools. The objectives of these groups have been to produce curricular materials that reflect the nature of modern science and to produce science activities that will enable youth to

develop skills that will allow them to continue to learn and understand science after they have left the high schools.

Inherent in the new science curricular materials are certain new teaching techniques that are necessary if the materials are to be used successfully. These new teaching techniques are, in some instances, quite different from the techniques that many science teachers have used heretofore. Also, early experience by the national curriculum groups revealed that many high school science teachers were not familiar with much of the subject matter contained in the new curricular materials. Relating to the BSCS Biology Program, Cox (7), reports that most beginning high school biology teachers are not familiar with the up-to-date biological information included in BSCS Biology. Recognizing that the teacher is the key factor in the success of the new science materials, the national curriculum groups have suggested special training programs for the preparation of the science teachers in both the new teaching techniques and the subject matter contained in the curricular materials.

While the national curriculum groups, who developed the new high school science curricula, have been concerned with improving the subject matter backgrounds of in-service teachers, other national groups have been occupied with the problem of the academic preparation of pre-service science teachers. With the high school science curricula as a frame of reference, these groups have proposed general subject matter areas in the science and mathematics that should be included in science teachers' training, i.e., certain subject matter areas have been suggested for biology teachers and other subject matter areas for chemistry teachers. While there is no doubt that these

suggestions have been of assistance to directors of specific science teacher preparation programs in designing their programs, the nature of the suggestions has left unanswered certain questions, i.e., what courses (from the many available), in which areas of science and science related areas should teachers take that will better prepare them to use the new science curricular materials? Also, questions, concerning what is to be taught in specific courses and how the content should be taught, remain unanswered.

Although several guidelines for science teacher preparation programs are available, the fact that several questions remain unanswered concerning the academic preparation of science teachers would suggest further study in this area. A specific area that would appear to be of value is a study of the academic patterns of training of science teachers with regard to their attitudes toward the new science curricular materials. Since a favorable attitude would be conducive to effective use of the materials, it would seem of value in the designing of patterns of training for both in-service and pre-service science teachers to know if there are patterns of academic preparation that are characteristic of those science teachers who demonstrate more favorable attitudes toward the new science curricular materials. For example, have biology teachers, who demonstrate a more favorable attitude toward BSCS Biology, had characteristic patterns of training in the biological and physical sciences, and mathematics? If such characteristic patterns exist, they could be used as models in selecting specific courses to be included in the preparation programs of science teachers. Therefore, it seems appropriate at this time to conduct a

study to analyze the patterns of academic preparation of high school science teachers in relation to their attitudes toward the new science curricular materials.

Need for the Study

In the publication, The Education of Teachers: Conflict and Consensus, one of the participants in a conference is reported to have said that the school's prime function is:

> . . . to provide a setting within which boys and girls can grow intellectually. This can only be accomplished through the learner's association with information, knowledge, and facts. Books can help. So can laboratories. So can numerous other types of learning materials. But always there stands the teacher, always on the stage, often front and center. What he knows can make a difference. What he does not know can be an irreparable loss. (11)

If we believe that what the teacher knows makes a difference, then the excellence of the academic programs in science teacher education must be of major concern. The fact that the academic preparation of science teachers is of concern is evidenced by attempts of various individuals and groups to devise programs that will adequately train teachers to teach high school science. However, there is little information available to indicate that the use of any of these programs have been appropriate for training high school science teachers to teach modern high school science. What constitutes an adequate academic preparation program for science teachers remains an unanswered question for science educators who are responsible for training high school science teachers.

Within this decade there have been several nationwide efforts to improve the academic preparation of in-service science teachers. The National Science Foundation has sponsored many in-service programs,

summer institutes, and academic year institutes for this purpose. There is little doubt that these programs have improved the science backgrounds of high school science teachers. However, there is evidence that some of the earlier NSF sponsored programs were not oriented toward the training of teachers to teach science as inquiry and as a way of thought; and these teaching methods are major objectives of the several new high school science curricula. Gruber (31), in a study, found that participants gained a significant amount of scientific knowledge as the result of their experiences in NSF Academic Year Institutes but very few of the participants indicated a "strong" interest in teaching science as a way of thought and as inquiry. He suggested that the orientation of NSF sponsored institutes should be more toward the teaching of science as inquiry and as a way of thought.

Since the development of the new high school science curricular materials, many of the National Science Foundation sponsored programs have used these curricular materials in the in-service training of science teachers. In stressing the importance of using the BSCS curricular materials in the in-service preparation of biology teachers, Hurd (33) states:

> There must be perspectives from which to work if a sound pattern of teacher preparation is to be evolved. The lack of any clear rationale results in either a random assortment of courses, or what is just as bad, a concentration of courses that is only partly related to the teaching of a high school biology course.

In the 1964 BSCS special publication for biology teacher preparation, Andrews (1) has listed the probable need to increase teachers' depth and breadth of subject matter knowledge particularly in the areas of biology stressed in BSCS biology. Also, he suggested that

the BSCS Program curricular materials could possibly be used profitably in the preparation of pre-service biology teachers. To use the subject matter contained in the BSCS Program curricular materials is a sound suggestion but the conceptual and interdisciplinary organization of this subject matter offers, at best, only broad suggestions as to which courses biology teachers should take to better prepare them to use the BSCS materials.

Concerning the pre-service academic preparation of science teachers, other groups have proposed innovations in the present undergraduate programs. In cooperation with the National Association of State Directors of Certification and Teacher Education (NASDCTE), the American Association for the Advancement of Science (AAAS) (12), has prepared guidelines for the designing of academic preparation programs for science teachers. Recently, Ginsburg (27) reported the recommendations of the Commission of Undergraduate Education in the Biological Sciences (CUEBS) for the academic preparation of prospective biology teachers. Also, Winter (45), in 1965, outlined the proposals of the Association for the Education of the Teachers of Science for the academic preparation of science teachers. All three of these national groups have suggested or implied that the new high school science curricula should serve as guides in the designing of specific teacher preparation programs and have suggested subject matter areas that should be included in the preparation of science teachers. However, the recommendations for science teacher preparation programs made by the above mentioned national groups differ somewhat and in all cases, the questions of what specific subject matter should be included in

specific courses and the teaching methods that should be used remain unanswered.

Other writers have agreed that the subject matter areas recommended by the various national groups are valid areas of study for high school science teachers but have also written that there is a need for more specific suggestions concerning the academic preparation programs for science teachers. Schlessinger (39) states, concerning the NASDCTE Guidelines, that outlining the subject matter areas and the essential concepts for each of the science certification areas, i.e., biology, chemistry, etc., may be of some immediate value in planning science teacher education programs, but he suggests that science educators and professors of the various disciplines may have differing interpretations of the recommendations.

Watson (43) has commented, concerning the above mentioned NASDCTE-AAAS guidelines, that the guidelines are closer to operational specifications but are still rather general. Relative to the need for study in the realm of more specific suggestions for developing academic preparation programs for science teachers, he writes, " . . . my feeling (is) that much more must be done to improve the pattern of science courses taken by future science teachers. This pattern must be clarified." Evidently there is a need for more specific suggestions relative to what patterns of academic training a science teacher should have and additional information would be of value in clarifying this pattern.

Since the ultimate goal of any academic preparation program for secondary school science teachers is to enable them to teach high school science, to know their attitudes toward the curricula

that is currently in widespread use in the high schools in relation to their academic preparation would be of value in designing preparation programs for science teachers. That there is a need to explore science teachers' attitudes concerning the new science curricula, and particularly biology teachers' attitudes toward BSCS curricular materials, has been expressed by other writers.

Blankenship (20), in his study, found that the special training in the use of BSCS materials did not necessarily guarantee a more favorable attitude by the biology teachers toward the materials. He remarked as a result of his study:

> The fact that approximately 50 percent of the teachers involved in the study demonstrated unfavorable attitudes toward the BSCS program suggests that studies need to be conducted to determine the reasons for the negative attitudes in order to determine whether or not these attitudes point up the need for changes that would improve the curricular materials.

Grobman (29) has reported that there are many unanswered questions concerning the BSCS Biology Program and has listed several areas of needed research. One question was in the area of biology teacher preparation and its effect upon the teacher's attitudes concerning the BSCS Biology Program.

It would seem, then that there is a need for more specific suggestions concerning the academic preparation of high school science teachers. Since the new science curricula are considered by many to be a valid frame of reference for the preparation of science teachers and a more favorable attitude toward these curricular materials is a desirable outcome of their training, it appears that a study to analyze the patterns of academic preparation that science teachers have had in relation to their attitudes toward the curricular materials

would furnish information that could be used in the designing of specific academic preparation programs for high school science teachers.

Statement of the Problem

The research in this study was designed to permit the author to analyze the patterns of academic preparation of a selected group of science teachers in relation to their reactions to the BSCS Biology Program. Through analysis of the distribution of courses that biology teachers have completed in science and mathematics in relation to their reactions toward BSCS biology, the investigator would be determining the relationship that exists between the patterns of academic preparation of teachers and teacher attitudes.

The general hypothesis investigated, stated in the form of a null hypothesis, was:

> There are no differences in the distribution of courses completed in science and mathematics between teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and teachers who demonstrate a less favorable attitude toward the BSCS Biology Program.

Specific questions for answering were:

1. Is there a significant difference in the distribution of a course completed in general biology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

2. Is there a significant difference in the distribution of a course completed in general botany between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and

science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

3. Is there a significant difference in the distribution of a course completed in plant physiology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

4. Is there a significant difference in the distribution of a course completed in systematic botany between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

5. Is there a significant difference in the distribution of a course completed in plant development (morphology) between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and the science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

6. Is there a significant difference in the distribution of a course completed in general zoology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

7. Is there a significant difference in the distribution of a course completed in animal physiology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

8. Is there a significant difference in the distribution of a course completed in embryology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and the science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

9. Is there a significant difference in the distribution of a course completed in ecology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

10. Is there a significant difference in the distribution of a course completed in evolution between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

11. Is there a significant difference in the distribution of a course completed in genetics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

12. Is there a significant difference in the distribution of a course completed in microbiology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

13. Is there a significant difference in the distribution of one year's study of general chemistry between science teachers who demonstrate a more favorable attitude toward BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

14. Is there a significant difference in the distribution of a course completed in organic chemistry between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

15. Is there a significant difference in the distribution of one year's study of physics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

16. Is there a significant difference in the distribution of the completion of at least one course in the earth sciences between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

17. Is there a significant difference in the distribution of one year's study of college mathematics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

18. Is there a significant difference in the distribution of the completion of a methods course in the teaching of science between

science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

19. Is there a significant difference in the number of science courses accompanied by laboratory work between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Biology Program?

The nineteen specific questions to be answered in this study arose from the particular variables that the investigator utilized in the study in an attempt to reduce the general hypothesis to manageable proportions. The intention of the writer is not to suggest that the subject matter areas and courses that were considered are the only courses and/or subject matter areas that might be contributing factors toward a more favorable attitude toward the BSCS Biology Program, rather the intention was that the courses and subject matter areas selected as variables represent what several individuals and groups consider to be the minimum subject matter knowledge that high school biology teachers should have to adequately teach BSCS biology. The basis for the selection of the variables was from an analysis of the recommended academic preparation programs for high school science teachers found in the literature.

Use of Terms

BSCS groups--refers to all of the members of the various committees of the Biological Science Curriculum Study who designed and developed BSCS biology for use in the secondary schools.

BSCS Biology Program--refers to all textbooks, laboratory manuals, laboratory blocks, teachers' guides, handbooks, pamphlet series, etc., that were developed by the BSCS groups for use in teaching and learning BSCS biology.

New high school science curricular materials--refers to all the high school curricular that have been developed through the cooperative efforts of science specialists, science teachers, and other interested individuals with financial support from the National Science Foundation.

Academic preparation programs--refers to the science and mathematics courses that are either required or available for election in a program for the preparation of secondary science teachers.

Academic patterns of training--refers to the academic courses that science teachers have completed in the various sciences and mathematics.

New teaching techniques--refers to those methods employed by the science teachers in teaching the new high school curricula that are designed to promote interest and concept formation and have not, in general, been used in the past by science teachers.

Intensive training period--refers to the introduction to, and use of, the BSCS curricular materials given in a summer institute where major emphasis is on acquiring knowledge of the BSCS philosophy, content, and methods.

Selected group of science teachers--refers to four groups of secondary science teachers that participated in intensive training programs in the use of BSCS materials during the summer of 1966.

Attitudes--refers to the reactions of science teachers to the philosophy, content, and methods of the BSCS Biology Program.

Limitations of the Study

Certain limitations existed that may have influenced the conclusions of this study:

1. The writer's use of the titles of courses completed by the teachers as an attempt to assess their knowledge and understandings in science and mathematics, is recognized, as being, at best, only an indication that they had been exposed to certain kinds of knowledge and understandings. This writer would be one of the first to admit that the mere completion of a course does not necessarily guarantee that knowledge and understandings of the course are gained. It is also recognized that the subject matter taught in one instructor's class will vary somewhat from that which is taught in another's classroom although the course titles are identical. However, it would seem a valid assumption that the major concepts and principles would be similar in courses with identical titles.

2. Another limitation is the lack of an objective way of testing teachers' competency in laboratory techniques and their appreciation of the investigative nature of science. Here again, the writer admits that the use of total numbers of courses that were accompanied by laboratory work is only an indication that the subjects in the study had had an opportunity to become proficient in laboratory techniques and had gained an appreciation for the investigative nature of science.

CHAPTER II

SELECTIVE REVIEW OF LITERATURE

A review of the literature relating to the academic preparation of high school science teachers reveals that much has been written in this area. A large percentage of the research studies have made use of surveys in attempts to ascertain the adequacy of the training of in-service high school science teachers. Many writers, basing their judgments on personal observations, have written that high school science teachers have not been appropriately trained to teach modern high school science and, hence call for revisions in the training of these teachers. Also, a number of national curriculum groups have concluded that the preparation programs of science teachers are out-moded and have published guidelines for the designing of training programs for high school science teachers.

The literature reviewed in this chapter will be that which has a direct relationship to the problem. In order to investigate this problem, it was necessary to gain an understanding of our existing knowledge concerning teacher attitudes and the instruments that are used to measure attitudes. To enable the investigator to relate this knowledge to the academic preparation of biology teachers and their reactions to the BSCS Biology Program, it was necessary to investigate what is being done in the preparation of high school biology teachers and to characterize briefly the new biological science program. A

thorough analysis of all of these factors should provide information for those who are concerned with the development of programs to prepare teachers to make the most effective use of the new high school curricula programs with similar philosophy and methodology.

Teacher Attitudes

Abundant literature exists in the area of teacher attitudes but only a limited number of studies have involved science teachers. Since science teachers are a subpopulation of the general teacher population, a brief review of knowledge pertaining to the attitudes of teachers in general is included.

The chief problem that faces investigators in the area of teacher attitudes is that of objective measurement of attitudes. One tentative solution to this problem has been obtained through the development of attitude instruments designed for use with teachers in general. Another tentative solution has been the designing of instruments for use with various subpopulations of the general teacher population.

Getzels and Jackson (9) report in a review of related research that the most widely used measure of attitudes is the Minnesota Teacher Attitude Inventory. This attitude inventory has been utilized in more than fifty research studies reported in the literature. The manual (47) accompanying the inventory states that the attitudes measured by the Minnesota Teacher Attitude Inventory are those of teachers toward children and schoolwork. The research studies which have made use of this inventory have generally been seeking information concerning changes in attitudes, comparing scores of prospective teachers with those of experienced teachers, and evaluation of teacher competence.

Popham and Trimble (38) report using the Minnesota Teacher Attitude Inventory and they concluded from their findings that it could be used as an indication of the type of social atmosphere maintained by the teacher in the classroom. Cook (24) and Gruber (30) used the Minnesota Teacher Attitude Inventory (MTAI) in connection with the Guilford-Zimmerman Temperament Survey. Both of these studies were characterized by the fact that the researchers were comparing scores of prospective teachers with the scores of experienced teachers.

Attempts have been made to relate the attitudes measured by the Minnesota Teachers Attitude Inventory to other personality variables, notably those measured by the Guilford-Zimmerman Temperament Survey, and the Kuder Preference Record, Vocational (Kuder). Leeds (36) studied the relationship between the MTAI and the Guilford-Zimmerman Temperament (GZTS) Survey. The MTAI and the GZTS were used with a sample of 300 teachers. The correlation coefficients between the MTAI and the 10 temperament measures of the GZTS ranged from -.07 to .52 and all but three of the coefficients were found to be significant at the .01 level. Leeds suggests that "to a certain extent, the MTAI score is an indirect measure of these temperament traits." Beamer and Ledbetter (19) investigated the relationship between the MTAI and Social Service preference as measured by the Kuder. The MTAI and the Kuder were administered to 164 experienced teachers. The correlation between the two measures was .35. Although there were variations for sex and for elementary and secondary teachers, no interaction effects were given. The two authors concluded that if the two instruments are valid, then many teachers do possess interests in social service and permissive attitudes toward children.

Instruments other than the widely used MTAI have also been used to assess teacher attitudes. Noteworthy among these instruments is the Teacher Characteristics Schedule that was developed and used by Ryans (13) and his co-workers in the Teachers Characteristic Study. Certain dimensions of teacher attitudes, verbal understandings, educational viewpoints, and emotional stability were investigated by using the Teacher Characteristic Schedule. Among the trends in the data included: (1) The attitudes of elementary school teachers toward pupils, administrators, and fellow teachers were more favorable than were similar attitudes of secondary teachers. (2) Actual pupil behavior in the classroom (based upon observers' assessments) did not appear to be related to the attitudes held by teachers. (3) The educational viewpoints expressed by secondary teachers were more traditional than those of elementary teachers.

In the area of elementary science teaching, workers have been interested in developing favorable teacher attitudes toward science and the subsequent measurement of these attitudes. Dutton and Stephens (25) developed a Science Attitude Scale for the assessment of the attitudes of elementary teachers toward science. The scale is intended to be used to study the general pattern of responses for an individual or for a class. Individual scale items, of which there are 50, show like or dislike for some particular aspect of elementary school science. The reliability of this scale, measured by the test-and-retest procedure is 0.93.

Oshima (37) utilized Dutton's Scale to measure changes in attitudes toward science of a group of prospective elementary teachers. The elementary teachers involved in Oshima's study were divided into

three groups, a control group and two experimental groups, for instruction in methods of teaching elementary school science. The control group was taught by using the lecture-demonstration method and a minimum amount of student participation. The investigatory approach was used to instruct the two control groups and they, thereby, were involved to the maximum extent in doing experiments and discussing the outcomes. The overall data showed that there was no significant difference in the gain in favorable attitudes toward science between the experimental and the combined experimental groups when two methods of instruction were used. However, when the median scores of the control groups and experimental group II on Dutton's Scale were compared, a significant gain in favor of the experimental group was found. With regard to the latter findings, Oshima suggests that a significant number of subjects made very small gains in attitudes. And with respect to his overall findings, Oshima, evidencing his conclusion on the findings of others, indicates the possibility that changes in attitudes may be found to exist after a longer time lapse.

Studies relating to the attitudes of secondary school science teachers are almost nonexistent. Blankenship (20) conducted a study of high school biology teachers and their attitudes concerning the BSCS Biology Program. This research involved the design, development, and use of an instrument, Biology Teacher Attitude Inventory, to determine teachers' reactions to certain features of the BSCS program as compared with similar features of "traditional" programs. The following data were obtained for the sample of 55 science teachers: (1) number of semester hours of academic course credit in undergraduate biology; (2) grade point average in undergraduate biology; (3) age; (4) years

of teaching experience; and (5) nine sub-scores on the California Psychological Inventory and the Allport-Vernon-Lindzey Study of Values.

Analysis of the data revealed that, in general, teachers who ranked higher on measures of capacity for independent thought and action and who had taught biology for three years or less reacted favorably to the BSCS program. Those teachers who ranked lower on measures of capacity for independent thought and action and who had been teaching high school biology for more than three years tended to react unfavorably to the BSCS program.

Academic Preparation of Secondary School Science Teachers

At the present time two factors seem to be the principal guidelines for teacher preparation. These factors are college degree requirements and state teacher certification requirements. Woellner and Wood (16), in the thirtieth edition of Requirements for Certification, list the recommendations of Regional Accrediting Associations. These six regional accrediting associations recommend minimum standards for instructional staff members of secondary schools within their individual regions. A review of these recommendations disclose a range from a statement by the New England Association that requirements are to be established by the different states in its region to a rather detailed set of recommendations set forth by the North Central Association of Colleges and Secondary Schools. This report also includes requirements of the individual states pertaining to certification of teachers. An analysis of state requirements listed for certification reveals great variation between states with some states listing a specific number of semester hours of science required for all secondary

school teachers along with specific semester hour requirements in science for science teachers. Other states list only the requirement that the individual applying for certification hold a bachelor's degree from an accredited college or university, thereby not specifically stating a minimum number of semester hours credit in science requirement for certification as a secondary school teacher of science.

In the past several years it has become increasingly apparent that the minimum college degree requirements and the state teacher certification requirements have not been the most effective way of providing adequate training for high school science teachers. A comprehensive review of the status of the science teacher in the American public schools during the school year 1957-1958 is disclosed in a research study conducted by the Research Division of the National Education Association (49). Approximately 60 per cent had acquired thirty or more semester hours of science. It seems significant, though, that nearly one-third of the secondary school principals responding in the same study reported that the greatest need for improvement on the part of science teachers was in the area of increased or more up-to-date knowledge.

Specifically in the areas of biology teaching, Cox (7), writing in Patterns for Preparation of BSCS Biology Teachers, points out the following: " . . . . most of the graduating seniors in biological science education will be unqualified to teach BSCS Biology." Cox also pointed out, "The information included in BSCS texts and laboratory manuals was not invented for BSCS . . . it is simply up-to-date biological information. But it is information that most beginning biology teachers do not have."

Hurd (33), writing on the "Education of Secondary School Biology Teachers", emphasizes that almost any suggestions for the improvement of biology teaching comes back to the improvement of teacher education. Hurd then lists the 1962 status of biology teachers:

1. Over 80 per cent of the teachers with a major in biology are graduates of liberal arts colleges and universities.

2. Generally, 120 semester hours were required for graduation, of which eighteen hours were in professional education courses.

3. Practically no biology teachers had completed a methods course on teaching biology.

4. The average biology teacher had twenty hours credit in biology. Five per cent of high school biology teachers have never had a college biology course.

5. Fifty per cent are biology teachers by administrative decision.

6. A majority of college biology majors become teachers at some level.

7. About 25 per cent of high school biology teachers teach only biology.

8. Forty per cent of all college graduates certified to teach high school biology do not.

9. Teacher turnover in science, due to all courses, is approximately 10 per cent. If we assume that it takes at least five years of experience to develop a good biology teacher, this means that at one time about 50 per cent of even the qualified teachers are novices.

Burnett (22), in a review of related literature, concludes that it is well established that high school science teachers are ill prepared to teach modern high school science courses. He further reports that during the period 1961-1964 there were literally no reports of significant research in pre-service education of secondary science teachers.

During this same period there has been some research pertaining to the in-service education of high school science teachers. The various NSF institutes and other programs, designed to up-grade science teachers, represent the most massive efforts ever made in in-service education. The first frontal attempts to evaluate the effectiveness of these efforts on a broad scale appeared recently. Gruber (31) studied nine NSF academic year institutes (AYI) to determine whether the AYI fellows, as a result of their institute experiences, were oriented toward the teaching of science more as a way of thought and inquiry than as a set of established facts and doctrines. Only 25 per cent showed "strong", and 60 per cent showed "negligible" interest in this approach to the teaching of science. Gruber concludes, as the result of his study, that the NSF institutes were successful in up-grading the scientific knowledge of the science teachers but suggests that the orientation of NSF institutes should be more toward the teaching of science as a way of thought and science as inquiry.

Numerous other workers have utilized questionnaires to study the results of participation by science teachers in NSF sponsored institutes. They cite increased scientific knowledge and better use of laboratory equipment as chief gains.

While not discounting the importance of the past efforts of the NSF sponsored programs in up-grading high school science teachers, many workers recommend a reorientation in the preparation of science teachers. These recommendations appear as proposed programs and guidelines for the designing of training programs for high school science teachers.

Suggested Programs for the Preparation of Secondary School Science Teachers

With the change of science in general and high school science in particular from a descriptive to an investigatory approach, science educators have advocated a science teacher preparation of a different sort than teachers have previously received.

In addition to the change of emphasis in high school science, the increasing emphasis in scientific knowledge has presented a problem in preparing high school science teachers. Glass (28) observes, that very early, it became apparent to the staff and steering committee of the BSCS that a formidable obstacle to the wide use of the new biology courses was the lack of adequate preparation of high school biology teachers in many areas of modern biology. In addition, Glass points out that the vast body of accumulated science knowledge and the rapid rate at which new knowledge is gained accounts, in part, for the lack of appropriate preparation of high school biology teachers. Schwab (40) follows the same theme in stating that knowledge learned in 1960 will be largely inadequate in 1968 and relatively obsolete by 1975.

In connection with the BSCS Biology Program, the BSCS groups initially recognized the fact that the investigative approach inherent within the program would be unfamiliar to the majority of high school biology teachers and that their background would have to be improved. Therefore, they have made provisions to train teachers in the use of the BSCS program materials. Initially, the teachers who were to use the BSCS biology materials were trained by members of the BSCS staff

but recently a series of special publications have been produced which contain suggested programs for the training of high school biology teachers.

The first of the BSCS special publications to appear was the BSCS Biology Guidelines for Preparation of In-Service Teachers (10) published in 1962 by the BSCS. The 1962 publication was followed in 1963 by Patterns for the Preparation of BSCS Biology Teachers edited by Cox (7). A third BSCS publication, BSCS Materials for Preparation of In-Service Teachers of Biology (1), was published in 1964.

The latter publication supercedes the two earlier publications concerned with teacher preparation and represents the current thinking of the BSCS committee on teacher preparation. This booklet was prepared to assist collegiate personnel concerned with the in-service preparation programs for teachers who wished to use BSCS Biology Materials. The contents of the booklet are organized into three parts: (1) history, philosophy, and rationale of BSCS; (2) use of BSCS materials in preparation of in-service teachers; and (3) suggested programs for teacher preparation.

Andrews (1), in the preface to BSCS Materials for Preparation of In-Service Teachers of Biology, lists the following desired changes in attitudes among teachers who have participated in in-service programs as outlined in the booklet:

1. to think of the major ideas of biology as the important understandings to be gained by his students,

2. to change his behavior patterns in the classroom, laboratory, and field, thus, establishing teaching-learning situations that are student-centered,

3. to guide his students into meaningful investigative activities that will result in the students understanding of inquiry and the process of science, and

4. to increase his own understanding of the major concepts in the subject matter areas in which he is deficient.

The use of the BSCS biology materials and their counterparts in physics, chemistry, and the earth science as perspectives in the retraining of high school science teachers has been the trend for the past few years. However, as noteworthy as the efforts are to retrain high school science teachers to use the new high school curricula, it would seem that similar preparation programs for pre-service teachers would eliminate, in part, the need for so much retraining. Watson (43), commenting on the training of science teachers, states:

> Considerable pooled experience with retraining programs for employed teachers, including many recent graduates, obliges us to ask how they were educated in college. A more effective program there would lessen the need for so much expensive retraining later.

Schlessinger (39) also has expressed a need for a need to study the preparation programs of pre-service science teachers. He has written:

> There is no doubt that the variety of (NSF sponsored) institutes have done much to up-date the knowledge and competencies of many of our secondary school science teachers. But is it not strange that the beginning science teacher finds it necessary to return as soon as possible to an institute to learn the content and methods of the "new curricula"? . . . Perhaps a careful study of the pre-service programs for science teachers is needed.

There have been efforts made in recent years to improve the pre-service training of high school science teachers. These efforts have been in the form of suggested guidelines for the designing of preparation programs for science teachers. The National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science (NASDTEC-AAAS) published in 1961 Guidelines for Preparation of Teachers of Secondary School Science and Mathematics (12). The Guidelines are principally concerned with

the subject matter of science and mathematics. They are offered as resources to be drawn upon by institutions of higher education in developing their preparation programs. The guidelines were intended to be flexible to allow colleges and universities to choose specific courses and still remain within the wide scope of the recommendations.

Included in the NASDTEC-AAAS Guidelines are recommendations for the development of high school biology preparation programs. Among the recommendations as to what should be included in a preparation program for biology teachers are the following:

1. A broad course in the principles of general biology, or the equivalent drawn from separate courses in botany, zoology, and microbiology.

2. Advanced courses in biology selected to give broad knowledge of plants and animals alike. Courses in plant physiology and anatomy, ecology, plant and animal development, genetics, evolution, protozoology, phycology and micro-techniques are listed as probable courses to give the broad biological knowledge needed by high school biology teachers. It is suggested that these courses be accompanied by both descriptive and experimental types of laboratory work.

3. A course in the methods of biology teaching.

4. A year of college physics together with a year of college chemistry, which includes an introduction to organic and biochemistry.

5. A semester of geology with emphasis on historical geology.

6. Mathematics through calculus and a good foundation in probability and statistics.

7. As a total, about one-fourth of the total four-year college program of a secondary school biology teacher should be allotted to the related science fields and mathematics, approximately equal to the amount of work taken in biology.

8. High school biology teachers should be prepared to teach BSCS biology as well as more traditional courses.

Viall (42), reporting on the recommendations of the NASDTEC-AAAS Guidelines, reports that nearly one hundred institutions have adopted the Guidelines for use in designing their teacher preparation programs.

Schlessinger (39) states that the NASDTEC-AAAS Guidelines are an improvement over earlier attempts to outline, in credit hours, the courses needed by pre-service students. He further states that science educators and professors of the various disciplines may have differing interpretations of the statements contained in the booklet.

Another organization that has been involved in suggesting plans for the preparation of in-service science teachers is the National Academy of Science (51). The academy sponsored a conference in the late 1950's on Undergraduate curricula in the biological sciences. At its final general session in 1957, the conference recommended the following curriculum for prospective biology teachers:

1. A one-year course or course sequence in introductory biology.

2. Equivalent to one and probably two years courses in biology of greater depth and scope than the introductory course could give. Among the areas suggested for study are molecular and cellular biology, physiology, growth and development, and ecology or environmental biology.

3. A year of general chemistry built in considerable part upon organic chemistry, including qualitative analysis, and emphasizing chemical principles; and a course in organic chemistry, which stresses principles and covers some biochemistry.

4. One year of physics, which gives some attention to biological problems and materials.

5. One quarter or semester in field biology--ecology.

6. One quarter or semester work in the methods of biology.

7. Experience as a supervised teaching assistant in a college laboratory.

Recently, the commission on Undergraduate Education in the Biological Sciences (27, 48) recommended a program for preparing high school biology teachers. The CUEBS has suggested a two- or three-year "core curriculum" for all students specializing in biology, including potential teachers. The "core" is conceived as being a series of coordinated courses under the auspices of a given department, as an interdepartmental program, or as a combination of the two. The core program includes an introductory portion that serves as a general education for all students, and a second layer that provides a more advanced background in common for all biology majors. The introductory portion is meant to include field and laboratory work and to be based on principles and intellectual issues relating inquiry to conclusions. Also, the key subject matter areas suggested to be included in the introductory portion are: cell theory, transmission genetics, metabolic systems, the gene and gene coding, and population genetics. Both plant and animal materials are intended to be used in such a way as to develop an integrated biology discipline.

Work beyond the core is comprised of courses which build on the core in greater depth and detail. The core courses may assume a variety of patterns, i.e., into units negotiable for credit and transfer purposes. The core is to be distributed in various ways through the four year program. Courses recommended beyond the "core" for prospective biology teachers include the following: broad training in psychology, educational methods, and serving as teaching assistants in the introductory part of the core; also, science education courses concerned with the examination of high school curricula.

The proposition is that this increased requirement for prospective biology teachers can be solved by moving to a five-year program or by reducing the total science requirements by omitting physical chemistry and calculus, providing a shorter course in organic chemistry, and requiring less biology course work beyond the core.

In developing a teacher education program, CUEBS calls for a natural science staff to include mathematics, physical scientists, and biologists who would plan integrated core curricula. CUEBS has assisted several institutions of higher learning in initiating science teacher preparation programs patterned after their recommended programs.

Other workers have been searching for an appropriate training program for high school science teachers. Lee (34), in suggesting a training program for high school biology teachers, outlines a 24 to 30 semester hour undergraduate program in biology which would provide the prospective biology teacher with not only an opportunity to gain the essential subject matter knowledge but would also provide 8 to 10 semester hours in actual research investigations in biology. Burnett (23), in an article on new concepts in the education of science teachers, suggests that the past few years of ferment in science education has given new clarity concerning the nature and processes of sound science teacher preparation. He draws attention to the programs and practice through which science teachers are presently being prepared for their work. Illustrative of good present practices in training in-service biology teachers throughout the United States, he outlined the course requirements in a midwestern university. The required courses were as follows:

1. Biological sciences: general botany, human physiology, plant morphology, or plant kingdom; systematic botany or field botany; entomology; microbiology; natural history of vertebrates; ecology or wildlife management and conservation; genetics; systematic zoology or invertebrate zoology; and biology for teachers, dealing with methods of teaching and a broad review of biology. This constitutes a total of 45 semester hours of biology.

2. Supporting science: general chemistry; an eight semester hour general education course in physical science or one course each in astronomy, geology, physics, and geography.

Concerning the science courses themselves, Burnett says the appropriateness of the various courses for biology teachers depends upon the extent that they are interrelated parts of the whole disciple of biology.

Among Burnett's concepts for developing a biology teacher's preparation program is the suggestion that the BSCS Biology Program be used as a frame of reference. He proposes college courses for prospective biology teachers patterned after the style and conceptual nature of BSCS biology.

The Biological Sciences Curriculum Study Biology Program

In 1959 the American Institute of Biological Sciences, with financial support of the National Science Foundation, established the Biological Sciences Curriculum Study (32) as a means to contribute to the improvement of biological education in the secondary schools of the United States.

A 27-member steering committee was composed of research biologists, high school biology teachers, and other interested educators. A base of operations for the BSCS was established at the University of Colorado, Boulder, Colorado. During 1959 and the early part of 1960, this committee, in a series of meetings, drew up the plans and

framework for the BSCS Program. Five committees were initially set up to examine five critical areas relating to an effective biology program. One of these committees, the committee on course content, of which Dr. John A. Moore, Columbia University, was appointed chairman, was given the task of designing a first course in biology for the secondary school. Two major factors influenced the selection of the course content of BSCS Biology. These factors were: (1) the attempt to identify the procedures and conceptions that best characterize modern biological science; and (2) the knowledge, attitudes, and skills relevant to biology that would best contribute to the students' personal lives and to the performance of their responsibilities in society.

After considerable discussion and study it was recognized by the BSCS that there is no single best way to design a course in biology. Therefore, the group developed a variety of materials from which teachers could select those most appropriate for their own use. However, all materials retained common features. As the program finally developed, three textbooks and numerous other materials were produced.

It was recognized early in the BSCS Program development that the laboratory should play a vital role in the high school biology course. Dr. Bently Glass, chairman of the BSCS Steering Committee, points out in "Renanscent Biology" (28) that in addition to teaching modern biology, there is the need to lead each study to conceive of biology as a science, and of the process of science as a reliable method of gaining objective information. Dr. Glass views the teaching laboratory as fulfilling two functions. One, the "illustrative function", which consists of presenting evidence from nature that supports our

biological concepts. This is the function most often found in conventional biology laboratories. The second function of the teaching laboratory which is considered most important is that of providing an opportunity for students to investigate, firsthand, some problem, the answer to which is unknown. This function is called the "investigatory function". Dr. Glass expresses the opinion that to understand the nature of the scientific process one must actively participate in it.

In an effort to assure that the investigative laboratory would be an integral part of the BSCS Program, another committee, the Committee on Innovation in Laboratory Instruction was established. This committee, of which Dr. Addison E. Lee of the University of Texas was appointed chairman, was given the responsibility of both evaluating the existing role of laboratory experiences and producing laboratory instructional materials which would reflect the investigative nature of up-to-date biology. This committee desired to involve the students at some point in the course in a truly experimental study. The committee felt that the ordinary, brief, confirming experiment, and the limitations of class time, were not conducive to an investigation of a biological problem in sufficient depth for students to understand and appreciate the nature and processes of science. The major accomplishment of this committee was the development of the "Laboratory Block" program (35). Approximately a dozen laboratory blocks were initially proposed. Each block was to consist of a comprehensive unit of laboratory and field work complete in itself. It was anticipated that each block would occupy the full time of the students for a period of six weeks and, therefore, only one block would be attempted

by any one class of students in the first course in high school biology. This procedure of investigating biological problems in a specific area in depth was envisioned as affording students an opportunity to understand and to appreciate the spirit in which scientists work and the procedures they use to discover knowledge. Realizing that all schools would not, for various reasons, be able to use the laboratory block program, a separate committee, the Committee on Laboratory Procedures, Dr. Bentley Glass, chairman, was given the responsibility of developing an improved series of more conventional exercises and demonstrations. These were to be of a shorter duration than the block investigations and were to be closely integrated with the subject matter content.

The other three committees initially established were the Committee on the Gifted Student, Dr. Paul F. Brandewein, Harcourt, Brace and Company, Inc., New York City, Chairman; the Committee on Teacher Preparation, Dr. Joseph J. Schwab of the University of Chicago, Chairman; and the Committee on Publication, Dr. Hilden T. Cox, Executive Director, American Institute of Biological Sciences, Chairman. Additional committees established as the program developed included a Committee on Learning Aids and a Committee on Evaluation.

Materials developed at a 1960 summer writing conference were built around nine unifying themes. Five of these themes are directly related to the course content, two of the themes are directly related to the structure of the textbooks, and two of the themes are intermediate in that they concern both structure and content. These nine unifying themes (32) are:

1. Changes of living things through time: evolution;
2. Diversity of type and unity of pattern in living things;
3. The genetic continuity of life;
4. The complementarity of organization and environment;
5. The biological roots of behavior;
6. The complementarity of structure and function;
7. Regulation and homeostatis: preservation of life in the face of change;
8. Science as inquiry; and
9. The history of biological conceptions.

In addition to the nine themes, the BSCS Biology was organized around "levels of biological organization." There are seven organizational levels that are treated in the three versions of a textbook. These are: (1) molecular; (2) cellular; (3) tissue and organ; (4) individual organism; (5) population; (6) community; and (7) the world biome. These levels of organization were included in order to give a complete picture of modern biology and to show how the various levels are interrelated in biological conceptual schemes. The inclusion of the seven "levels of biological organization" is in contrast to conventional high school biology which has emphasized the tissue and organ level to the almost exclusion of the other levels.

The treatment of the seven levels of biological organization in the three BSCS textbook versions differs from one version to the other only in the relative emphasis at a different level. For example, in relation to one another, the blue version has a greater emphasis on the molecular level; the green version emphasizes the community and world biome more than the others; and the yellow version has a greater

emphasis on the cellular level. However, with the exception of the tissue and organ level of organization, the three BSCS textbook versions emphasize all levels more than had the conventional biology course.

The BSCS courses represent not only a reorganization of content, but a fresh conceptual approach to secondary school biology. A statement appearing in BSCS Newsletter 17 (17) reports the intent of the BSCS writers:

> . . . The writers seek to teach science as a way of thinking--as a method of seeking answers. To do this, they stress underlying concepts and understandings. Student work is centered in the laboratory, where real problems are explored; open ended experiments and other materials are used as the media for conveying an understanding of science. Through emphasis of basic concepts and the illustration of such concepts in many ways, the student is given practice in drawing generalizations, in seeking relationships, and in finding his own answers.

The BSCS materials produced in the summer of 1960 were first taught in preliminary trials in 1960-1961. Fifteen experimental teaching centers were established across the United States. In each center, six or seven teachers were chosen to teach the BSCS Program. It was agreed that all teachers use the same text version and would elect to either use or not use a laboratory block as a part of the course. The text versions had, by this time, been identified by colors, blue, green, and yellow. There were 105 test center teachers and 13 independent teachers who taught BSCS biology during the 1960-1961 school year. Each test center teacher prepared a weekly summary of the results of his use of the materials. These weekly reports became a part of a summary report, "feedback", that was sent to BSCS. These "feedback" reports were analyzed by BSCS and were used to guide them in subsequent revisions of the materials.

A second writing conference was held in the summer of 1961 at which time the BSCS materials were revised. Again the BSCS materials were trial-tested. During the 1961-1962 evaluation program, approximately five hundred teachers and approximately 50,000 students in thirty-five states and the District of Columbia were involved. Included as a part of the 1961-1962 evaluation program was an extensive testing program with a statistical analysis of the results (41). Findings of the evaluation program, based on student achievement on BSCS version tests and common end-of-year final exams, indicated that BSCS students were able to master the BSCS biology materials and to achieve the desired objectives to the satisfaction of the BSCS and the teachers using the materials. Average and above average students did well in all three versions. The analysis of variables in BSCS performance as measured by a BSCS comprehensive final examination revealed no significant difference in such teacher characteristics as age, years of experience and number of undergraduate and graduate hours in biology for the sample used. The BSCS biology materials have subsequently undergone repeated revision and were released by commercial publishers for general use in the fall of 1963.

The activities of the BSCS have included the development of many curricular materials for use by both students and teachers. The three text versions that have been developed are: The Blue Version, Biological Science: Molecules to Man (12), which uses the biochemical and physiological approach; the Green Version, Green Version: High School Biology (6), an approach through a study of the ecological and behavioral aspects of biology; and the Yellow Version, Biological Science: An Inquiry Into Life (5), which is organized around the

concepts of biological unity, diversity, and continuity, and stresses the cellular level of organization. A number of laboratory blocks which give students an opportunity to investigate selected biological problems in depth have been developed and are available for use. Laboratory materials and apparatus needed to teach BSCS biology more effectively have been produced. Supplementary materials such as films, monographs, and other reference materials are available to aid both the teacher and the student.

Recent activities of the BSCS have included the development of a BSCS Biology Second Course and BSCS Special Materials. A 1963 summer writing conference designed a preliminary second course in high school biology which incorporated three laboratory blocks. The BSCS Biology Second Course, after having been trial tested and revised several times, became available for general use from commerical publishers in 1965. The commercial edition of the second course is entitled Biological Science--The Interaction of Experiments and Ideas (3). The course was developed for secondary students who have had a previous course in biology. It builds upon the BSCS materials that were prepared for high school sophomores. It is laboratory oriented to a greater extent than the basic version texts. A primary goal of the course is to provide experiences that stimulate biological research so that students will gain an understanding of science from direct experience in the laboratory.

Recently the BSCS Special Materials were developed for use by 10th grade students who cannot use the basic BSCS version texts. The findings of the evaluation programs of the BSCS version texts reveals that students scoring below the 40th percentile on a general ability

test can not successfully use the materials (15). However, many teachers report that thest students show abilities to think and solve biological problems in the laboratory. Thus, the BSCS decided to develop a course that these students could use, one that was laboratory oriented, and one that required less verbal ability on the part of the students. Therefore, a BSCS Special Materials subcommittee was established to develop such a course. Initially, the subcommittee developed a series of special units in those areas of biology that seemed to be most difficult for less able students. These units originally developed were on cell energy, ecology, and genetics. In 1963, these units, as well as a breif program of graphing and the use of the microscope were organized into a Special Materials Teachers' Manual. The Manual contained suggestions for teaching procedures and leading questions for teachers to ask students in order to develop their understanding of biological concepts. The students' manual consisted of brief background readings and self-test questions, but mostly had blank pages that students were encouraged to write, in their own words, their understandings of biological concepts, and ultimately write their own book. The experimental units were tested in the classroom and were found to be successful. Several revisions of the original units have been made, based on classroom testing, and additional units have been prepared. Finally, all of the units were incorporated into a fourth version of high school biology, now known as Biological Science: Patterns and Processes (4). The commerical edition became available for general use in July of 1966.

Further materials that have been developed by BSCS are evaluation aids. Quarterly tests and a final test for each of the three versions

and two other tests (which are common to all three basic versions) have been prepared and are available for use by high school teachers. The latter two are: 1) the BSCS Comprehensive Final Examination and 2) Test on the Processes of Science. In addition, tests have been prepared for the BSCS Special Materials, the Laboratory Blocks, and for the BSCS Second Course.

The BSCS had conducted a series of evaluation programs in attempts to ascertain the feasibility of BSCS objectives and usability of the materials. A part of these evaluation programs has been the development and standardization of tests that can be appropriately used with the BSCS Programs. Recently, the BSCS conducted the 1964-65 evaluation study (18) based upon the performance of more than 11,000 students in grade 10 biology classes who used the BSCS materials during the 1964-65 school year. Data collected forthe standardization program also provided the data for the evaluation study.

The evaluation studies dealt with analyses of the BSCS tests and their relationship to other tests given in connection with the BSCS curricula. The study included comparisons of the student achievements between sexes, between forms (R & S) of the BSCS achievement and final examinations, and among the three basic curricula versions. Also included was a study of BSCS student performance on two reading tests: the Davis Reading Test and the Illinois Natural Science Reading Comprehension Test. The major results of the study are:

1. The academic ability and BSCS achievement tests were appropriate in difficult for the groups used.

2. Males generally had higher test means than females on both ability and achievement tests.

3. Differences in mean raw scores between Form R and Form S groups were very small and were considered of no importance.

4. Consistent differences appeared in both ability and achievement among the groups in the three curricula versions. The Blue Version groups had the highest means, the Yellow version groups were next, and the Green Version groups had the lowest scores.

5. Both reading tests were highly related to the academic ability tests and to the BSCS achievement tests.

The BSCS Program has been studied by several private investigators. These research studies have been concerned chiefly with comparisons of student achievement between students having completed a conventional high school biology course and students having completed a BSCS course. Only a few research studies have been devoted to the teacher's role in the BSCS Program.

One study undertaken to investigate the role of the teacher in achieving the goals of the BSCS was executed by Gallagher (26). In his study, Gallagher investigated the strategies used by a group of biology teachers in developing the concepts and skills inherent in the study of photosynthesis. The subjects for study were all using the BSCS Blue Version as a test book. It was found that the teachers used a variety of interpretations of the BSCS approach to teaching and a single BSCS approach was not recognizable. His data discloses that the classes were, to a large degree, dominated by teacher talk and the class discussions showed little that resembled an interchange of intellectual ideas between students and teachers. Also, there was little emphasis by the teachers on inquiry or searching for answers to problems which is one of the main objectives of BSCS.

In the conclusions from his study, Gallagher stresses the importance of properly trained teachers in the classroom, especially in the proper way to direct a class discussion. He points up the critical need for teacher preparation as an intrinsic and integral part of a curriculum study, for a teacher unfamiliar with the subject matter and instructional strategies to be used is not as effective in terms of the total program as one so prepared.

As mentioned previously, the BSCS has been active in preparing guidelines for the preparation of high school biology teachers to use the BSCS materials. However, the investigator was unable to find published results of the effectiveness of the BSCS-suggested programs in the training of teachers to use the BSCS materials. The BSCS has expressed a need for study in this area and has invited private investigators to participate with them in this endeavor.

Currently the BSCS Biology Program Materials are in wide use throughout the United States and, indeed, they have been adapted for use in several foreign countries. BSCS has a continuing evaluation program that is evaluating existing programs and additional new materials that presently are in an experimental stage. On the basis of the results of the evaluation programs, the materials will continuously be revised.

Summary

A review of literature pertaining to the training of science teachers discloses that research which has been done in this area has largely been attempts to ascertain the adequacy of the science background of in-service science teachers. Burnett (22), in a review of

related literature, states that it is a well established fact that high school science teachers are ill-prepared to teach modern high school science courses. He further points out that science teachers will continue to be inappropriately prepared to teach modern science until revisions are forth coming in the preparation programs of these teachers.

Other individuals and curriculum groups express a need for renovating the preparation programs of high school science teachers. The general opinion of these workers is that the type of training that these teachers have received in past years is not appropriate for teaching science as inquiry and showing the various sciences as an interrelated whole.

In order to contribute to the preparation of high school science teachers to teach modern science, several guidelines for the designing of teacher preparation programs have appeared. For example NASDTEC-AAAS (12), and CUEBS (27, 48), have published guidelines which have been used by several institutions in designing their preparation programs. No published evaluations of the effectiveness of these programs were discovered by the investigator.

Since the development of the BSCS Biology Program, the BSCS has been active in attempting to prepare high school biology teachers to use the BSCS materials in their teaching. A series of BSCS guidelines have appeared, (1, 7, 10, 15) which suggest methods of familiarizing the teachers with the philosophy, methodology, and contents of the BSCS Program. However, research studies that attest to the success of these programs patterned after the BSCS-suggested training programs were not found in the literature. In fact, there exists some evidence

that a BSCS-suggested program to prepare high school biology teachers to use the BSCS materials is not necessarily successful. Blankenship (20) found in his study that approximately 50 per cent of his sample of 55 high school biology teachers, who had studied the philosophy, methods, and content of the BSCS Program, demonstrated unfavorable attitudes toward the program.

An overall analysis of the literature pertaining to the academic preparation of high school biology teachers points up the fact that many curriculum workers are in agreement that high school biology teachers should have a program of training that is patterned after the philosophy, methodology, and content of the BSCS Program. Although several preparation programs similar to the BSCS Program are in current use in various institutions of higher education, there exists little evidence confirming the effectiveness of these programs in preparing biology teachers to teach modern high school biology.

CHAPTER III

RESEARCH DESIGN

This research study, as described in Chapter I, was designed in order to investigate the relationship between the patterns of academic preparation in science and mathematics of biology teachers and their reactions to the BSCS Biology Program. The specific subject matter areas and courses selected as a basis for determining the academic patterns of preparation of the biology teachers were: general biology, general botany, plant morphology, plant physiology, systematic botany, general zoology, animal physiology, embryology, ecology, evolution, genetics, microbiology, one year's work in general chemistry, one course in organic chemistry, one year's work in physics, one year's work in mathematics, one course in earth science, a methods course in the teaching of secondary school science, and at least 14 laboratory courses.

These particular subject matter areas and courses in science and mathematics were selected after the investigator had studied the patterns of biology teacher preparation that have been recommended by various individuals and several national curriculum groups. Also, the subject matter content found in the BSCS biology materials was taken into consideration.

The academic preparation of the biology teacher samples used in this study was obtained from NSF Application Forms that each teacher

had submitted to the Director of his particular institute. Data-card processing techniques were used to assure complete anonymity to data obtained.

The biology teachers' reactions to the BSCS Biology Program were evaluated in this study by the teachers' demonstrated behavior as observed through the use of three separate measures: An Attitude Inventory, a Peer Rating, and an Instructors' Rating. These instruments are described and the reasons for their being utilized are found in a later section of this chapter. The data used in determining the teachers' reactions to the BSCS Program were all obtained following the training periods in which the teachers were given the opportunity to become thoroughly acquainted with the Program.

Selection of the Biology Teacher Sample

In selecting a sample for this study, certain conditions were desirable: (1) a sufficiently large sample of biology teachers; (2) a training program that would enable these biology teachers to become thoroughly familiar with the content, methods and philosophy of the BSCS Biology Program; and (3) a period immediately following the training period in which to gather data.

To obtain the above-mentioned desired conditions, four National Science Foundation Summer Institutes for high school biology teachers were selected. These NSF Institutes were held on the campuses for higher education in three different western states. The biology teachers in each of these Institutes are referred to as: Group "A", Group "B", Group "C", and Group "D".

These particular Institutes were selected by the investigator for the following reasons: (1) the anticipated number of participants was large enough to give an adequate sample; (2) the stated objectives of each of the institutes afforded the participants the opportunity to become thoroughly familiar with the BSCS Program; (3) the proximity of the institutions were near enough to the writer's location that the data collecting was possible; (4) the training programs involved would be drawing participants from a wide geographic area of the United States; and (5) the basis on which the participants were selected furnished a wide range of academic preparation of the teachers.

Description of the Training Programs

The training programs for the four groups of biology teachers that were used in this study differed in some respects. The training period for biology teacher Group "A" was of eight weeks duration during the summer of 1966. Information obtained from the director of the Institute included requirements for acceptance as a participant, objectives of the Institute, and course work to be offered to the participants.

The requirements for acceptance as a participant were possession of an A.B. or B.S. degree and a teaching assignment in biology. The program was designed to benefit those with one year or less training in the biological sciences. Applicants were considered solely on the basis of their ability to benefit from the program of the Institute, and their capacity to develop as science teachers.

The institute objectives as stated in brochures mailed to prospective applicants included: to prepare secondary teachers to use the

Green Version (ecological approach) of the BSCS Biology Program, the Laboratory Block Study, Genetic Continuity, and the BSCS biology second level course, Biological Science: Interaction of Experiments and Ideas; to fully acquaint participants with all of the BSCS curricular materials; to encourage scientific inquiry and scientific writing in the field of biology; to assist participants in developing a functional program of biological science in their own school; and to improve the techniques and capabilities of the participants in the field and laboratory.

The academic courses offered were designed to strengthen the participants' backgrounds in the areas related to the BSCS Green Version textbook and laboratory manual, the genetics block, and the second level course in biology. Also a seminar in scientific inquiry was required of all participants. The nature of the seminar was to acquaint the teachers with science teaching methods and the practical applications of inquiry in biology teaching.

Biology teacher Group "B" received their training during the summer of 1966 in a program lasting eight weeks.

To become participants in the NSF Institute summer program, Group "B" teachers had to meet certain requirements. The requirements for participation included the possession of a teaching certificate, three years experience in the teaching of biology and a current teaching position in biology. Strong preference was given to applicants who had completed between 12-22 hours in biology. Applicants were selected only on the basis of their ability to benefit from the program, and potentiality to develop as teachers of science.

The major objective of the Institute program was to improve the subject matter competencies of practicing high school biology teachers in the biological and related sciences through a series of regular graduate level courses. However, one of the courses designed specifically for institute participants was a four semester hour course devoted to the study of the philosophy and rationale, subject matter content and laboratory materials of BSCS Blue Version; and an introduction to the BSCS Biology Program in its entirety.

The training that Group "B" received in the course, Advanced Biology for Teachers, was the type of training recommended by the BSCS Teacher Preparation Committee to prepare teachers to use the BSCS Materials. Through informal seminars, lectures, outside readings, laboratory work from the Blue Version Student Laboratory Manual and the laboratory block study, Genetic Continuity of Life, this group was given the opportunity to become familiar with all of the BSCS Program. As is suggested by the BSCS Teacher Preparation Committee, one of the version textbooks and its accompanying laboratory manual was the focus of concentrated study by the biology teachers. Group "B" teachers concentrated on the Blue Version and the exercises contained in its accompanying laboratory manual. The before-mentioned lectures were devoted to background information related to the version in which teachers needed further study. The teachers spent six hours per week for the first four weeks of the training period doing the Blue Version laboratory exercises, writing laboratory reports on them, and using inquiry methods in discussing each of them. Approximately the last three weeks were spent working with the genetics block study. The

procedure followed was similar to that followed when working through the Blue Version laboratory exercises.

The Group "C" biology teachers received their training during the summer of 1966 in a program lasting eight weeks. Participants in this institute were required to be certified secondary teachers. Preference was given to those applicants with at least three years of teaching experience, 18 credit hours in biology, and to the teachers who indicated definite plans to use the BSCS Yellow Version in their teaching.

The objectives of the institute that Group "C" teachers attended included the following: (1) to develop an appreciation and understanding of the AIBS, BSCS materials; (2) to familiarize the participants with the unique features of the Yellow Version of BSCS materials; (3) to improve the biological competence of the participants by introducing them to recent advances in biology; and (4) to enable the participants to feel more competent in organizing and supervising laboratory experiments.

The course of study for these teachers included lectures, laboratory experiences, seminars and field trips. The lecture topics were directly related to the subject matter content of the Yellow Version Text. The laboratory experience included selected exercises from the laboratory manual that accompanies the Yellow Version. The seminars were designed to integrate the lecture information with the laboratory exercises. Field trips were used primarily to elucidate the principles of biology found in the Yellow Version.

The Group "D" biology teachers received their training in the use of BSCS materials during the summer of 1966 in a program which

lasted six weeks. The primary criteria for the selection of the participants included the following: a bachelor's degree; an indication of satisfactory scholarship and professional competence; currently teaching biology; and a demonstration of the ability to benefit from the Institute. Preference was given to those participants who had never attended a BSCS Institute and who planned to teach BSCS in the fall. The Institute was structured to prepare high school biology teachers to present new concepts contained in the BSCS Blue Version, with emphasis on molecular and evolutionary themes. Both theory and laboratory work were designed to develop the rationale of BSCS biology, which stresses investigational methods and the processes of science, as well as the acquisition of factual material.

Laboratory procedures, selected from BSCS Second Course Material and Laboratory Blocks were offered as alternatives, for those participants already having some familiarity with Blue Version Methods.

The course of study included lectures, discussions, seminars, laboratory and field work. The principal subjects covered during the Institute included: biochemistry, origin of life, statistics, genetics, ecology, cellular physiology, and plant and animal physiology.

The lectures and discussions followed the above listed sequence of subjects and incorporated the integrating concepts of evolution and molecular biology. The laboratory work emphasized investigation rather than confirmation and introduced open-ended problems.

Description of the Data Gathering Information

Five data gathering instruments were utilized in collecting the necessary information for the study. A brief

description of each of the instruments and the reasons for its being used follows:

The Attitude Inventory—The Attitude Inventory used in this study was used as one of the three measures utilized for determining the reaction of a selected group of biology teachers to the BSCS Biology Program. The Attitude Inventory was developed and used by Blankenship (19) in a related study.

The Attitude Inventory consists of forty-six concise statements which reflect either a view favorable to the BSCS Program or a view unfavorable to the Program. Half of the statements reflect attitudes and opinions commonly held by those persons who designed the BSCS Program; thus, agreement with these statements can be considered to represent attitudes favorable to the program. The other half of the statement reflect attitudes and opinions common to those persons who have spoken or written in favor of the traditional biology course or in opposition to the BSCS Program.

An individual's score on the Attitude Inventory was determined by computing the number of items checked which were favorable to the BSCS Program minus the number of items checked which were unfavorable to the BSCS Program. The maximum score possible on the Inventory, therefore, is a +23, indicating selection of all statements favorable to the BSCS Program. The minimum score possible was a -23, indicating selection of all statements not favorable to the BSCS Program.

In developing the Attitude Inventory, Blankenship thoroughly familiarized himself with the BSCS Program through a review of literature related to the Program and by interviews with research scientists and high school science teachers who were involved in

development of the BSCS material. By means of written comments from a group of science teachers who had studied the BSCS Program, Blankenship obtained information concerning teacher reactions to the materials. These teachers' comments were related to the strengths and weaknesses of the BSCS Program as each teacher interpreted its practicability for his own school situation. Included among this group of teachers were individuals who had indicated unfavorably reactions to the BSCS Biology Program. After careful study of the information that he had gathered, Blankenship, tentatively prepared a seventy-statement inventory. Half of the statements reflected attitudes and opinions held by persons who designed the BSCS Biology Program; thus favorable attitudes toward the Program. The other half of the statements reflected attitudes and opinions common to those persons who spoke or wrote in favor of the traditional biology course or in opposition to the BSCS Program.

This tentative inventory was administered to a group of people who had been involved with the design and development of the BSCS Program.

Through the use of an item analysis of the tentative inventory and by incorporating suggestions from those who had responded to the statements in the inventory, it was reduced from seventy items to fifty items. The basic format of the inventory was retained. The order of the statements in the inventory was determined through the use of a table of random members. This fifty-item inventory was resubmitted to the examining group for suggestions and, following a second revision, the final form of the inventory was reduced to forty-six concise statements.

Blankenship's Attitude Inventory was selected for use in this study for two main reasons: (1) it was designed specifically to ascertain the reaction to the BSCS Program of science teachers who were thoroughly familiar with the Program and (2) because of its effectiveness in assessing teacher attitude. Blankenship (20), writing on the effectiveness of methods of determining science teacher attitudes toward the BSCS Biology Program, reports that the Attitude Inventory, when used with a Peer Rating, was 72 per cent accurate in identifying teacher attitudes toward BSCS biology. This rate of accuracy was based on the use of the top and lower quarter scores on the Attitude Inventory as indications of the favorable and unfavorable attitudes, respectively. Blankenship reports that had he used the upper and lower halves of scores on the Inventory to indicate favorable and unfavorable attitudes, the combined effectiveness of the Attitude Inventory and the Peer Rating would have been 96 per cent accurate.

The Attitude Inventory was administered to the biology teacher sample at the conclusion of the summer training program. A copy of the Inventory is included in the appendix.

The Peer Rating-- At the conclusion of the training periods each biology teacher was asked to perform a peer rating in the following manner. Each individual was given a list of names of all the participants in the program. The individual was then asked to locate his own name on the list and circle it. Then, beginning with the first name on the roster, each individual was asked to compare himself with the person whose name was being considered and decide whether he, the rater, possessed a more favorable attitude toward the BSCS Biology Program than the other individual being considered. If the rater

considered himself more favorable than the person whose name he was considering, he would place a plus mark for himself by the name of that person. Conversely, if the rater considered himself to possess a less favorable attitude than the person whose name he was considering, he would place a minus sign for himself by that person's name. The rater was to continue, considering each name on the list, one at a time, compared with his own name, until he had given himself a plus or minus rating by each name.

The completed peer ratings, when placed on a two-way grid and tabulated, yielded two evaluations—the relative position in the group of each individual as seen by himself and the relative position in the group of each individual as seen by all the other group members. Previous research studies (20, 44) have revealed that after individuals have worked closely together in training situations similar to the BSCS training program, the members of the group are able to evaluate rather accurately the attitudes of their peers.

The Peer Rating score used in this study was obtained by determining the relative position of each indivdual in the group as seen by all the other group members. This relative position was determined by counting the plus ratings assigned to a particular individual by his peers. The individual receiving the lowest number of plus ratings would be seen by his fellow students as being most favorable to the program and the person receiving the greatest number of plus ratings would be seen as being least favorable.

The Instructors' Rating—At the conclusion of the summer training programs, each instructor was given a list of the names of the individuals in the program. The instructor was asked to indicate beside

the name of each individual the attitude of that individual toward the BSCS Biology Program. The instructors were asked to base this rating on any behavior demonstrated by the individual, which definitely, in the judgment of the instructor, placed the individual in either the favorable attitude or unfavorable attitude category. If the individual had not committed himself, the instructor was asked to indicate this.

The Laboratory Checklist--The Laboratory Checklist utilized in this study was developed by the investigator in order to obtain information concerning the extent of the laboratory work experiences of each of the biology teachers. The Checklist was prepared for two reasons: (1) the writer desired to investigate the total number of laboratory courses completed by each biology teacher in relation to his reaction to the BSCS Biology Program and (2) in most cases, the teachers' application forms did not distinguish between laboratory and nonlaboratory courses.

In developing the Checklist, the investigator studied several college and university catalogs to ascertain the science courses and course titles that are most commonly offered. In cases where course titles differed but the course descriptions were similar, a broader course title was used. The catalog information, along with suggestions from several persons who advise biology teacher trainees, was used to prepare a general outline of the more common science subdisciplines and the courses most often offered within these subdisciplines.

After obtaining the information from the NSF Application Forms, a comparison was made between the science courses completed by each of the biology teachers involved in this study and the above-mentioned

general outline. On the basis of this comparison, the general outline was modified to form the Laboratory Checklist.

In the Laboratory Checklist, the courses are arranged in science subdisciplines with blank spaces provided for writing in additional courses not included in the Checklist. When completing the instrument, teachers were instructed to check only the science courses completed by them that were accompanied by laboratory work, thus indicating the total number of laboratory courses completed by each teacher.

Each teacher's score on the Checklist was obtained by counting the number of courses that had been checked. The Checklist was administered to each of the biology teachers at the conclusion of their summer training program. A copy of the instrument is included in the appendix.

The statistical methods used in the analysis of the data are described and the findings of the study are presented in Chapter IV.

CHAPTER IV

FINDINGS OF THE STUDY

The results of this study are summarized in Tables I through XVI which are located in the following pages.

The science teachers were classified into three categories based upon their composite ratings on the three attitude measures. The three categories were: 1) those science teachers who had clearly demonstrated a more favorable attitude toward the BSCS Biology Program; 2) those science teachers who had clearly demonstrated a less favorable attitude toward the BSCS Biology Program; and 3) those science teachers whose attitude could not clearly be determined.

The criteria for being placed in the category of possessing a more favorable attitude were: a score in the top quarter of the Attitude Inventory; or a rating in the top quarter of the Peer Rating as rated by fellow students. In addition, to be considered as possessing a more favorable attitude, the teacher must have been given either a more favorable attitude rating or an indeterminate attitude rating by the instructors; a less favorable attitude rating by the instructors prevented an individual from being considered more favorable. The teacher was considered as possessing a less favorable attitude if he scored in the bottom quarter on either the Attitude Inventory or the Peer Rating; or if he received a less favorable attitude rating from the instructor. Teachers not falling in either the more favorable

or less favorable attitude categories were placed in an indeterminate attitude category.

The above-mentioned criteria for classification of the samples into the three categories were set forth prior to the beginning of the collection of the data.

The results of the categorizing of the four groups of biology teachers that were involved in the study were as follows: 1) Group "A" with an N of 39, 14 more favorable, 16 less favorable, and 9 indeterminate; 2) Group "B" with an N of 27, 8 more favorable, 12 less favorable, and 7 indeterminate; 3) Group "C" with an N of 50, 14 more favorable, 20 less favorable, and 16 indeterminate; 4) Group "D" with an N of 48, 17 more favorable, 20 less favorable, and 11 indeterminate.

After categorizing the biology teachers into more favorable and less favorable groups, the science and mathematics courses completed by each of the teachers within these two groups were compared with the subject matter areas and courses that had been selected by the investigator as a basis for determining the pattern of preparation of each teacher. The comparison was accomplished by arranging the nineteen subject matter areas and courses that comprised the investigator's "pattern" and the code numbers of the more favorable and less favorable biology teachers along the top and side of a two-way grid. (Groups "A", "B", "C", and "D" were considered separately in this endeavor.) Then, by considering each teacher's code number individually, check marks were placed in the spaces on the grid that correspond to the code number of the teacher and the "pattern" subject matter areas and courses in which each had completed work that was identical or similar in nature. Courses similar in nature were

construed to be those courses that had different titles but encompassed the same scientific principles. For example, general biology and natural science were considered sufficiently similar to be listed together under general biology in the grid. Among other similar courses encountered were courses entitled plant morphology and plant kingdom. These were listed together as plant morphology.

Following the comparisons of individual teacher's science and mathematics background with the "pattern", the investigator compared the science and mathematics preparation of the more favorable and less favorable teachers. This was effected by, first, taking each Group separately, counting the number of check marks appearing under each of the nineteen "pattern" areas of study. This gave the number of biology teachers within both the more favorable and less favorable categories who had finished work corresponding to the "pattern".

The results of the comparisons made between the academic patterns of training of the more favorable and less favorable teachers, with each group treated separately, were tested through the use of the Chi Square 2x2 fold contingency table, corrected for continuity. The test is reported by Garrett (8) as being appropriate for testing this type of data. The formula that was used is:

$$X_c^2 = \frac{N(/AD-BC/ - \frac{1}{2}N)^2}{(A+B)\ (C+D)\ (A+C)\ (B+D)}$$

When Groups "A", "B", "C", and "D" were combined and comparisons were made between their academic patterns of training, the additive property of Chi Square was used. According to Garrett (8), this is an acceptable procedure:

> When several X^2's have been computed from independent experiments (i.e., from tables based upon different samples), these may be summed to give a new chi square with df=the sum of the separate df's. The fact that chi squares may be added to provide an overall test of a hypothesis is important in many experimental studies. . . . Combining the data from several experiments will often yield a conclusive result, when separate experiments, taken alone, provide only indications.

For a discussion of the results of these comparisons and tests, attention is directed to the tables in the chapter.

In Table I, there is shown, for Group "A", the distribution of variables, the percentage differences in the distribution of the variables among the more favorable and significance of the differences in the distribution of the nineteen variables. In the table, two facts are apparent: the difference in the distribution of only one of the nineteen variables is statistically significant, and the distribution of the remaining 18 variables are not statistically significant; and for each of the nineteen variables, a slightly higher per cent, with the exception of one variable, of the more favorable teachers had completed work in the variables than had the less favorable teachers.

In Table II, pertaining to Group "A", is recorded the distribution of the variables, the differences in the distribution of the variables completed and not completed among the more favorable biology teachers. Chi squares and the statistical significance of the differences in the distribution of the nineteen variables are included in the table. Information in Table II reveals that the differences in the distribution of six of the variables are statistically significant; threee at the .01 level of confidence, two at the .02 level, and one at the .05 level. The differences in the distribution of the remaining 14

TABLE I

THE DISTRIBUTION OF VARIABLES, THE PERCENTAGE DIFFERENCES IN THE DISTRIBUTION OF THE VARIABLES AMONG THE MORE FAVORABLE AND LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND SIGNIFICANCE OF THE DIFFERENCES OF THE NINETEEN VARIABLES

GROUP "A"

VARIABLE	MF*	LF*	%MF-%LF	CHI SQ.	SIGNIFICANCE
V- 1 Gen. Bio.	8	10	-5.36	0.00056	N.S.
V- 2 Gen. Bot.	12	12	10.71	0.0753	N.S.
V- 3 Plant Morph.	5	2	23.51	1.1388	N.S.
V- 4 Plant Physio.	1	1	.89	0.4042	N.S.
V- 5 Sys. Bot.	6	5	11.60	0.536	N.S.
V- 6 Gen. Zoo.	14	15	6.25	0.9052	N.S.
V- 7 Animal Physio.	13	9	36.60	3.4159	N.S.
V- 8 Genetics	11	9	22.32	0.8203	N.S.
V- 9 Embryology	12	9	29.45	1.9384	N.S.
V-10 Ecology	9	6	26.78	1.2054	N.S.
V-11 Evolution	4	1	22.32	1.3125	N.S.
V-12 Microbio.	10	6	33.92	2.2248	N.S.
V-13 1 yr. Gen. Chem.	11	3	59.82	0.8203	N.S.
V-14 1 crs. Org. Chem.	6	6	5.35	0.0056	N.S.
V-15 1 yr. Physics	7	5	18.75	0.4520	N.S.
V-16 1 crs. Earth Sci.	5	2	23.21	1.1388	N.S.
V-17 1 yr. Math.	7	5	18.75	0.4520	N.S.
V-18 Methods Crs.	10	7	27.67	1.3387	N.S.
V-19 14 lab. crs.	10	4	46.42	5.6255	.02

*MF - More favorable teachers (N of MF teachers - 14)

*LF - Less favorable teachers (N of LF teachers - 16)

variables are not statistically significant. Another fact that can be noted from the table is that the differences in the distribution of eleven of the variables are in favor of the more favorable teachers who had completed work in each of the variables.

In Table III, also relating to Group "A", is shown the distribution of the variables and differences in the distribution of the variables completed and not completed among the less favorable biology teachers, chi squares, and the significance of the differences in the distribution of the nineteen variables. It can be noted in this table that the differences of the distribution of seven of the variables are statistically significant while the differences in the distribution of the remaining 12 variables are not significant. For variable "2", which is significant at the .02 level of confidence, the differences in its distribution are positive. For the other six variables which are statistically significant, the differences in their distribution are negative. This means that for variable "2" more less favorable teachers had completed a course in general botany than less favorable teachers who had not completed the course. The converse is true for the remaining six variables in question. Table III further reveals that for 13 of the variables, although only five are statistically significant, the differences in their distribution are negative. This indicates that a fewer number of the less favorable teachers who had completed the variables were found than less favorable teachers who had not completed them.

A comparison between the data in Table II and III reveals that the statistically significant differences in the distribution of three of the variables, general botany, general zoology, and plant physiology

TABLE II

THE DISTRIBUTION AND THE DIFFERENCE IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE MORE FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "A"

VARIABLE	MF_c *	MF_{nc} *	$MF_c - MF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1 Gen. Bio.	8	6	2	0.7142	N.S.
V- 2 Gen. Bot.	12	2	10	5.7858	.02
V- 3 Plant Morph.	5	9	- 4	0.6428	N.S.
V- 4 Plant Physio.	1	13	-12	8.6428	.01
V- 5 Sys. Bot.	6	8	- 2	0.7142	N.S.
V- 6 Gen. Zoo.	14	0	14	12.0714	.01
V- 7 Animal Physio.	13	1	12	8.6428	.01
V- 8 Genetics	11	2	9	4.3423	.05
V- 9 Embryology	12	2	10	5.7858	.02
V-10 Ecology	9	5	4	0.6450	N.S.
V-11 Evolution	4	10	- 6	1.7858	N.S.
V-12 Microbio.	10	4	6	1.7858	N.S.
V-13 1 yr. Gen. Chem.	11	3	8	3.5000	N.S.
V-14 1 crs. Org. Chem.	6	8	- 2	0.7142	N.S.
V-15 1 yr. Physics	7	7	0	0	N.S.
V-16 1 crs. Earth Sci.	5	9	- 4	0.6424	N.S.
V-17 1 yr. Math.	7	7	0	0	N.S.
V-18 Methods Crs.	10	4	6	1.7858	N.S.
V-19 14 lab. crs.	10	4	6	1.7858	N.S.

*MF_c - more favorable teachers who had completed the courses

*MF_{nc} - more favorable teachers who had not completed the courses

N of MF - 14

TABLE III

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "A"

VARIABLE	LF_c*	LF_{nc}*	$LF_c - LF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1 Gen. Bio.	10	6	4	0.5626	N.S.
V- 2 Gen. Bot.	12	4	8	6.3234	.02
V- 3 Plant Morph.	2	14	-12	7.5626	.01
V- 4 Plant Physio.	1	15	-14	10.5626	.01
V- 5 Sys. Bot.	5	11	- 6	1.5626	N.S.
V- 6 Gen. Zoo.	15	1	14	10.5626	.01
V- 7 Animal Physio.	9	7	2	0.0626	N.S.
V- 8 Genetics	9	7	2	0.0626	N.S.
V- 9 Embryology	7	9	- 2	0.0626	N.S.
V-10 Ecology	6	10	- 4	0.0626	N.S.
V-11 Evolution	1	15	-14	10.5626	.01
V-12 Microbio.	6	10	- 4	0.5626	N.S.
V-13 1 yr. Gen. Chem.	9	7	2	0.5626	N.S.
V-14 1 crs. Org. Chem.	6	10	- 4	0.5626	N.S.
V-15 1 yr. Physics	5	11	- 6	1.5626	N.S.
V-16 1 crs. Earth Sci.	2	14	-12	7.5626	.01
V-17 1 yr. Math.	5	11	- 6	1.5626	N.S.
V-18 Methods Crs.	7	9	- 2	0.0626	N.S.
V-19 14 lab. crs.	4	12	- 8	6.3234	.02

*LF_c - the less favorable teachers who had completed the courses

*LF_{nc} - the less favorable teachers who had not completed the courses

N of LF teachers - 16

are common in both tables. If the variable, general botany, is noted, it can be seen that a greater number of the more favorable teachers had completed the course than the more favorable teachers who had not completed it. Also within the less favorable group, a greater number of the teachers who had completed general botany than the less favorable teachers who had not completed the course can be seen. This would imply that there was no relationship between the completion of a course in general botany, specifically, and the biology teachers' reactions to the BSCS Biology Program. The same comparison between the two groups can be noted for general zoology. In the case of plant physiology, an overwhelming majority of both the more favorable and less favorable teachers had not completed the course. This, too, would indicate that plant physiology was not necessarily a factor in teachers' attitudes toward BSCS.

In Table IV is shown for Group "B" teachers, the distribution of variables, the percentage differences in the distribution of the variables among more favorable and less favorable biology teachers, chi squares, and the statistical significance of the differences in the distribution of the nineteen variables. The information in the table discloses that the distribution of only one variable, a science teachers' methods course, is statistically significant. The differences in the distribution of the remaining 18 variables are not statistically significant. It can be noted, however, with the exception of two variables, that a higher percentage of the more favorable teachers had completed each of the variables than had the less favorable teachers.

TABLE IV

THE DISTRIBUTION OF VARIABLES, THE PERCENTAGE DIFFERENCES IN THE DISTRIBUTION OF THE VARIABLES AMONG THE MORE FAVORABLE AND LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND SIGNIFICANCE OF THE DIFFERENCES OF THE NINETEEN VARIABLES

GROUP "B"

	VARIABLE	MF*	LF*	%MF-%LF	CHI SQ.	SIGNIFICANCE
V- 1	Gen Bio.	8	7	41.67	1.4695	N.S.
V- 2	Gen. Bot.	7	9	-12.50	0.0130	N.S.
V- 3	Plant Morph.	5	2	45.84	2.6465	N.S.
V- 4	Plant Physio.	2	0	25.00	1.1343	N.S.
V- 5	Sys. Bot.	4	1	41.67	2.5000	N.S.
V- 6	Gen. Zoo.	8	10	-16.67	0.2083	N.S.
V- 7	Animal Physio.	6	5	33.54	1.0185	N.S.
V- 8	Genetics	7	5	46.04	2.5087	N.S.
V- 9	Embryology	2	1	16.67	1.4706	N.S.
V-10	Ecology	4	4	16.67	0.0781	N.S.
V-11	Evolution	4	1	47.67	2.5000	N.S.
V-12	Microbio.	4	3	25.00	0.4487	N.S.
V-13	1 yr. Gen. Chem.	5	7	4.17	0.0781	N.S.
V-14	1 crs. Org. Chem.	5	4	29.17	0.6818	N.S.
V-15	1 yr. Physics	4	5	8.54	0.0084	N.S.
V-16	1 crs. Earth Sci.	3	5	3.93	0.0781	N.S.
V-17	1 yr. Math.	5	3	37.50	1.4670	N.S.
V-18	Methods Crs.	6	0	75.00	8.9286	.01
V-19	14 lab. crs.	6	4	41.67	1.8750	N.S.

*MF - more favorable teachers (N of MF teachers - 8)

*LF - less favorable teachers (N of LF teachers - 12)

Tables V and VI are concerned with Group "B" teachers and report the distribution and differences in the distribution of the variables completed and not completed among the more favorable teachers and among the less favorable teachers, respectively. Chi squares and the statistical significance of the differences in the distribution of the nineteen variables are also included in each of the two tables. It can be seen in Table V that the differences in the number of more favorable teachers who had completed the variables and more favorable teachers who had not oompleted the variables are statistically significant for only two of the nineteen variables. Both are significant at the .02 level of confidence. Although the differences in the distribution of only two the variables are statistically significant, the data reveals that for eleven of the variables, a greater number of the more favorable teachers had completed the variables than those more favorable teachers who had not completed them. It is shown in Table V that the differences in the distribution of the variables among the less favorable teachers are significant for seven of the nineteen variables. Also, it can be noted that a larger number of the less favorable teachers had not completed 15 of the variables than the less favorable teachers who had completed them.

When Tables V and VI, both concerned with Group "B" teachers, are compared, it can be observed that only one of the statistically significant differences in the distribution of the variables is common to the two groups. This being general zoology. A closer look at this variable reveals that a greater number of both more favorable and less favorable teachers had completed the course than those teachers in each

TABLE V

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE MORE FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "B"

	VARIABLE	MF_c*	MF_{nc}*	$MF_c - MF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	8	0	8	6.1250	.02
V- 2	Gen. Bot.	7	1	6	3.1250	N.S.
V- 3	Plant Morph.	5	3	2	1.2500	N.S.
V- 4	Plant Physio.	2	6	-4	1.2500	N.S.
V- 5	Sys. Bot.	4	4	0	0	N.S.
V- 6	Gen. Zoo.	8	0	8	6.1260	.02
V- 7	Animal Physio.	6	2	4	1.2500	N.S.
V- 8	Genetics	7	1	6	3.1250	N.S.
V- 9	Embryology	2	6	-4	1.1250	N.S.
V-10	Ecology	4	4	0	0	N.S.
V-11	Evolution	4	4	0	0	N.S.
V-12	Microbio.	4	4	0	0	N.S.
V-13	1 yr. Gen. Chem.	5	3	2	1.2500	N.S.
V-14	1 crs. Org. Chem.	5	3	2	1.2500	N.S.
V-15	1 yr. Physics	4	4	0	0	N.S.
V-16	1 crs. Earth Sci.	3	5	-2	1.2500	N.S.
V-17	1 yr. Math.	5	3	4	1.2500	N.S.
V-18	Methods Crs.	6	2	4	1.1250	N.S.
V-19	14 lab. crs.	6	2	4	1.1250	N.S.

*MF_c - more favorable teachers who had completed the courses

*MF_{nc} - more favorable teachers who had not completed the courses

N of MF - 8

TABLE VI

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "B"

	VARIABLE	LF_c*	LF_{nc}*	$LF_c - LF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	7	5	2	0.0833	N.S.
V- 2	Gen. Bot.	9	3	6	2.0833	N.S.
V- 3	Plant Morph.	2	10	-8	4.0834	.05
V- 4	Plant Physio.	0	12	-12	10.0834	.01
V- 5	Sys. Bot.	1	11	-10	6.7500	.01
V- 6	Gen. Zoo.	10	2	8	4.0834	.05
V- 7	Animal Physio.	5	7	-2	0.0833	N.S.
V- 8	Genetics	5	7	-2	0.0833	N.S.
V- 9	Embryology	1	11	-10	6.7500	.01
V-10	Ecology	4	8	-4	0.7500	N.S.
V-11	Evolution	1	11	-10	6.7500	.01
V-12	Microbio.	3	9	-6	2.0834	N.S.
V-13	1 yr. Gen. Chem.	7	5	2	0.0833	N.S.
V-14	1 crs. Org. Chem.	4	8	-4	0.7500	N.S.
V-15	1 yr. Physics	5	7	-2	0.0833	N.S.
V-16	1 crs. Earth Sci.	5	7	-2	0.0833	N.S.
V-17	1 yr. Math.	3	6	-3	2.0834	N.S.
V-18	Methods Crs.	0	12	-12	10.0834	.01
V-19	14 lab. crs.	4	12	-8	0.7500	N.S.

*LF_c - the less favorable teachers who had completed the courses

*LF_{nc} - the less favorable teachers who had not completed the courses

N of LF teachers - 12

respective groups who had not completed the course. This would imply that the completion of general zoology, in Group "B", was not, specifically, related to the teachers' attitudes toward BSCS.

Table VII records, for Group "C" teachers, the distribution of the nineteen variables, and the percentage differences in the distribution of the variables among the more favorable and less favorable biology teachers. Also, recorded are chi squares and the statistical significance of the differences in the distribution of the variables. From the table, it can be observed that the differences in the distribution of four of the variables are statistically significant, and the differences in the distribution of the other 15 variables are not statistically significant. Also, it can be seen that a higher percentage of more favorable teachers than the less favorable teachers had completed 14 of the 19 variables.

In Tables VIII and IX, concerned with Group "C", are shown the distribution of the variables and differences in the distribution of the variables completed and not completed among more favorable teachers and less favorable teachers, respectively. In addition, the two tables record chi squares and the statistically significance of the distribution of the variables. The data in Table VIII reveals that the differences in the distribution of six of the nineteen variables are statistically significant, and, with the exception of three variables, a larger number of more favorable teachers had completed each of the variables than those more favorable teachers who had not completed the variables. In Table IX, it is shown that the differences in the distribution of five of the nineteen variables are statistically significant. It can be noted, also, that a greater

TABLE VII

THE DISTRIBUTION OF VARIABLES, THE PERCENTAGE DIFFERENCES IN THE DISTRIBUTION OF THE VARIABLES AMONG THE MORE FAVORABLE AND LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND SIGNIFICANCE OF THE DIFFERENCES OF THE NINETEEN VARIABLES

GROUP "C"

	VARIABLE	MF*	LF*	%MF-%LF	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	11	13	- .30	0.1008	N.S.
V- 2	Gen. Bot.	16	10	44.40	6.6300	.02
V- 3	Plant Morph.	11	2	54.70	9.8443	.01
V- 4	Plant Physio.	5	1	24.41	2.4719	N.S.
V- 5	Sys. Bot.	9	4	32.94	3.0819	N.S.
V- 6	Gen. Zoo.	15	15	13.23	0.3778	N.S.
V- 7	Animal Physio.	15	16	- 8.23	0.1059	N.S.
V- 8	Genetics	8	11	- 2.95	0.2580	N.S.
V- 9	Embryology	9	10	- 2.94	0.2040	N.S.
V-10	Ecology	10	6	28.82	2.0728	N.S.
V-11	Evolution	5	6	- .59	0.0974	N.S.
V-12	Microbio.	14	11	27.35	2.0404	N.S.
V-13	1 yr. Gen. Chem.	14	14	12.35	0.2487	N.S.
V-14	1 crs. Org. Chem.	10	9	13.85	0.2676	N.S.
V-15	1 yr. Physics	13	9	31.47	2.1690	N.S.
V-16	1 crs. Earth Sci.	6	2	25.29	2.1690	N.S.
V-17	1 yr. Math.	14	9	37.35	4.0153	.05
V-18	Methods Crs.	12	9	25.58	1.0896	N.S.
V-19	14 lab. crs.	13	6	46.47	6.2366	.02

*MF - More favorable teachers (N of MF teachers - 27)

*LF - Less favorable teachers (N of LF teachers - 20)

TABLE VIII

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE MORE FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "C"

	VARIABLE	MF_c*	MF_{nc}*	$MF_c - MF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio	11	6	5	0.9410	N.S.
V- 2	Gen. Bot.	16	1	15	11.0588	.01
V- 3	Plant Morph.	11	6	5	0.9410	N.S.
V- 4	Plant Physio.	5	12	- 7	2.1176	N.S.
V- 5	Sys. Bot.	9	8	1	0.1176	N.S.
V- 6	Gen. Zoo.	15	2	13	8.4704	.01
V- 7	Animal Physio.	15	2	13	8.5704	.01
V- 8	Genetics	8	9	- 1	0.1176	N.S.
V- 9	Embryology	9	8	1	0.1176	N.S.
V-10	Ecology	10	7	3	0.2352	N.S.
V-11	Evolution	5	12	7	2.1176	N.S.
V-12	Microbio.	14	3	11	5.8822	.05
V-13	1 yr. Gen. Chem.	14	3	11	5.8822	.05
V-14	1 crs. Org. Chem.	10	7	3	0.2352	N.S.
V-15	1 yr. Physics	13	4	9	3.7646	N.S.
V-16	1 crs. Earth Sci.	6	11	- 5	2.1689	N.S.
V-17	1 yr. Math.	14	3	11	5.8822	.05
V-18	Methods Crs.	12	5	7	2.1176	N.S.
V-19	14 lab. crs.	13	4	9	3.7646	N.S.

*MF_c - more favorable teachers who had completed the courses

*MF_{nc} - more favorable teachers who had not completed the courses

N of MF - 17

TABLE IX

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "C"

	VARIABLE	LF_c*	LF_{nc}*	$LF_c - LF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	13	7	7	1.2500	N.S.
V- 2	Gen. Bot.	10	10	0	0	N.S.
V- 3	Plant Morph.	2	18	-16	11.2500	.01
V- 4	Plant Physio.	1	19	-18	14.4500	.01
V- 5	Sys. Bot.	4	16	-12	6.0500	.02
V- 6	Gen. Zoo.	15	5	10	3.4050	N.S.
V- 7	Animal Physio.	16	4	12	6.0500	.02
V- 8	Genetics	11	9	2	0.0500	N.S.
V- 9	Embryology	10	10	0	0	N.S.
V-10	Ecology	6	14	- 8	2.4500	N.S.
V-11	Evolution	6	14	- 8	2.4500	N.S.
V-12	Microbio.	11	9	2	0.5000	N.S.
V-13	1 yr. Gen. Chem.	14	6	8	2.4500	N.S.
V-14	1 crs. Org. Chem.	9	11	- 2	0.0500	N.S.
V-15	1 yr. Physics	9	11	- 2	0.0500	N.S.
V-16	1 crs. Earth Sci.	2	18	-16	11.2520	.01
V-17	1 yr. Math.	9	11	- 2	0.5000	N.S.
V-18	Methods Crs.	9	11	- 2	0.5000	N.S.
V-19	14 lab. crs.	6	14	- 8	2.4500	N.S.

*LF_c - the less favorable teachers who had completed the courses

*LF_{nc} - the less favorable teachers who had not completed the courses

N of LF teachers - 20

number of the less favorable teachers had not completed 11 of the 19 variables than the less favorable teachers who had completed the same variables.

A comparison among the differences in distribution of the variables which are significant in Tables VIII and IX discloses that only one of the significant differences is common to both groups. This being animal physiology. As has been the case previously, a greater number of more favorable teachers and less favorable teachers had completed the course than those in both groups who had not completed it; thus, the implication is that there was no relationship between the completion of animal physiology and teachers' attitudes toward the BSCS Program.

In Table X, relating to Group "D" teachers, is listed the distribution of the variables and the percentage differences in the distribution of the variables among the more favorable and less favorable biology teachers, chi squares and significance of the differences of the distribution of the nineteen variables. Of the nineteen variables, only the differences in the distribution of seven are statistically significant. For 16 of the variables, though, it can be observed that a higher percentage of the more favorable teachers had completed work in each of the variables than had the less favorable teachers.

In Tables XI and XII, for Group "D" teachers, are shown the distribution of the variables and the differences in the distribution of the variables completed and not completed among the more favorable teachers and among the less favorable teachers, respectively. In

TABLE X

THE DISTRIBUTION OF VARIABLES, THE PERCENTAGE DIFFERENCES IN THE DISTRIBUTION OF THE VARIABLES AMONG THE MORE FAVORABLE AND LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND SIGNIFICANCE OF THE DIFFERENCES OF THE NINETEEN VARIABLES

GROUP "D"

	VARIABLE	MF*	LF*	%MF-%LF	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	10	9	26.42	1.3843	N.S.
V- 2	Gen. Bot.	14	13	35.00	4.2152	.05
V- 3	Plant Morph.	7	3	35.00	3.3196	N.S.
V- 4	Plant Physio.	6	4	22.85	0.1176	N.S.
V- 5	Sys. Bot.	6	4	22.85	0.1176	N.S.
V- 6	Gen. Zoo.	14	17	-15.00	0.8161	N.S.
V- 7	Animal Physio.	11	16	- 1.43	0.1086	N.S.
V- 8	Genetics	11	8	38.57	3.5382	N.S.
V- 9	Embryology	7	4	30.00	2.1545	N.S.
V-10	Ecology	10	4	51.42	6.9947	.01
V-11	Evolution	10	6	41.42	4.1323	.05
V-12	Microbio.	7	8	10.00	0.0455	N.S.
V-13	1 yr. Gen. Chem.	14	10	50.00	7.6545	.01
V-14	1 crs. Org. Chem.	9	7	29.28	1.7813	N.S.
V-15	1 yr. Physics	7	2	40.00	4.8706	.05
V-16	1 crs. Earth Sci.	6	3	27.85	2.0082	N.S.
V-17	1 yr. Math.	7	9	- 5.00	0.0038	N.S.
V-18	Methods Crs.	9	3	49.28	7.5359	.01
V-19	14 lab. crs.	11	5	53.57	6.2366	.02

*MF - More favorable teachers (N of MF teachers - 14)

*LF - Less favorable teachers (N of LF teachers - 20)

TABLE XI

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE MORE FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "D"

	VARIABLE	MF_c*	MF_{nc}*	$MF_c - MF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	10	4	6	1.7958	N.S.
V- 2	Gen. Bot.	14	0	14	12.072	.01
V- 3	Plant Morph.	7	7	0	0	N.S.
V- 4	Plant Physio.	6	8	-2	0.7142	N.S.
V- 5	Sys. Bot.	6	8	-2	0.7142	N.S.
V- 6	Gen. Zoo.	14	0	14	12.0712	.01
V- 7	Animal Physio.	11	3	8	3.5000	N.S.
V- 8	Genetics	11	3	8	3.5000	N.S.
V- 9	Embryology	7	7	0	0	N.S.
V-10	Ecology	10	4	6	1.7858	N.S.
V-11	Evolution	10	4	6	1.7858	N.S.
V-12	Microbio.	7	7	0	0	N.S.
V-13	1 yr. Gen. Chem.	14	0	14	12.072	.01
V-14	1 crs. Org. Chem.	9	5	4	1.1428	N.S.
V-15	1 yr. Physics	7	7	0	0	N.S.
V-16	1 crs. Earth Sci.	6	8	-2	0.7142	N.S.
V-17	1 yr. Math.	7	7	0	0	N.S.
V-18	Methods Crs.	9	5	4	1.1428	N.S.
V-19	14 lab. crs.	11	3	8	3.5000	N.S.

*MF_c - more favorable teachers who had completed the courses

*MF_{nc} - more favorable teachers who had not completed the courses

N of MF - 14

TABLE XII

THE DISTRIBUTION AND THE DIFFERENCE IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

GROUP "D"

	VARIABLE	LF_c*	LF_{nc}*	$LF_c - LF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	9	11	- 2	0.5000	N.S.
V- 2	Gen. Bot.	13	7	6	1.2500	N.S.
V- 3	Plant Morph.	3	17	-14	8.4500	.01
V- 4	Plant Physio.	4	16	-12	6.0500	.02
V- 5	Sys. Bot.	4	16	-12	6.0500	.02
V- 6	Gen. Zoo.	17	3	14	8.4500	.01
V- 7	Animal Physio.	16	4	12	6.0500	.02
V- 8	Genetics	8	12	- 4	0.4500	.01
V- 9	Embryology	4	16	-12	6.0500	.02
V-10	Ecology	4	16	-12	6.0500	.02
V-11	Evolution	6	14	- 8	2.4500	N.S.
V-12	Microbio.	8	12	- 4	0.4500	N.S.
V-13	1 yr. Gen. Chem.	10	10	0	0	N.S.
V-14	1 crs. Org. Chem.	7	13	- 6	1.2500	N.S.
V-15	1 yr. Physics	2	18	-16	11.2520	.01
V-16	1 crs. Earth Sci.	3	17	-14	8.4500	.01
V-17	1 yr. Math.	3	11	- 2	0.5000	N.S.
V-18	Methods Crs.	3	17	-14	8.4500	.01
V-19	14 lab. crs.	5	15	-10	4.5000	.05

*LF_c - the less favorable teachers who had completed the courses

*LF_{nc} - the less favorable teachers who had not completed the courses

N of LF teachers - 20

the tables also are recorded chi squares and the significance of the differences in the distribution of the nineteen variables. For the more favorable teachers, in Table XI, it can be seen that the differences in the distribution of only three of the nineteen variables are statistically significant. Another fact from the data in Table XI is that for 11 of the 19 variables a greater number of more favorable teachers had completed work in the variables than the more favorable teachers who had not completed the work. In Table XII, for the less favorable teachers of Group "D", it is shown that the differences in the distribution of 11 of the variables are statistically significant. Further observation reveals that for 15 of the 19 variables a greater number of less favorable teachers had not completed the variables than less favorable teachers who had completed them.

If the differences in the distribution of variables which are statistically significant in Tables XI and XII are compared, it is seen that none of the significant differences in the distribution of the variables are common to both groups.

In Table XIII can be observed, for the combined Groups "A", "B", "C", and "D", the distribution of variables and the percentage differences in the distribution of the variables among the more favorable and less favorable biology teachers. In addition, chi squares and the significance of the differences in the distribution of the 19 variables can be found. This data reveal that the differences in the distribution of five of the nineteen variables are statistically significant. The differences in the distribution of general botany and ecology are statistically significant at the .05 level of confidence. The differences in the distribution of plant morphology and

TABLE XIII

THE DISTRIBUTION OF VARIABLES, THE PERCENTAGE DIFFERENCES IN THE DISTRIBUTION OF THE VARIABLES AMONG THE MORE FAVORABLE AND LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND SIGNIFICANCE OF THE DIFFERENCES OF THE NINETEEN VARIABLES

COMBINED GROUPS

	VARIABLE	MF*	LF*	%MF-%LF	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	37	39	-12.46	2.9601	N.S.
V- 2	Gen. Bot.	49	44	27.75	10.9336	.05
V- 3	Plant Morph.	28	9	39.60	16.9492	.01
V- 4	Plant Physio.	14	6	17.59	5.1280	N.S.
V- 5	Sys. Bot.	25	14	26.58	6.7531	N.S.
V- 6	Gen. Zoo.	51	57	-12.40	2.1274	N.S.
V- 7	Animal Physio.	45	46	-17.26	4.6015	N.S.
V- 8	Genetics	37	33	21.29	6.8830	N.S.
V- 9	Embryology	30	24	21.31	5.5839	N.S.
V-10	Ecology	34	24	28.86	10.3510	.05
V-11	Evolution	23	14	22.81	8.0422	N.S.
V-12	Microbio.	35	28	24.86	4.7594	N.S.
V-13	1 yr. Gen. Chem.	44	34	33.01	8.8016	N.S.
V-14	1 crs. Org. Chem.	30	26	18.37	2.7363	N.S.
V-15	1 yr. Physics	31	21	27.61	7.9431	N.S.
V-16	1 crs. Earth Sci.	20	12	20.09	5.3941	N.S.
V-17	1 yr. Math.	35	26	27.80	5.9381	N.S.
V-18	Methods Crs.	37	19	41.87	18.8928	.01
V-19	14 lab. crs.	39	19	45.64	21.7323	.01

*MF - more favorable teachers (N of MF teachers - 53)

*LF - less favorable teachers (N of LF teachers - 68)

a science teachers' methods course are statistically significant at the .01 level of confidence. It can also be seen in the table that in a majority of cases, a greater percentage of more favorable teachers than less favorable teacher had completed work in each of the variables.

Table XIV, pertaining to the combined "A", "B", "C", and "D" Groups, contains the distribution and differences in the distribution of the variables completed and not completed among the more favorable biology teachers. Other information includes chi squares and significance of the differences in the distribution of the nineteen variables. Two facts are conspicuous in this table: the differences in the distribution of seven of the variables are statistically significant and for 15 of the 19 variables there is a greater number of the more favorable teachers who have completed work in these variables than those more favorable teachers who had not completed this work.

Table XV contains, for the combined Groups "A", "B", "C" and "D", the distribution and the differences in the distribution of the variables completed and not completed among the less favorable biology teachers. Also shown are chi squares and the significance of the differences in the distribution of the 19 variables. In this table it can be observed that the differences in the distribution of 13 of the variables are statistically significant. Too, it can be seen that for 14 of the 19 variables there are more less favorable teachers who had not completed the variables than less favorable teachers who had completed the variables. Further observations that may be made are that the differences in the distribution of two of the statistically significant variables, general zoology and animal physiology, favor the less favorable teachers who had completed the two courses. The

TABLE XIV

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE MORE FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCES IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

COMBINED GROUPS

	VARIABLE	MF_c*	MF_{nc}*	$MF_c - MF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	37	16	21	9.4760	N.S.
V- 2	Gen. Bot.	49	4	45	32.0416	.01
V- 3	Plant Morph.	28	25	3	3.5580	N.S.
V- 4	Plant Physio.	14	39	-25	12.7246	.02
V- 5	Sys. Bot.	25	28	- 3	1.5450	N.S.
V- 6	Gen. Zoo.	51	2	49	38.7390	.01
V- 7	Animal Physio.	45	8	37	21.8632	.01
V- 8	Genetics	37	16	21	10.2426	.05
V- 9	Embryology	30	23	13	7.0284	N.S.
V-10	Ecology	33	20	13	2.7660	N.S.
V-11	Evolution	23	30	-13	5.6892	N.S.
V-12	Microbio.	35	18	17	7.6680	N.S.
V-13	1 yr. Gen. Chem.	44	9	35	22.7036	.01
V-14	1 crs. Org. Chem.	30	23	13	3.3422	N.S.
V-15	1 yr. Physics	31	22	9	3.7646	N.S.
V-16	1 crs. Earth Sci.	20	33	-13	4.7755	N.S.
V-17	1 yr. Math.	33	20	13	7.0072	N.S.
V-18	Methods Crs.	37	16	21	6.2120	N.S.
V-19	14 lab crs.	40	13	27	10.1640	.05

*MF_c - more favorable teachers who had completed the courses

*MF_{nc} - more favorable teachers who had not completed the courses

N of MF - 53

TABLE XV

THE DISTRIBUTION AND THE DIFFERENCES IN THE DISTRIBUTION OF VARIABLES COMPLETED AND NOT COMPLETED AMONG THE LESS FAVORABLE BIOLOGY TEACHERS, CHI SQUARES AND THE SIGNIFICANCE OF THE DIFFERENCE IN THE DISTRIBUTION OF THE NINETEEN VARIABLES

COMBINED GROUPS

	VARIABLE	LF_c*	LF_{nc}*	$LF_c - LF_{nc}$	CHI SQ.	SIGNIFICANCE
V- 1	Gen. Bio.	39	29	10	2.3959	N.S.
V- 2	Gen. Bot.	44	24	20	9.6567	.05
V- 3	Plant Morph.	9	59	-50	31.3460	.01
V- 4	Plant Physio.	6	62	-56	41.1460	.01
V- 5	Sys. Bot.	14	54	-40	20.4126	.01
V- 6	Gen. Zoo.	57	11	46	23.5110	.01
V- 7	Animal Physio.	46	22	24	12.2459	.02
V- 8	Genetics	33	35	- 2	0.6459	N.S.
V- 9	Embryology	22	46	-24	12.8626	.02
V-10	Ecology	20	48	-28	9.8126	.05
V-11	Evolution	14	54	-40	22.2126	.01
V-12	Microbio.	28	40	-12	7.5460	N.S.
V-13	1 yr. Gen. Chem.	40	28	12	2.5959	N.S.
V-14	1 crs. Org. Chem.	26	42	-16	2.6126	N.S.
V-15	1 yr. Physics	21	47	-36	12.9479	.02
V-16	1 crs. Earth Sci.	12	56	-44	28.0976	.01
V-17	1 yr. Math.	26	42	-16	4.6460	N.S.
V-18	Methods Crs.	19	49	-30	19.0960	.01
V-19	14 lab. crs.	19	49	-30	15.2126	.01

*LF_c - the less favorable teachers who had completed the courses

*LF_{nc} - the less favorable teachers who had not completed the courses

N of LF teachers - 68

remaining significant differences in the distribution of the variables favor the less favorable teachers who had not completed them.

A comparison of Tables XIV and XV discloses that five of the differences in the distribution of the variables that are statistically significant are common to the data of both tables. However, for three of the variables, general botany, plant physiology, and general zoology, it can be noted that a greater number of both the less favorable and more favorable teachers had completed work in the courses than had the teachers who had not. This would imply that these courses, specifically, are not necessarily correlated with the teachers' reactions to the BSCS Biology Program.

Summary of the Findings

Through the use of an Attitude Inventory, a Peer Rating, and an Instructors' Rating, the four groups of biology teachers involved in this study were placed in three categories according to their demonstrated attitude toward the BSCS Biology Program. The categories used were more favorable, less favorable, and indeterminate. The results of this grouping were: 53 more favorable teachers, 68 less favorable teachers and 43 indeterminate teachers.

Three kinds of comparisons were made between the more favorable and the less favorable teachers. These comparisons were: (1) among the more favorable and less favorable teachers; (2) within the more favorable teacher groups; and (3) within the less favorable teacher groups. The results obtained, when these comparisons were made and chi square tests were applied, were as follows:

I. When a comparison of the differences in the distribution of the 19 subject matter areas (variables) among the more favorable and less favorable biology teachers was made, with each of the four Groups taken separately, the following results were found:

A. Group "A" and "B" had significant differences in the distribution of one variable; Group "C" had four; and Group "D" had seven. A comparison of the differences in the distribution of variables which were significant shows only three variables common to more than one Group. General botany was common to Groups "C" and "D" and a science methods course was found in Groups "B" and "D". Fourteen laboratory courses were common to Groups "A", "C", and "D".

B. Other results revealed that in each of the four Groups, a greater number of the more favorable teachers had completed more of the 19 variables than had the less favorable teachers.

II. When a comparison of the differences in the distribution of the 19 subject matter areas (variables) among the more favorable and less favorable teachers was made, with all Groups combined, the following results were found:

A. The differences in the distribution of only five of the 19 variables were statistically significant. These were: general botany, plant morphology, ecology, a science teachers' methods course, and 14 laboratory courses.

B. Other results showed that for 16 of the 19 variables a larger percent of the more favorable teachers than the less favorable teachers had completed the variables.

III. When a comparison of the differences in the distribution of the variables completed and not completed among the more favorable teachers was made, with each Group taken separately, the following results were found:

A. Group "A" had significant differences in the distribution of six variables; Group "B" had two; Group "C" had six; and Group "D" had three. Only four of the variables whose differences in distribution were statistically significant were common to more than one of the Groups. General zoology was found in all Groups; general botany was common to Groups "A", "C", and "D"; one year's work in general chemistry was found in both Groups "C" and "D"; and animal physiology was common to Groups "A" and "C".

B. For each of the 19 variables a larger number of the more favorable teachers had completed work than the more favorable teachers who had not completed work in a majority of the variables.

IV. When a comparison of the differences in the distribution of the variables completed and not completed among the more favorable teachers was made, with all Groups combined, the following results were found:

A. The differences in the distribution of seven of the nineteen variables were statistically significant. These variables were: general botany, plant physiology, general zoology, animal physiology, genetics, one year's work in general chemistry and 14 laboratory courses. In the case of plant physiology, it was found that a greater number of the more favorable teachers had not completed the course than the more favorable teachers who had completed it;

implying that the completion of the course was not necessarily related to the teachers' reactions to the BSCS Biology Program.

B. A greater number of the more favorable teachers had completed 16 of the 19 variables than those more favorable teachers who had not completed the variables.

V. When a comparison of the differences in the distribution of the variables completed and not completed among the less favorable teachers was made, with each of the Groups taken separately, the following results were found:

A. Groups "A" and "B" had significant differences in the distribution of seven of the variables; Group "C" had five; and Group "D" had eleven. A comparison of the differences in the distribution of the statistically significant variables showed that ten of the variables were common to two or more of the four Groups. Plant morphology and plant physiology were common in all Groups. General zoology was common to Groups "A", "B", and "C". Courses in earth science and systematic botany were common to Groups "A", "C", and "D" and Groups "B", "C", and "D", respectively. Significant differences in the distribution of 14 laboratory courses were found common to Groups "A" and "D"; embryology and a science teachers' methods course were common to Groups "B" and "D"; and animal physiology was common to both "C" and "D" Groups.

B. A closer look at the ten variables, cited above, revealed some enlightening information. Plant morphology and plant physiology were not completed by a majority of the less favorable teachers, but the same instance was true for the more favorable teachers. The differences in the distribution of general zoology was found

statistically significant in three of the less favorable groups, but a greater number of the less favorable teachers had completed the courses than the less favorable teachers who had not completed it. Also, the same was true for the more favorable teachers. The differences in the distribution of earth science, embryology, and systematic botany were found significant in two or more of the Groups, but here as well as in the more favorable groups of teachers, relatively few of the teachers had completed these two courses. Concerning animal physiology, the information was contradictory. In Group "C" more of the less favorable teachers had not completed the course than those who had, however, in Group "D", a greater number of the less favorable had completed the course than the less favorable teachers who had not completed it. Thus, a closer look at the differences in the distribution of seven of the ten significant variables showed that these courses, specifically, were not necessarily correlated with the teachers' attitudes toward the BSCS Biology Program.

VI. When a comparison of the differences in the distribution of the variables completed and not completed among the less favorable teachers was made, with all Groups combined, the following results were found:

A. The differences in the distribution of 13 of the 19 variables were statistically significant. The variables were: general botany, plant morphology, plant physiology, systematic botany, general zoology, animal physiology, embryology, ecology, evolution, one year's work in physics, one course in earth science, a science teachers' methods course, and 14 laboratory courses.

B. When a closer look was taken at the above-mentioned 13 variables, the following information was found: general botany, general zoology, and animal physiology had been completed by a greater number of the less favorable teachers and by a greater number of the more favorable teachers; plant morphology, plant physiology, embryology, and evolution had not been completed by a majority of either the less favorable or the more favorable teachers; systematic botany, physics, and earth science had not been completed by a majority of the less favorable teachers and about an equal number of the more favorable teachers had and had not completed the courses. Thus, the completion of ten of the thirteen variables seemed to show no correlation with the teachers' attitudes toward the BSCS Biology Program. However, the differences in the distribution of ecology, fourteen laboratory courses and a science teachers' methods course seemed to have been related to the teachers' attitudes toward the BSCS Biology Program.

VII. When the differences in the distribution of the variables, which were statistically significant and were common in two or more of the Groups (reference is made to Table XVI) were summarized, the following results were found:

A. Statistically significant differences in the distribution of seventeen of the nineteen variables were common to two or more of the Groups.

B. When the distribution of these seventeen variables were compared with the information concerning the same variables in the individual Tables (Table I - XV), the following was noted:

1. Animal physiology, general botany, and general zoology were completed by a greater number of both the more favorable and the less favorable teachers than the teachers in both categories who had not completed the courses. This would imply that the completion of these courses was not, necessarily, related to the teachers' attitudes toward the BSCS Biology Program.

2. A year's work in mathematics, general chemistry and physics and courses in microbiology, earth science and genetics were not found wifely distributed in the data of the Tables, therefore, it appeared that there were not correlations between the completion of these subject matter areas and courses and the teachers' reactions to the BSCS Biology Program.

3. Courses in plant morphology, plant physiology, embryology and evolution had not been completed by a majority of either the more favorable or the less favorable teachers. Systematic botany had not been completed by a majority of the less favorable teachers and approximately an equal number of the more favorable teachers had and had not completed the course. This would imply that the completion of these courses was not, necessarily, related to the teachers' attitudes toward the BSCS Biology Program.

4. The differences in the distribution of 14 laboratory courses, a science teachers' method course, and ecology were statistically significant in several of the various methods of comparing and testing the Groups; therefore, the conclusion that there was a relationship between the completion of these courses and the teachers' attitudes toward the BSCS Biology Program seemed warranted.

TABLE XVI

A COMPOSITE SUMMARY OF TABLES I-XV, SHOWING THE STATISTICALLY SIGNIFICANT DIFFERENCES IN THE DISTRIBUTION OF THE VARIABLES THAT ARE IN COMMON WHEN COMPARISONS ARE MADE AMONG MORE FAVORABLE AND LESS FAVORABLE TEACHERS, COMPARISONS AMONG THE MORE FAVORABLE TEACHERS AND COMPARISONS AMONG THE LESS FAVORABLE TEACHERS

	DISTRIBUTION OF VARIABLES					
	(Separate Groups) MF-LF	(Combined Groups) MF-LF	(Separate Groups) MF_c-MF_{nc}	(Combined Groups) MF_c-MF_{nc}	(Separate Groups) LF_c-LF_{nc}	(Combined Groups) LF_c-LF_{nc}
Animal Physiology	Gp A		Gp A,C	X*	Gp C,D	X
14 lab. courses	Gp A,C,D	X	Gp A	X	Gp A,D	X
Sci. Methods Crs.	Gp B,D	X			Gp B,D	X
Gen. Bot.	Gp C,D	X	Gp A,C,D	X	Gp A	X
Plant Morphology	Gp C	X			Gp A,B,C,D	X
1 yr. Mathematics	Gp C		Gp C			
Ecology	Gp D	X			Gp D	X
1 yr. of Gen. Chem.	Gp D		Gp A.C.D	X		
1 yr. of Physics	Gp D				Gp D	X
Plant Physiology	Gp A	X			Gp A,B,C,D	X
Gen. Zoology	Gp A,B,C,D	X			Gp A,B,D	X
Genetics	Gp A			X		
Microbiology	Gp C					
Sysematic Botany					Gp B,C,D	X
1 crs. in Earth Sci.					Gp A,C,D	X
Embryology					Gp B,D	X
Evolution	Gp D				Gp A,B	X

X - indicates that the variables were significant when the Groups were combined.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

Conclusions from the Study

The purpose of this investigation was to test the hypothesis that there are no significant differences in the distribution of courses in science and mathematics between science teachers who demonstrated a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrated a less favorable attitude toward the Program. In order to reduce this hypothesis to manageable terms, nineteen subject matter areas were selected as variables composing a "model academic pattern" of training for high school biology teachers.

The conclusions to be drawn from the findings of this study are discussed, in the most part, in terms of the nineteen questions (variables) posed in Chapter I; and in terms of the entire sample of high school biology teachers rather than as separate Groups.

When the statistically significant differences in the distribution of several of the 19 variables are observed in the Groups, compared separately, the completion or lack of completion of some of the variables appears to be related to the biology teachers' attitudes toward the BSCS Program; however, when comparisons are made of these same variables when the four Groups of teachers are combined, only

three of the variables seem to be related to the teachers' attitudes toward the BSCS Program.

Therefore, considering the four Groups of teachers as one sample of high school biology teachers, the questions posed to be answered in this study are answered in the following manner:

There is no significant difference in the distribution of a course completed in general biology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in general botany between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in plant physiology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in systematic botany between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in plant morphology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in general zoology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in animal physiology between science teachers who demonstrate a more favorable attitude the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in embryology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is a significant difference in the distribution of a course completed in ecology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in evolution between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in genetics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in microbiology between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of one year's study of general chemistry between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of a course completed in organic chemistry between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significance in the distribution of one year's study of physics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of the completion of at least one course in the earth sciences between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

There is no significant difference in the distribution of one year's study of college mathematics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program

and science teachers who demonstrate a less favorable attitude toward the Program.

There is a significant difference in the distribution of the completion of a course in the teaching of secondary science between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the BSCS Program.

There is a significant difference in the distribution of at least 14 courses that were accompanied by laboratory work between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

It can be noted above that the differences in the distribution of only three of the nineteen subject matter areas are statistically significant. These are ecology, a science teachers' method course, and at least 14 courses accompanied by laboratory work. When a comparison is made between the types of training usually received in these three areas and the philosophy of teaching and learning inherent in the BSCS Biology Program, it appears highly significant that a greater number of teachers who demonstrated a more favorable attitude toward the BSCS Program had completed these three areas of study than had the teachers who demonstrated a less favorable attitude toward the Program.

A look at the nature of these three areas of study will amplify this point: 1) A course in ecology affords the type of training that shows the interrelationships among the many subdivisions of science. This is one of the objectives of BSCS. 2) In a science teachers'

methods course, training in the strategies of teaching and methods of evaluation are often received. This, too, is an important part of the BSCS Biology Program; and 3) The BSCS Program is laboratory oriented. The proficiency in laboratory techniques and procedures received in laboratory courses is an asset to teachers who teach BSCS Biology.

The similarities that exist between the type of training usually received in these three areas of study and the philosophy of teaching and learning required in BSCS Biology and the fact that a greater number of the more favorable teachers than the less favorable teachers had completed work in these areas of study tends to lend support for the recommendations of several science educators concerning the training of high school biology teachers. Watson (43), Burnett (23), Schlessinger (39), Hurd (33), and others, recommend that the preparation programs of biology teachers be patterned after the style and content of the BSCS Program. They suggest that each course of study should afford an opportunity to practice science as inquiry and a way of thinking. Also, each course should be an interrelated part of the whole discipline of biology. Study in ecology, a science methods course, and at least 14 laboratory courses conform to these recommendations.

There are several reasons that might be given for not finding significant differences in the distribution of 16 of the 19 subject matter areas (variables) among the more favorable and less favorable biology teachers:

1) The teaching methods used by some of the past instructors of the more favorable teachers could have been similar to the philosophy and methodology of BSCS.

2) The knowledge and understandings gained from each course completed could have been greater for a larger number of the more favorable teachers than for the less favorable teachers.

3) Certain personal characteristics could have been the major determining factor in influencing the teachers' attitudes toward BSCS. As previously mentioned, Blankenship (19), in a similar study found that the biology teachers who had a greater capacity for independent thought and action demonstrated a favorable attitude toward the BSCS Biology Program.

4) The investigator's efforts to compare the total academic patterns of training of the teachers through analyzing individual courses may have been ineffective. Perhaps a look at the whole pattern was not accomplished.

5) A composite of all of the above reasons could have attributed to the reactions of the biology teachers to the BSCS Program and the patterns of academic training are only a single contributing factor and were not detected by the methods used in the study.

The differences in the distribution of three of the 19 subject matter areas and courses were found to be statistically significant. Therefore, the results of the study indicated that there is a difference in the distribution of courses and subject matter areas in science and mathematics, in the "model pattern" developed by the investigator, between science teachers who demonstrate a "more favorable" attitude toward the BSCS Biology Program and science teachers who demonstrated a "less favorable" attitude toward the BSCS Biology Program.

On the basis of the evidence obtained from this investigation, the null hypothesis is rejected and the investigator concludes that there is a statistical significant difference in the distribution of

courses completed in science and mathematics between science teachers who demonstrate a more favorable attitude toward the BSCS Biology Program and science teachers who demonstrate a less favorable attitude toward the Program.

The investigator recognizes that certain limitations of the study restrict the conclusions drawn. For example, the biology teacher sample used may have been unique in some respects and may not be representative of the total high school biology teacher population.

Implication for Further Study

It should be clear from the findings of this study that the basic questions concerning the pattern of training that constitutes the more appropriate training for high school science teachers still go unanswered. These questions should continue to be asked and attempts be made to answer them.

Since many leading educators recommend that the academic training of high school biology teachers should be patterned after the style and content of BSCS Biology, further studies should be made to see if teachers who react favorable to the program have had a characteristic pattern of training. The basic design of the present study could be used but rather than use course titles, tests should be devised to assess the knowledge and understanding gained in each course. Also attempts should be made to ascertain the methods of teaching used in each course.

Other studies are needed concerning the BSCS Program for other reasons. Approximately 50 per cent of the biology teachers involved in this study demonstrated a less favorable attitude toward the Program.

There is a need to determine why so many teachers react less favorable to a program that is in widespread use in the country and is esteemed by many scientists and science educators as being exemplary of modern biological science. These studies should explore the BSCS Biology Program itself to see if changes in the patterns of writing the materials can be made which would result in a higher percentage of more favorable attitudes toward the Program. Additional studies should be made to see if training in the strategies of class discussion and other methodologies inherent in the BSCS Program would result in more favorable attitudes toward the Program.

Perhaps the answers to the questions posed above will lead science educators closer to the answer of what constitutes an appropriate training program for high school science teachers. Even so, science educators should continuously ask questions and seek answers concerning the training of high school science teachers. For, after all, the real test of any curriculum program is the teacher's performance in the classroom, and how he performs relies heavily on how he has been taught.

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APPENDIX

SCIENCE TEACHER CHARACTERISTICS STUDY

Name _____

In the research that we are conducting it is necessary that we know the number of science courses that you have completed that involved laboratory work. Listed below are various courses in several areas of science. Please place a check in the space provided before each of the course titles that involved laboratory work.

Additional spaces are provided so that you may list courses not included in the checklist.

REMEMBER: CHECK ONLY THOSE COURSES COMPLETED THAT INVOLVED LABORATORY WORK.

____ General Biology	____ Plant Pathology	____ Human Biology
____ _____	____ Plant Physiology	____ Animal Physio.
____ _____	____ Plant Ecology	____ Physio. & Ana.
____ General Botany	____ General Ecology	____ Animal Anatomy
____ _____	____ Field Biology	____ _____
____ Plant Taxonomy	____ _____	____ Embryology
____ _____	____ Evolution	____ Compar. Ana.
____ _____	____ General Zoology	____ Verte. Zoology
____ Plant Anatomy	____ _____	____ Mammalogy
____ Plant Morphology	____ _____	____ Field Zoology
____ _____		____ _____

____ Animal Ecology

____ _____

____ Parasitology

____ Entomology

____ _____

____ Microbiology

____ Bacteriology

____ _____

____ _____

____ Histology

____ Cytology

____ Cell Biology

____ _____

____ Genetics

____ Laboratory Procedures

____ General Chemistry I

____ General Chemistry II

____ _____

____ Organic Chemistry

____ _____

____ Qualitative Analysis

____ Quantitative Analysis

____ Biochemistry

____ _____

____ General Physics I

____ General Physics II

____ _____

____ _____

____ _____

____ General Physical Science

____ General Geology

____ Historical Geology

____ Physical Geography

____ _____

____ _____

____ Astronomy

____ Meterology

____ Climatology

____ Research Problem

____ Thesis

OTHERS:

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SCIENCE TEACHER CHARACTERISTICS STUDY

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INSTRUCTIONS

Attached are statements pertaining to the high school biology programs with which you are acquainted. These statements reflect a wide range of attitudes concerning these biology programs.

We would like for you to read each statement carefully and ask yourself whether you agree or disagree with the statement. We realize that in some cases the decision will be a difficult one. If you agree with the statement, place a check mark in the space provided by the statement. If you do not agree with the statement, leave the space provided blank.

Remember: Place a check mark only by those statements with which you definitely agree.

____ 1. Laboratory work in high school biology should be more closely integrated with the text material.

____ 2. The high school biology program should be designed and controlled only by high school biology teachers.

____ 3. The high school biology laboratory work would be more interesting if the nature of laboratory work were more investigative.

____ 4. Demonstrations are not as effective as student participation type laboratory work.

____ 5. Students gain more scientific knowledge by participation in BSCS-type laboratory work than they do in the conventionally patterned laboratory work.

____ 6. It would be difficult, if not impossible, to teach the BSCS biology course in its present form.

____ 7. It is not necessary that a student actually perform laboratory work in order to understand the principles of scientific investigation.

____ 8. The BSCS biology program reflects the current trend in the biological sciences.

____ 9. The situations which students are exposed to in BSCS biology are similar to those situations faced by a scientist in his every day work.

____10. The BSCS biology program has failed to provide for some of the most important aspects of the high school biology course.

____11. A practical biology course that has immediately useable information for the student is what is needed in the high school.

____12. BSCS biology adequately provides for differences in student ability.

____13. The major emphasis in high school biology should be the structure and functions of organs and tissues.

____14. Well-prepared motion pictures could be substituted for all high school biology laboratory work.

____15. Our knowledge in the life sciences has been derived from limited observations.

____16. A slight modification of the existing high school biology program is all that is needed to provide an effective high school biology program.

____17. BSCS biology would enable the student to understand better the ways in which hypotheses are developed and tested.

____18. Students come to understand science through participating in laboratory work rather than by reading about science and watching demonstrations.

____19. Accurate evaluation of a student's achievement in a laboratory-oriented course, such as the BSCS course, would be impossible.

____20. At the present time, there is no need for a major revision of the high school biology program.

____21. The use of six weeks of concentrated laboratory work in one area of biology is justifiable.

____22. College-bound students would profit more from the conventional type of biology course than they would from the BSCS biology program.

____23. In high school biology, major emphasis should be placed on the molecular, cellular, and community aspects of biology.

____24. In considering the high school biology program as a whole, it appears that the existing program is adequate.

____25. Biological laws are only summations of experiences, consequently, in the future one may expect these laws to become modified or even discarded.

____26. The BSCS biology program seems designed exclusively for the above-average student.

____27. It is only by engaging in the steps of scientific inquiry that a student becomes able to discern the difference between experimentation and complex instrumentation.

____28. Actually, the so-called conventional high school biology course and the recommended BSCS biology course are quite similar.

____29. The biology textbooks and laboratory manuals currently in use in the high schools are adequate.

____30. The study of science as inquiry should be one of the major objectives of high school biology.

____31. The benefits that a student derives from actual first-hand laboratory experimentation cannot be justified in terms of the amount of teacher time and materials required.

____32. Laboratory investigations and open-ended experiments are excellent means for conveying an understanding of science.

____33. Demonstrations performed by the science teacher are just as effective as student-performed laboratory experiments.

____34. It is more important for the average student to understand the purpose and method of science than for him to be acquainted with the latest theory of the universe or the newest hormone.

____35. BSCS biology could be taught just as effectively without the extensive laboratory investigations suggested.

____36. Laboratory exercises should stress the names of structures and processes.

____37. The traditional biology course offered in the high school is no longer adequate.

____38. The need for the students to acquire factual information is greater than the need for them to understand the ways in which hypotheses are developed.

____39. Research biologists should be involved with others in designing the high school biology curriculum.

____40. Biology should be taught as a body of factual information.

____41. The BSCS biology program reflects careful planning of a practicable course.

____42. In high school biology, student work should be centered in the laboratory where real problems are explored.

____43. It is doubtful that the BSCS approach to teaching high school biology would result in the students' acquiring a better understanding of the true work of the scientist.

____44. The amount of time suggested for laboratory investigation in the BSCS biology program is excessive.

____45. A student comes to understand science through participating in science, rather than by serving as a bystander who only reads about science.

____46. Wholesale revision of the conventional high school biology course is imperative if a modern curriculum is to be developed.

VITA

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Candidate for the Degree of

Doctor of Education

Thesis: AN ANALYSIS OF THE PATTERNS OF ACADEMIC PREPARATION OF HIGH SCHOOL BIOLOGY TEACHERS IN RELATION TO THEIR ATTITUDES TOWARD THE BSCS BIOLOGY PROGRAM

Major Field: Higher Education

Biographical:

Personal Data: Born in Indianola, Oklahoma, February 10, 1929, the son of Erdie A. and Myrtis S. Butler. Married R. Joan Dunlap, October 22, 1953; two children, Martha Carole and David Brian.

Education: Attended grade school and high school in Indianola, Oklahoma. Graduated from high school in 1947. Served in the U. S. Air Force from 1947 to 1950. Graduated from Southeastern State College, Durant, Oklahoma, in 1953 with the degree of Bachelor of Science in Education. Received the degree of Education Masters in 1957 and the degree of Masters in Natural Science in 1963 from the Oklahoma University, Norman, Oklahoma.

Professional Experience: Taught high school science in Hugo, Oklahoma from 1953 to 1954; in Friona, Texas from 1954 to 1956; Oklahoma City, Oklahoma from 1956 to 1964. One year's experience, while in the Oklahoma City Public Schools, teaching natural science by educational television. Piloted and supervised the introduction of the BSCS Biology Program in the Oklahoma City Public Schools from 1962 to 1964. Assisted in the development of an elementary teachers' science methods course and taught the course by extension from the Oklahoma State University from 1964 to 1965. Taught botany and biology at East Central State College, Ada, Oklahoma from 1966 to 1967.

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