

PRESENT SUBJECT MATTER PREPARATION AND FUTURE TRENDS IN THE
PREPARATION OF HIGH SCHOOL BIOLOGY TEACHERS

by

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THE PROBLEM AND DESIGN OF THE STUDY

With each successive generation the wealth of scientific knowledge continues to accumulate at an ever increasing pace. In accordance with the times, the biological sciences are moving forward with a new found vigor. The number of investigators increases yearly. New research tools and techniques are being acquired daily. Discoveries are being advanced more rapidly than can conceivably be anticipated.

The achievements listed above, plus an intensified dissatisfaction with the contents and methods of the high school biology courses being offered, presented an urgent need to reformulate the biology courses which were intended for secondary education. During the summer of 1960¹, a number of high school biology teachers, research biologists, and educators met to prepare a new biology program. Eventually, three versions of biology were produced. Each version was organized around a conceptual theme intended to provide a balanced introduction to the study of biology. In contrast to many of the existing textbooks, biology as a process of inquiry was emphasized. Other writers and publishers soon abandoned the archaic 'inventory of the conclusions of research' method and followed with new and current versions of their own.

These new versions have created many additional problems for high school biology teachers and the educators of these teachers. It is no secret that the sciences are being drawn closer together by their unifying concepts. For example, certain aspects in the fields of physics,

¹Paul Dehart Hurd, Biological Education in American Secondary Schools 1890-1960 (Baltimore: Waverly Press, 1961), p. 178.

mathematics, and chemistry are becoming a more integral part of biology. Subjects in calculus, physics, statistics, and biochemistry are essential to the thorough understanding of current topics in many journals intended for secondary biology teachers.

Additionally, many areas of study within the biological sciences have become essentials in the pre-service training of competent biology teachers. Genetics, physiology, and ecology, which have previously been considered elective, are now necessary to merely keep abreast of the current high school textbooks. With the continued advance of knowledge, it would be simple to visualize the teacher that does not possess these essentials, becoming obsolete after only a few short years of teaching.²

The Problem

Statement of the problem. The purpose of this study was to ascertain the opinions of the biology teachers in the City of Milwaukee regarding pre-service subject matter training programs. Comparisons of their recommendations were then made with the existing pre-service subject matter training programs offered by the colleges and universities of Wisconsin and the pre-service training of the teachers.

Subordinate objectives were (1) to determine the changes which the high school biology teachers would recommend; (2) to detect any

²Thomas A. Hutto, "Some Current Problems and Issues in the Training of Biology Teachers," School Science and Mathematics, 67:357-364, April, 1967; Paul Klings, "Whats Ahead in Biology Education," The American Biology Teacher, 27:326, May, 1965; and Ferdinand Payne, "Thoughts on the Training of Teachers," The American Biology Teacher, 29:49-52, January, 1967.

trends which may be developing in the training of high school biology teachers; and (3) to determine how closely the subject matter training which the present biology teachers possess, corresponds to the recommendations of The American Association for the Advancement of Science.

Significance of the study. In the majority of the colleges and universities of Wisconsin, the required subject matter of biology teacher preparation programs is usually of a non-specific nature. A certain number of required hours in the field of biology and in one or more related areas appears to be the chief characteristic. Course work beyond the introductory level is usually the decision of a student's academic advisor. However, the student is often allowed to make this decision and, as a result, areas of study necessary for the teaching of biology are often neglected.

After gaining some degree of experience, biology teachers may find that they have failed to receive training in certain key subjects. In this study an attempt was made to provide evidence that experienced biology teachers are aware of the areas in which future biology teachers need specific preparation. The results of this study should prove to be useful to colleges and universities in evaluating the pre-service subject matter preparation of their future biology teachers.

Definitions of Terms Used

Biology teacher. A biology teacher devotes at least two periods of each day to the teaching of biology.

Credits. Credits are the semester hours earned in various subjects

or courses during the teacher's pre-service training.

Educator. The science education advisor and the science method professor, who are often the same person.

Field of biology. The field of biology is composed of the following subdivisions:

- Area A: Principles of biology- characteristics of living organisms, structure and functions of plants, animals, and microorganisms, cell theory, health and disease.
- Area B: Plant and animal physiology- comparative study of functional processes of cells, tissues, and organs, basic mechanisms of organic maintenance and integration, behavior.
- Area C: Anatomy and morphology- growth and development, comparative study of structure, microtechnique, preparation and use of biological materials.
- Area D: Ecology and conservation- relationships of plants and animals to the physical and biological conditions under which they live, adaptation of structure and function, organization and interrelationship of communities, dispersal and distribution, conservation of natural resources.
- Area E: Genetics- principles of heredity, evolution.³

High school. Any school which includes the tenth through the twelfth grades.

³Cooperative Committee (AAAS), "Recommendations for the Preparation of High School Teachers of Science and Mathematics-1959," The American Biology Teacher, 21:302-310, November, 1959; Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics, A Report Prepared by the National Association of State Directors of Teacher Education and Certification and the American Association for the Advancement of Science (Washington, D. C., AAAS, 1961), pp. 1-16.

Junior high school. Any school which includes the seventh through the ninth grades.

Pre-service training. The education which a person receives before he actually begins to teach, is defined as pre-service training.

Professional education. Professional education consists of only the methods of teaching subject and student teaching.

Qualification to teach. In order to teach in the state of Wisconsin, each teacher must meet the requirements of the Wisconsin State Board of Education. For minimum certification a teacher needs thirty-four semester hours in the subject to be taught and twenty-two semester hours in the minor field.⁴

Related subjects. Subjects taken in the fields of chemistry, physics, mathematics, or geology are considered to be related subjects.

Subject matter preparation. The portion of the teacher's pre-service training devoted to the study of the subject (biology) to be taught.

Limitations and Design of the Study

This study was limited to and based on data concerning the biology teachers employed by the City of Milwaukee Public School System during

⁴Elizabeth H. Woellner and M. Aurilla Wood, Requirements for Certification (thirty-first edition; Chicago: The University of Chicago Press, 1966), pp. 154-55.

the 1966-67 school year. Only instructors who were teaching two or more classes of biology daily were considered in the study.

Since neither transcripts nor copies of undergraduate preparation could be supplied by the Milwaukee Public School System, it was necessary to collect all pertinent data by means of a questionnaire. The questionnaire included data concerning (1) teacher opinion of twenty-four key preparation subjects and (2) pre-service training in the same twenty-four subjects.

Questionnaires were sent to a total of seventy-seven teachers. Seventy-one of these teachers were teaching in the city's fifteen high schools, while the remaining six were teaching advanced students in six of the city's junior high schools. Replies concerning teacher opinion were received from 79 per cent of the teachers, while 74 per cent of the teachers replied concerning their own pre-service training.

Information was also obtained from the bulletins of twenty-nine colleges and universities in Wisconsin. Included were data concerning the required subjects in biology, the required number of hours in biology, and the suggested subjects in the related sciences.

REVIEW OF THE LITERATURE

A concern about the nature of science teaching in the high schools has been the cause of much discussion. The attentions of many well known individuals and countless organizations have been drawn into the debate. This realization of the importance of science in the education of youth has resulted in numerous studies intended for the betterment of science education.

As a result, the literature has become infiltrated with numerous inquiries into the academic and professional background of science teachers. Perhaps, the most important aspect of any high school biology course is the competency of the classroom teacher. The high school teacher is currently recognized as the key toward increasing the supply of raw material from which future scientists, engineers and science teachers may be trained.

The professional teacher of biology needs to understand more than the biological sciences. Understanding the subject to be taught is necessary, but not a sufficient condition for good or professional biology teaching.⁵ Nevertheless, an individual can not be a successful teacher of biology without a coherent grasp of the subject. This can be attained only by training the individual well beyond the introductory level.⁶

⁵Hulda Grobman, "Why Aren't There More Good Teachers?," The American Biology Teacher, 23:164, March, 1966; James T. Robinson, "Biology Method Courses," The American Biology Teacher, 23:309, December, 1966.

⁶James Bryant Conant, The Education of American Teachers (New York: McGraw Hill Book Company, Inc., 1963), p. 107.

Literature concerning the academic preparation of high school biology teachers can be divided into two major areas. These areas include (1) the actual preparation of biology teachers and (2) the recommended preparation of biology teachers.

Literature on the Preparation of Biology Teachers

As part of a study conducted in 1950, Nelson⁷ analyzed the pre-service training of sixty-one beginning biology teachers in the state of Illinois. Course work taken in general biology, zoology, botany, ecology, bacteriology, and physiology constituted training in the biological sciences. For the majority of teachers, training was unevenly distributed in the previously mentioned areas. Some of the teachers had failed to receive training in zoology, while others were void of training in botany. Finally, when compared to their credits in other areas of biology, many had received negligible training in the fields of botany and zoology.

The range of training in science subject matter was found to be from 12 to 95 semester hours with a median of 47 hours. In the field of biology, the teachers had received from three to 77 hours of training. The median, at 24.6 semester hours, was the equivalent of two subjects short of a major. Thirty-eight per cent were without training in physics. It was also found that 22 per cent had received no training in chemistry.

⁷T. A. Nelson, "What Administrators Want in the Training of Science Teachers and the Actual Training of Beginning Biology Teachers in the State of Illinois," Science Education, 40:24-43, February, 1956.

Eleven teachers or 17 per cent of the sample were lacking training in both subjects. No measurement was conducted concerning mathematics.

Pella⁸ analyzed the preparation of 367 Wisconsin biology teachers during the 1956-57 school year. The average teacher of biology had spent time equivalent to one-half of a baccalaureate degree studying science and mathematics. The range in the number of science credits earned was from five to 100, with a median of 41. However, 54 per cent of the teachers had less than twenty hours of credit in biology. This would be the equivalent of two or three subjects beyond the introductory level. Physics was included in the academic preparation of 59 per cent of the teachers, while credits in chemistry had been earned by 80 per cent of the teachers. Two-thirds of the teachers had received some training in mathematics.

As part of a survey conducted in 1957, Baker and Brooks⁹ found that only 37.6 per cent of the science teachers had actually majored in a science field. Of the 599 teachers who taught biology, only fifty were full time biology teachers. At the time, certification allowed anyone with twenty-four hours of college science to teach high school biology. It was necessary that six of the twenty-four hours be in the field of biology.

⁸Milton O. Pella, "The Nature of the Academic Preparation in Science of Wisconsin High School Teachers of Physics, Chemistry, Biology, and General Science," Science Education, 42:115-122, March, 1958.

⁹Weldon N. Baker and Merle S. Brooks, "Preparation of Kansas High School Teachers of Science," The American Biology Teacher, 20:132-136, April, 1959.

Of the biology teachers, 66 per cent had received credit in zoology, 58 per cent in botany, 47 per cent in general biology, and only 13 per cent in field biology. In the related areas, 68 per cent had earned credit in the introductory chemistry course, 27 per cent in organic chemistry, and 44 per cent in physics.

Also in 1957, Koelsche¹⁰ made a survey of the academic preparation of 240 biology teachers in Ohio. The median number of credits earned in the combined science areas was 33. For biology subjects, the median was 24 semester hours. Only 30 per cent of the biology teachers had enough semester hours to possess the equivalent of an academic major in the biological sciences. Greater than ten per cent had received only the two introductory subjects or less.

Chemistry was missing in the preparation of one-half of the teachers, while less than one-third of the teachers had received any training in physics. The median for chemistry was the equivalent of three subjects. The equivalent of two courses constituted the median for physics.

In 1964, Watson¹¹ conducted a survey which reported the frequency of courses as reported by thirty-nine prize fellowship seniors majoring in biology at thirty-four colleges. In mathematics, 23 per cent had

¹⁰Charles L. Koelsche, "The Academic and Teaching Backgrounds of Secondary Science Teachers in the State of Ohio," Science Education, 43:134-139, March, 1959.

¹¹Fletcher G. Watson, "To the Council on the Education of Teachers of Science," The American Biology Teacher, 27:11-17, January, 1965.

received credit in calculus, while only 15 per cent could report credit in statistics. Physics, or a course in physical science, was reported by 85 per cent of the seniors. Four of the thirty-nine had not even received a single credit in chemistry. Credits in organic chemistry were possessed by 44 per cent. Projections from this figure would give a low percentage of seniors with credit in either biochemistry or physical chemistry. Only 38 per cent had taken a basic geology course.

Variations of percentages of the twelve surveyed subjects in the biological sciences were even more pronounced. The credits were as follows: General Biology - 100 per cent; Genetics - 77 per cent; Vertebrate Anatomy - 74 per cent; Physiology - 54 per cent; Microbiology - 44 per cent; Taxonomy - 38 per cent; Ecology - 36 per cent; Field Biology - 28 per cent; Invertebrate Zoology - 26 per cent; Embryology - 23 per cent; Evolution - 15 per cent; and, Conservation - 10 per cent.

Finally, Stewart¹² prepared a study for the purpose of showing how science student teachers were trained at North Carolina College during the ten year period of 1951-1961. Only 44 per cent of 194 student teachers had completed more than thirty hours of biology. Of even more significance, over 90 per cent were deficient in mathematics and physics. Only 6 per cent of the students possessed a minor in mathematics. There were no minors in physics.

¹²John L. Stewart, "A Report on the Training of Science Student Teachers for the Secondary Schools at the North Carolina College at Durham," School Science and Mathematics, 44:271-31, April, 1964.

A majority of the large scale surveys¹³ conducted reveal that more than one-fifth of all science teachers have fewer than twenty semester hours of credit in the field of science. In the larger schools this figure may be nearer to forty semester hours. Even these facts often conceal the inappropriateness of the instructor's scientific background for his assignment. Hurd¹⁴ has found that approximately 80 per cent of the biology teachers are graduates of liberal arts colleges or universities. The majority of these possess academic majors in botany, zoology, physiology, or bacteriology. The result, which is inappropriate for a high school biology teacher, is an all too narrow view of the field.

Literature on Programs of Preparation for Biology Teachers

In 1949, Cahoon¹⁵ cited the President's Scientific Research Board on Manpower for Research, and mentioned the following recommendations in regard to the pre-service training of secondary science teachers:

(1) Certification should be in closely related subjects within the broad area of science and mathematics.

(2) Approximately one-half of the program or sixty semester hours should be allotted to the comprehensive teaching area of science and mathematics.

¹³Herbert A. Smith and Guy B. Homan, "The Academic and Professional Preparation of Teachers of Science," Review of Educational Research, 31:291, June, 1961.

¹⁴Paul Dehart Hurd, "The Education of Secondary School Biology Teachers," The American Biology Teacher, 24:327-31, May, 1962.

¹⁵Science and Public Policy. Vol. 4, p. 59, cited by George P. Cahoon, "Teaching Science for General Education in the Secondary School," School Science and Mathematics, 49:287, April, 1949.

(3) Every teacher of science should complete the basic courses (six to ten semester hours) in biology, chemistry, mathematics, and physics.

(4) A minimum of eighteen semester hours of study should be required for certification in a particular subject.

(5) The comprehensive area should include study beyond the basic course in at least two and preferably three of the sciences (the sixty semester hours will allow for eighteen hours in three subjects and six hours in the fourth science.)

Recommendations, with a great deal of similarity, have been offered by other groups and individuals. Administrators have indicated that they prefer teachers with scientific training spread over several fields, and intensive training in one of these fields. They have also indicated a preference for teachers who possess sufficient training to teach in more than one field. Intensive training in one field and negligence in the other scientific areas have been given a consistent low rating by administrators.¹⁶

The American Association for the Advancement of Science¹⁷ has proposed a common core of subjects for all future science teachers. Included in the common core are the introductory subjects in biology, chemistry, physics, earth science, and mathematics. Recommendations for a biology major are thirty semester hours in biology and twelve semester

¹⁶T. A. Nelson, "What Administrators want in the Training of Science Teachers and the Actual Training of Beginning Science Teachers in the State of Illinois," Science Education, 40:24-43, February, 1956.

¹⁷Cooperative Committee (AAAS), "Recommendation for the Preparation of High School Teacher's of Science and Mathematics-1959," The American Biology Teacher, 21:287, November, 1959; G. K. Podanfield and T. M. Stinnett, The Education of Teachers (Englewood Cliffs, N. J.: Prentice Hall, 1961), p. 36.

hours in chemistry. Projections into a fifth year of training would raise the biology credits to forty-two semester hours and the chemistry totals to sixteen semester hours. During the five year training period, a prospective teacher would receive eighty-one semester hours of credit in the field of science. Conant maintained that twelve courses or thirty-six hours are necessary to gain a coherent grasp of biology. He recommended sixteen courses or forty-eight hours as a teaching minimum.¹⁸

Hurd has suggested that good teachers should be educated far beyond the level they are expected to teach. He insisted that biology teachers must be qualified for graduate work in the field and capable of curriculum improvement. Finally, he recommended that a general biology course be taken by each student after he has obtained his specialized biological training. The course would present a synoptic view of the student's background.¹⁹

¹⁸Conant, op. cit., p. 107.

¹⁹Paul Dehart Hurd, "The Education of Secondary School Biology Teachers," The American Biology Teacher, 24:327-331, May, 1962.

PRESENTATION AND ANALYSIS OF DATA

As has been stated previously, teacher response to the questionnaire included data concerning (1) teacher opinion of twenty-four preparation subjects and (2) pre-service training in the same twenty-four subjects. Of the seventy-seven biology teachers included in the sample, sixty-one (79.2 per cent) responded to the teacher opinion section while fifty-seven (74.0 per cent) responded to the section concerning pre-service training.

The data regarding teacher opinion of related subject matter are presented in Table I, page 16. Examination of the table revealed that the field of chemistry received a greater number of required and recommended ratings than the other related fields. General chemistry was considered a required subject by 91.3 per cent of the respondents. Organic chemistry was selected by two-thirds of the teachers and biochemistry was picked by 55.7 per cent of the teachers. A minor in the field of chemistry is indicated.

Although there has been an increased emphasis on mathematics and the physical sciences in biological investigations, subjects in these areas did not receive high ratings. Almost one-half of the replying teachers thought calculus to be unnecessary. Statistics was either recommended or required by 55.7 per cent of the teachers. Only 32.8 per cent would require an introductory course in geology while 52.5 per cent considered paleontology to be of value. Only 29.5 per cent of the teachers would require physics. However, an additional 37.7 per cent recommended the subject.

TABLE I

TEACHER OPINION CONCERNING RELATED SUBJECTS
AS REPORTED BY SIXTY-ONE MILWAUKEE
SECONDARY BIOLOGY TEACHERS,
1966-67

Subjects	Require		Recommend		Elective		Unnecessary	
	Number	Pct	Number	Pct	Number	Pct	Number	Pct
Calculus	0	0.0	9	14.8	22	36.0	30	49.2
Statistics	8	13.1	26	42.6	21	34.4	6	9.8
Physics	18	29.5	23	37.7	17	27.9	3	4.9
General Chemistry	56	91.8	5	8.2	0	0.0	0	0.0
Organic Chemistry	42	68.8	15	24.6	4	6.6	0	0.0
Biochemistry	34	55.7	21	34.4	6	9.8	0	0.0
Geology	20	32.8	16	26.2	22	36.0	3	4.9
Paleontology	9	14.8	23	37.7	21	34.4	8	13.1

The American Association for the Advancement of Science has suggested a common core of subjects for all secondary science teachers.²⁰ It would consist of the introductory courses in biology, earth science, chemistry, physics, and mathematics. The introductory biology subjects will be discussed with Table II, page 13. Concerning chemistry, both the teachers and the Association were in agreement. Additionally, the teachers recommended chemistry as the second area of development. Physics was moderately recommended while introductory earth science was left as an elective.

Presented in Table II, page 13, are data concerning teacher opinion of the subjects in the field of biology. Nine of the fourteen subjects were selected as imperative subjects by two-thirds or more of the respondents. The major areas of biology, as selected by the American Association for the Advancement of Science, were represented by one or more of the nine subjects.²¹ Both botany and zoology, the two basic introductory subjects, were selected as requirements by 93.4 per cent. This was the highest rating given to any of the subjects. Genetics and physiology, which are two of the major areas, were indicated by 90.2 per cent and 85.2 per cent of the sample respectively. The areas of anatomy and morphology were represented by vertebrate anatomy (32.0 per cent) and invertebrate zoology (75.4 per cent). The final area, ecology and conservation, was represented by two subjects: ecology was selected by

²⁰Cooperative Committee (AAAS), loc. cit.

²¹Ibid.

TABLE II

TEACHER OPINION CONCERNING BIOLOGY SUBJECTS AS REPORTED BY SIXTY-ONE MILWAUKEE SECONDARY BIOLOGY TEACHERS, 1966-67

Biology Subjects	Requires		Recommend		Opinion		Unnecessary	
	Number	Pct	Number	Pct	Number	Pct	Number	Pct
Botany	60	98.4	1	1.6	0	0.0	0	0.0
Zoology	60	98.4	1	1.6	0	0.0	0	0.0
Vertebrate Anatomy	50	82.0	10	16.4	0	0.0	1	1.6
Invertebrate Zoology	46	75.4	11	18.1	3	4.9	1	1.6
Physiology	52	85.2	4	6.6	5	8.2	0	0.0
Embryology	36	59.0	18	29.5	7	11.5	0	0.0
Microbiology	42	63.9	13	21.3	6	9.8	0	0.0
Genetics	55	90.2	5	8.2	0	0.0	1	1.6
Ecology	49	80.4	10	16.4	1	1.6	1	1.6
Field Biology	41	67.2	15	24.6	4	6.6	1	1.6
Conservation	32	52.5	16	26.2	11	18.1	2	3.2
Taxonomy	29	47.6	21	34.4	8	13.1	3	4.9
Microtechnique	23	37.7	22	36.0	13	21.3	3	4.9
Evolution	30	49.2	18	29.5	10	16.4	3	4.9

80.4 per cent of the replying teachers while 67.2 per cent of the teachers would require course work in field biology. Microbiology was considered necessary by 68.9 per cent of the teachers.

The remaining five subjects were regarded as essentials by less than 60 per cent of the current biology teachers. Embryology was recommended by 58.5 per cent of the teachers. Two-thirds of the fifty-four teachers which recommended the subject would also require it. Conservation, a requirement for certification in Wisconsin, was considered to be essential by 52.5 per cent of the sample. However, eleven of the sixty-one respondents (18.1 per cent) thought that the subject should be elective. Almost, one-half of the teachers would require a course in evolution to follow the course in genetics. It was recommended by 78.7 per cent of the sample. Taxonomy (47.6 per cent) and microtechnique (37.7 per cent) were the lowest rated subjects.

Table III, page 20, shows teacher opinion concerning the two professional education subjects. Although one teacher was of the opinion that student teaching was unnecessary, fifty-five of the sixty-one biology teachers (90.2 per cent) regarded it as an essential subject. There was a marked fall off in the number of teachers requiring the methods of teaching subject. This subject, which usually precedes student teaching, was listed as required by 72.1 per cent of the teachers. It was considered to be unnecessary by 8.2 per cent of the respondents.

The data with regard to the frequency of subjects as reported by the secondary biology teachers of Milwaukee, are presented in Table IV, page 21. Only two of the eight related subjects were reported by a

TABLE III

TEACHER OPINION CONCERNING PROFESSIONAL EDUCATION
 SUBJECTS AS REPORTED BY SIXTY-ONE MILWAUKEE
 SECONDARY BIOLOGY TEACHERS, 1966-67

Subjects	Opinion							
	Require Number	Pct	Recommend Number	Pct	Elective Number	Pct	Unnecessary Number	Pct
Methods of Teaching	44	72.1	9	14.8	3	4.9	5	8.2
Student Teaching	55	90.2	5	8.2	0	0.0	1	1.6

TABLE IV
 FREQUENCY OF SUBJECTS, FOR AT LEAST ONE SEMESTER,
 AS REPORTED BY FIFTY-SEVEN MILWAUKEE
 SECONDARY BIOLOGY TEACHERS,
 1966-67

Subjects	Number of teachers	Percentage of teachers
Related Subjects:		
Calculus	12	21.5
Statistics	23	40.4
Physics	35	61.4
General Chemistry	50	87.7
Organic Chemistry	27	47.4
Biochemistry	17	29.8
Geology	25	43.6
Paleontology	4	7.0
Biology:		
Botany	53	93.0
Zoology	56	98.3
Microbiology	27	47.4
Physiology	51	89.5
Vertebrate Anatomy	44	73.6
Genetics	51	89.5
Evolution	19	33.3
Ecology	37	64.9
Taxonomy	27	47.4
Embryology	26	45.6
Invertebrate Zoology	34	59.6
Field Biology	28	49.1
Conservation	45	78.9
Microtechnique	21	36.8
Professional Education:		
Methods of Teaching	52	91.2
Student Teaching	53	93.0

majority of the respondents. Credit in general chemistry was reported by 87.7 per cent of the teachers but only 61.4 per cent of the teachers had received training in physics. Training in earth science was deficient, as 43.6 per cent indicated credit in introductory geology. Only four (7.0 per cent) of the teachers reported credit in paleontology. Seventeen of the twenty-two teachers who failed to receive credit in physics also failed to receive credit in geology. Two of these teachers were also void of training in chemistry.

With the exception of chemistry, many of the current biology teachers do not meet the recommendations of the American Association for the Advancement of Science.²² However, the majority did not possess a minor in chemistry since only 47.4 per cent of the teachers reported credit in organic chemistry and 29.8 per cent reported credit in biochemistry.

No provision was made for the measurement of introductory mathematics. However, Calculus had been taken by 21.5 per cent of the teachers while 40.4 per cent of the teachers had received credit in statistics.

The most frequently reported subjects in biology were zoology (98.3 per cent), botany (93.0 per cent), physiology (89.5 per cent), and genetics (89.5 per cent). Credit in these four subjects not only satisfies recommendations in three of the five major areas of biology, but also gives the teacher a broad foundation in the field of biology.²³ Vertebrate

²²Ibid.

²³Ibid.

anatomy (73.6 per cent) was the most frequently mentioned subject in the area of anatomy and morphology. The state required subject in conservation had been taken by 78.9 per cent of the teachers. Credit in some phase of ecology had been earned by 64.9 per cent of the teachers.

Although it was not arranged in tabular form, further analysis of the data revealed that twelve (21.1 per cent) of the teachers were deficient in one or more of the major areas in the biological sciences, three were deficient in more than one area, and one was deficient in principles of biology, genetics, and ecology and conservation. Concerning the other two, one was minus training in physiology and anatomy while the other was void of credits in ecology and genetics.

Nine of the fifty-four teachers, with training in the area of ecology and conservation, had received credit in only one subject. For six of these teachers the credit was in conservation. Only one subject was taken by sixteen of the fifty-six teachers with credit in the area of anatomy and morphology. For nine of these teachers the credit was in vertebrate anatomy. Five had received credit for invertebrate zoology.

In the area of professional education, 93.0 per cent of the teachers had credit in student teaching and 91.2 per cent indicated credit in methods of teaching. Two teachers had also received training in B. S. C. S. methods. It is probable that teachers void of credit in this area began teaching before methods courses and student teaching were state certification requirements.

In Table V, page 24, a comparison was conducted of the percentage of teachers with credit in a subject and the percentage of teachers

TABLE V
 PERCENTAGE COMPARISON OF ACTUAL TEACHER CREDITS
 AND "REQUIRED" RESPONSE AS INDICATED BY
 SIXTY-ONE MILWAUKEE SECONDARY
 BIOLOGY TEACHERS, 1966-67

Subjects	"Required" response	Actual credits
Related Subjects:		
Calculus	0.0	21.5
Statistics	13.1	40.4
Physics	29.5	61.4
General Chemistry	91.8	87.7
Organic Chemistry	68.8	47.4
Biochemistry	55.7	29.8
Geology	32.8	43.6
Paleontology	14.8	7.0
Biology:		
Botany	98.4	93.0
Zoology	98.4	98.3
Microbiology	68.9	47.4
Physiology	85.2	89.5
Vertebrate Anatomy	82.0	73.6
Genetics	90.2	89.5
Evolution	49.2	33.3
Ecology	80.4	64.9
Taxonomy	47.6	47.4
Embryology	59.0	45.6
Invertebrate Zoology	75.4	59.6
Field Biology	67.2	49.1
Conservation	52.5	78.9
Microtechnique	37.7	36.8
Professional Education:		
Methods of Teaching	72.1	91.2
Student Teaching	90.2	93.0

indicating that a subject should be required of future biology teachers. There was a significant difference in the response for six of the related subjects, eight of the biology subjects, and one of the professional education subjects. The "required" response was lower than the actual credits response for the professional education subjects and in four of the six related subjects. The reverse situation was true for the biology subjects since the response for requirement was higher than the actual credit response for seven of the eight subjects.

The greater declines in "required" response were evident in physics and mathematics. Credit in physics was earned by 61.4 per cent of the sample but less than one-third (29.5 per cent) of this number would require this subject of future biology teachers. This contrasts with the recommendations of many national groups and most of the colleges and universities in Wisconsin. Although credit in Calculus was earned by more than one-fifth of the biology teachers, none thought that it should become a requirement. Statistics was listed as a requirement by 13.1 per cent of the sample. This was a difference of 27.3 per cent from the number which had received credit in the subject.

Less than one-third (32.9 per cent) of the teachers would require a subject in geology. This was 10.3 per cent less than the actual credit response. Paleontology would be required by 14.9 per cent but only 7.0 per cent of the teachers reported credit in the subject.

Sizeable differences were recorded in the advanced chemistry subjects. The number which would require organic chemistry was 21.4 per cent higher than the number which had received credit in the subject. A

similar difference of 25.9 per cent was recorded for biochemistry. The teachers have indicated that advanced training in chemistry is necessary. It is not inconceivable to visualize a double major consisting of biology and organic oriented chemistry to be required of all future biology teachers.

No appreciable difference between the two categories was recorded for botany, zoology, physiology, genetics, taxonomy, and micro-technique. Increases in microbiology (47.4 to 68.9 per cent), evolution (33.3 to 49.2 per cent), embryology (45.6 to 59.0 per cent), ecology (64.9 to 80.4 per cent), and field biology (49.1 to 67.2 per cent) illustrate the increased interest and emphasis in these areas. The only significant difference (26.4 per cent) was recorded in conservation. Only one-half (52.5 per cent) of the teachers felt that the state required subject was necessary. With the 15.5 per cent increase in ecology, and the 18.1 per cent increase in field biology, it would appear that the biology teachers may prefer a more complete view of nature.

There was a difference of 19.1 per cent between the two categories in regard to methods of teaching. Thirteen of the seventeen teachers who did not believe credit in methods of teaching was necessary had received credit in the subject themselves. Four of the five teachers who did not possess credit in the subject were of the opinion that it should be required.

Data regarding the range of pre-service subjects in biology are presented in Table VI, page 27. Credit in six to eight of the biology subjects can generally be regarded as a minor in the field. Slightly

TABLE VI

RANGE OF PRE-SERVICE SUBJECTS IN BIOLOGY
AS REPORTED BY FIFTY-SEVEN MILWAUKEE
SECONDARY BIOLOGY TEACHERS,
1966-67

Range of Subjects									
0-2		3-5		6-8		9-11		12-14	
Number	Pct	Number	Pct	Number	Pct	Number	Pct	Number	Pct
1	1.75	1	1.75	20	35.1	25	43.9	10	17.5

more than one-third (35.1 per cent) of the teachers were in this category. Thirty-five of the teachers possessed the equivalent of a major. Teachers who had earned credit in at least nine subjects would have no difficulty in meeting the state requirement of thirty-four hours in the major field. The ten teachers within the upper grouping would easily meet the recommendation of sixty or more hours in the field of science. Only two teachers possessed less than a minor while two others indicated credit in the fourteen subjects included in the survey.

A proposed plan for the pre-service training of biology teachers is presented in Table VII, page 29. The opinions of the sixty-one responding biology teachers provided the basis for the arrangement. A question may arise at this point concerning the qualifications of teachers in selecting a curriculum for the training of biology teachers. Lozonoff found "that, among the people most suited to determine the preparation for teaching, the classroom teacher must be considered."²⁴ Novak and Brooks found that teacher recommendations for college preparation programs in science were somewhat modest when compared to the recommendations of many national committees. However, these same recommendations exceeded most certification requirements.²⁵ It is the contention from this study that experienced biology teachers need

²⁴Paul Lozonoff, "The Effectiveness of Higher Institution's in the Preparation of Biology Teachers," The American Biology Teacher, 27:18, January, 1965.

²⁵Joseph D. Novak and Merle E. Brooks, "College Preparation of Science Teachers," The Science Teacher, 26:473, November, 1959.

TABLE VII

PROPOSED PLAN FOR PRE-SERVICE TRAINING OF BIOLOGY
TEACHERS AS INDICATED BY SIXTY-ONE MILWAUKEE
SECONDARY BIOLOGY TEACHERS, 1966-67

Require	Recommend	Elective	Unnecessary
General Chemistry	Physics	Statistics	Calculus
Organic Chemistry	Biochemistry	Geology	
Botany	Embryology	Paleontology	
Zoology	Conservation		
Genetics	Microtechnique		
Physiology	Evolution		
Vertebrate Anatomy			
Invertebrate Zoology			
Ecology			
Microbiology			
Field Biology			
Methods of Teaching			
Student Teaching			

specific preparation.

In order for a subject to be listed as a requirement, it was necessary that a minimum of two-thirds of the sample indicate the "required" response. If the "required" response was less than two-thirds, then the subject could be listed as recommended, elective, or unnecessary. A subject would be considered recommended if (1) less than two-thirds of the sample considered it required, but (2) a combination of required and recommended responses totaled two-thirds of the sample or greater. Elective and unnecessary subjects were calculated in a similar manner.

The proposed program would consist of required subjects in professional education, chemistry, and biology. Methods of teaching and student teaching would be required subjects. There was an indication that teachers would prefer the methods of teaching subject to be in biology. Since credit varies in different institutions, no semester hours of credit can be assigned to the subjects.

A major in biology and a minor in chemistry would be required of all future biology teachers. The minor in chemistry would include credits in two semesters of both general chemistry and organic chemistry. The major in biology would require thirty-six to thirty-nine semester hours of credit and nine subjects in the field of biology. Zoology, botany, and microbiology usually carry five semester hours of credit. Depending upon the institution, four or five semester hours of credit may be granted for physiology, vertebrate anatomy, and invertebrate zoology. Three semester hours of credit are given for each course in genetics, ecology, and field biology.

Strongly recommended are two related subjects, physics and biochemistry. Embryology, conservation, microtechnique, taxonomy, and evolution were the biology subjects recommended by the sample. However, these subjects would add an additional twenty-eight semester hours to the program. In order to receive credit in all the required and recommended subjects, it would be necessary to establish a five year program for the training of biology teachers.

Statistics, geology, and paleontology were considered to be electives. Calculus was the only subject that was considered to be unnecessary.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to ascertain the opinions of the biology teachers in the City of Milwaukee regarding pre-service subject matter training programs. Comparisons of their recommendations were then made with the existing pre-service subject matter training programs offered by the colleges and universities of Wisconsin and the pre-service training of the teachers. It was assumed that biology teachers were capable of pinpointing the necessary areas of concentration.

Summary. All pertinent data were collected by means of a questionnaire. It included data concerning (1) teacher opinion of twenty-four key preparation subjects and (2) pre-service training in the same twenty-four subjects. Data concerning the required subjects in biology, the required number of hours in biology, and the suggested subjects in the related sciences were obtained from the bulletins of twenty-nine colleges and universities in Wisconsin.

A summary of the data follows:

(1) Ratings reported by the sample placed a higher value on subjects in the field of chemistry than the subjects in the other related sciences. General chemistry was considered necessary by 91.8 per cent, organic chemistry by 68.8 per cent, and biochemistry by 55.7 per cent.

(2) Teachers were not in complete agreement with a 'common core of subjects' as proposed by the American Association for the Advancement of Science.²⁶

²⁶Cooperative Committee (AAAS), loc. cit.

(3) The teachers indicated that they would require botany, zoology, genetics, physiology, vertebrate anatomy, invertebrate zoology, ecology, field biology, and microbiology. Each of the five major areas of biology were represented by one or more of these subjects.

(4) Only 72.1 per cent of the respondents would require methods of teaching. There was an indication that the subject should be constructed specifically for the teaching area.

(5) With the exception of general chemistry (87.7 per cent) and physics (61.4 per cent), the majority of teachers were deficient of credit in the related sciences.

(6) Of the fifty-seven reporting teachers, 78.9 per cent had received credit in each of the five major areas. Zoology (98.3 per cent), botany (93.0 per cent), physiology (89.5 per cent), and genetics (89.5 per cent) were the most frequently reported subjects.

(7) The teachers have indicated that advanced training in chemistry is necessary. Organic oriented subjects leading toward a double major in biology and chemistry is advisable.

(8) Almost one-half of the teachers were in opposition to a state required subject in conservation.

(9) More than one-third of the teachers did not possess the equivalent of a major in biology. However, 61.4 per cent of the teachers found no difficulty in meeting the state requirement of thirty-four semester hours in the major field.

(10) Credit in a number of subjects should be emphasized in preference to semester hour credit.

(11) A pre-service program of thirty-six to thirty-nine hours in nine biology subjects and a minor in chemistry were recommended by the sample.

Conclusions. From the study it may be concluded that the majority of biology teachers of the City of Milwaukee had taken an adequate number of subjects and semester hours in the field of biology. There was an even stronger indication that the subjects were divided evenly over the major areas of biology. It is realized that the number of credits or credit in particular subjects does not necessarily make an individual a better teacher. However, it has been indicated that the amount of academic credit does have some bearing on the adequacy of teacher preparation.

As was expected, the teachers were somewhat deficient in the related subjects. A possible explanation could be that course selections in the physical sciences and mathematics are often limited to academic majors. As a result, the major emphasis is upon the natural sciences.²⁷

The discrepancy between actual credits earned and the "required" response for the related subjects was somewhat unexpected. It was evident that, with the exception of chemistry, these subjects were lightly regarded. It was also apparent that many science education advisors did recommend such subjects for their students. More than likely, there is a realization that (1) the state of scientific know-

²⁷Lozonoff, loc. cit.

ledge is continually changing and (2) despite the fact of specialization, the sciences are being continually drawn together by certain unifying concepts.

Qualifications for graduation and certification are most often expressed as a certain number of hours. There is an indication that credit in a number of subjects or areas would be more realistic. A teacher with thirty-four semester hours of training spread over the five major areas should be more adequately qualified than a teacher who specialized in one area.

Finally, the respondents' opinion of future pre-service training exceeds the current state requirements for certification. It is also more specific than the requirements listed in the bulletins of the colleges and universities in Wisconsin. However, their recommendations are low in the related science areas when compared to the recommendations of the American Association for the Advancement of Science.

Recommendations. The following recommendations are based upon the summary and conclusions of this survey:

(1) State certification and graduation requirements should be made more specific.

(2) Credit in the number of subjects or areas should be emphasized in preference to semester hour credit.

(3) The methods of teaching subject should be constructed to be specific for the teaching area.

(4) A minor in chemistry, which would include two semesters of organic chemistry, is mandatory. Training in biochemistry is strongly

advisable.

(5) A major in biology consisting of approximately thirty-six semester hours in nine subjects is a minimum.

(6) Introductory subjects in the related areas are advisable.

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APPENDIX

May 8, 1967

The attached questionnaire is concerned with determining the opinions of biology teachers regarding undergraduate subject matter preparation of future biology teachers. It is hoped that the result of this study will provide a preliminary basis for improving the pre-service subject matter preparation of the future biology teachers.

I am particularly desirous of obtaining your response since your experience as a biology teacher makes you aware of the areas in which future teachers need specific preparation. The questionnaire has been pretested and revised to obtain all of the necessary data while requiring a minimum of your time.

It will be appreciated if you will complete the questionnaire prior to May 15 and return it in the enclosed stamped envelope. Other phases of this research cannot be carried out until I receive all of the questionnaire results.

Thank you for your cooperation.

Sincerely,

Vincent L. Santine

Instructions

Page 1

Please place a check in the space provided for the subject which you feel should be (a) required, (b) recommended, (c) left as elective, or (d) considered unnecessary in the pre-service training of biology teachers.

Page 2

Please place a check in the space provided to indicate whether you have or have not received undergraduate credit in each subject. If you have, indicate the number of semester hour credits.

Please use the reverse side for extra courses or comments if necessary.

Do you wish to receive a copy of the summary of the results:

Yes

No

If yes:

Name: _____

Address: _____

Subjects	Credits	No Credits	Number of Credits
Calculus			
Statistics			
Physics			
General Chemistry			
Organic Chemistry			
Biochemistry			
Geology			
Paleontology			
Botany			
Zoology			
Vertebrate Anatomy			
Invertebrate Zoology			
Physiology			
Embryology			
Microbiology			
Genetics			
Ecology			
Field Biology			
Conservation			
Taxonomy			
Microtechnique			
Evolution			
Methods of Teaching			
Student Teaching			
Others-Please Specify.			

Subjects	Require	Recommend	Elective	Unnecessary
Calculus				
Statistics				
Physics				
General Chemistry				
Organic Chemistry				
Biochemistry				
Geology				
Paleontology				
Botany				
Zoology				
Vertebrate Anatomy				
Invertebrate Zoology				
Physiology				
Embryology				
Microbiology				
Genetics				
Ecology				
Field Biology				
Conservation				
Taxonomy				
Microtechnique				
Evolution				
Methods of Teaching				
Student Teaching				
Others-Please Specify.				

PRESENT SUBJECT MATTER PREPARATION AND FUTURE TRENDS IN THE
PREPARATION OF HIGH SCHOOL BIOLOGY TEACHERS

by

VINCENT LEE SANTINE

B. S., Southwestern State College, 1963
Weatherford, Oklahoma

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

The purpose of this study was to ascertain the opinions of the biology teachers in the City of Milwaukee regarding pre-service subject matter training programs. Comparisons of their recommendations were then made with the existing pre-service subject matter training programs offered by the colleges and universities of Wisconsin and the pre-service training of the teachers.

All pertinent data was collected by means of a questionnaire. It included data concerning (1) teacher opinion of twenty-four key preparation subjects and (2) pre-service training in the same twenty-four subjects. Data concerning the required subjects in biology, the required number of hours in biology, and the suggested subjects in the related sciences were obtained from the bulletins of twenty-nine colleges and universities in Wisconsin.

A summary of the data follows:

(1) Ratings reported by the sample placed a higher value on subjects in the field of chemistry than the subjects in the other related sciences. General chemistry was considered necessary by 91.8 per cent, organic chemistry by 68.8 per cent, and biochemistry by 55.7 per cent.

(2) Teachers were not in complete agreement with a 'common core of subjects' as proposed by the American Association for the Advancement of Science.

(3) The teachers indicated that they would require botany, zoology, genetics, physiology, vertebrate anatomy, invertebrate zoology, ecology, field biology, and microbiology. Each of the five major areas of biology were represented by one or more of these subjects.

(4) Only 72.1 per cent of the respondents would require methods of teaching. There was an indication that the subject should be constructed specifically for the teaching area.

(5) With the exception of general chemistry (97.7 per cent) and physics (61.4 per cent), the majority of teachers were deficient of credit in the related sciences.

(6) Of the fifty-seven reporting teachers, 78.9 per cent had received credit in each of the five major areas. Zoology (93.3 per cent), botany (93.0 per cent), physiology (89.5 per cent), and genetics (89.5 per cent) were the most frequently reported subjects.

(7) The teachers have indicated that advanced training in chemistry is necessary. Organic oriented subjects leading toward a double major of biology and chemistry is advisable.

(8) Almost one-half of the teachers were in opposition to a state required subject in conservation.

(9) More than one-third of the teachers did not possess the equivalent of a major in biology. However, 61.4 per cent of the teachers found no difficulty in meeting the state requirement of thirty-four semester hours in the major field.

(10) Credit in a number of subjects should be emphasized in preference to semester hour credit.

(11) A pre-service program of thirty-six to thirty-nine hours in nine biology subjects and a minor in chemistry were recommended by the sample.

From the study, it may be concluded that the majority of biology teachers of the City of Milwaukee had taken an adequate number of subjects and semester hours. The subjects were evenly divided over the major areas of biology. However, there was some deficiency in the related subjects.

Qualifications for graduation and certification would be more realistic if expressed as a number of subjects or areas. The respondent's opinions not only exceed, but they are more specific than the current state requirements in Wisconsin. However, their recommendations are low when compared to the recommendations of the American Association for the Advancement of Science.