A COURSE OF STUDY IN THE PHYSICAL SCIENCES FOR SENIOR HIGH SCHOOL STUDENTS IN THE LABORATORY SCHOOL

A Thesis

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Master of Science

by

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CHAPTER I

INTRODUCTION

Statement of the Problem. In order to provide a well rounded science program for the pupil who has no intention of specializing in science, "de-technicalized" physical science courses have been added to the science curriculum of many high schools. A survey of periodical literature concerning these courses seems to indicate that there is little uniformity among them and that a wide variety of subject matter has been taught in the name of physical science. The bounds of these courses may be understood by the generally accepted definition of a physical science course: "Any course of one semester or more in length which is given above grade IX and which includes material from two or more physical sciences and excludes material of biological sciences."[1] The problem of this thesis is to compile units for a one-year high school physical science course. These units will be especially adapted to the science curriculum of the Laboratory School of Indiana State Teachers College.

Criteria for Selection of Objectives for a Physical Science Course. The committe which prepared the science program presented in the Thirty-First Yearbook of the National

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[1] D. R. Watson, "Objectives of Survey Courses in Physical Science," The School Review, 48:685, October, 1940.

Society for the Study of Education[2] recognizes the aim of science teaching to be contributory to the aim of education--"life enrichment through participation in a democratic social order."[3] The committee proposed "that the curriculum in science for a program of general education be organized about large objectives, that understanding and enlargement of these objectives shall constitute the contributions of science teaching to the ultimate aim of education."[4] Dr. G. S. Craig compiled such a list of general objectives[5] as a basis for preparing a science curriculum for the Hoarce Mann Elementary School. From Craig's list and other similar studies, the committee selected the following statements which they deem "to be of importance sufficient to justify their use for guidance in the selection of specific objectives for science in the elementary school, in the junior high school, and the senior high school:"[6]

1. The sun is the chief source of energy for the earth.

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[2] "A Program for Science Teaching," Thirty-First Yearbook of the National Society for the Study of Education, (Bloomington, Illinois: Public School Publishing Company, 1932), pp. 53-54.

[3] Ibid., p. 57

[4] Ibid., p. 58

[5] G. S. Craig, "Certain Techniques used in Developing a Course of Study in Science for the Horace Mann Elementary School," Contributions to Education, No. 276, (New York: Teachers College, Columbia University, 1927), p. .

[6] "A Program for Science Teaching," op. cit., p. 53.

2. Matter and energy cannot be created or destroyed, but may be changed from one form to another.

3. The energy of solar radiation is continually working changes in the surface of the earth.

4. There have been profound changes in the climate, not only of certain regions, but also of the earth as a whole.

5. The evolution of the earth has come as a result of natural forces.

6. Units of time are defined by the earth's movements in relation to the sun.

7. The earth seems very old when its age is measured in the ordinary units of time.

8. Distances in space seem extremely vast when compared with distances on earth.

9. Chemical and physical changes are manifestations of energy changes.

10. There are fewer than one hundred chemical elements.

11. Every substance is one of the following: (a) a chemical element, (b) a chemical compound, (c) a mechanical mixture.

12. Light is a limiting factor to life.

13. Sound is caused by waves which are produced by a vibrating body and which can affect the auditory nerves of the ear.

14. Gravitation is the attractive force that influences

or governs the movements of astronomical bodies.

15. Machines are devices for accomplishing useful transformations of energy.

16. Any machine, no matter how complicated, may be analyzed into a few simple types.

17. The properties of the different elements depend on the number and arrangement of the electrons and protons contained in their atoms.

18. All matter is probably electrical in structure.

19. The applications of electricity and magnetism in the home and in industry have revolutionized the methods of living of many people.

20. The kinetic energy of the molecules determines the physical states of matter.

21. The gravitational attraction between the earth and a mass of unconfined gas or liquid causes the pressure of the liquid or gas on the surface of the earth.

22. Liquid or gas pressure is exerted equally in all directions.

23. Chemical changes are accompanied by energy changes.

24. A change in rate or direction of motion of an object requires the application of an external force.

25. Radiant energy travels in straight lines through a uniform medium.

26. Electricity is a form of energy that results from

disturbing the position of the regular paths of electrons.

27. In a chemical change a quantitative relationship exists between the amounts of substances reacting and the amounts of the substances that are the products of the reaction.

While the committee felt that this list[7] represented their best efforts at the time of its preparation, they hoped that the list would in no sense be considered final and that these principles would be enlarged or curtailed in the light of new studies. The writer has modified this list in the light of students' present scientific needs and interests as revealed by studies summarized in Chapters II and III respectively.

Organization of Remainder of Thesis. Chapter II is a summary of three studies of science articles in periodicals. The first of these is a recent study made by the writer. The results of this study were compared with previous studies made by Curtis and Searle.

Chapter III is a summary of three studies of students' science interests. The studies of Pollock and Curtis were made approximately fifteen years before Zim's study, which was completed in 1940.

In the fourth chapter the general objectives on pages

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[7] This list of generalizations as published in the yearbook contained statements concerning biological as well as physical science. However, only those which apply to physical science have been listed here.

3 and 4 were evaluated in the light of the conclusions reached in Chapter II and Chapter III. Since these units were prepared primarily for the high school students of the Indiana State Teachers College Laboratory School, the previous science training of these students was a final factor in evaluation of these general objectives. The final accepted list contains twenty-four objectives, and these were considered the fundamental concepts to be developed in the physical science course. These were placed in groups according to their scientific relation to each other. The resulting ten groups of fundamental concepts constituted the foundation on which ten units were built.

CHAPTER II

SCIENTIFIC KNOWLEDGE NECESSARY FOR AN INTELLIGENT READING OF PERIODICALS

Since most people get their information about what is going on in the world by reading magazines and newspapers, the ability to understand scientific articles should contribute to the aim of all education--life enrichment. "Teaching our youth the fundamental principles and vocabularies of the various sciences should be one of the major aims of our public schools."[1]

If we are to prepare students to understand scientific articles which appear in laymen's magazines, we must know something about the scientific content of the periodicals. This knowledge is obtained by analysis of magazine articles. Several studies of this nature have been made in the past, and those of Searle[2] and Curtis[3] were used in this study.

The purpose of this investigation was two-fold: first,

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[1] Edwin H. Hoffhaus, "Relation of Science to Pupils' Reading Activities," (Unpublished Master's Thesis, Indiana State Teachers College, 1936), 53 pp.

[2] A. H. Searle and G. M. Ruch, "A Study of Science Articles in Magazines," School Science & Mathematics, 26:389, April, 1926.

[3] Francis Day Curtis, "Some Values Derived from Extensive Reading of General Science," Contributions to Education, Number 163, (New York: Teachers College, Columbia University, 1924).

to determine what physical science[4] terms appear in recent magazine articles; and second, to compare the findings of this recent study with similar studies made approximately fifteen years earlier.

Magazines investigated. The recent investigation included an issue a month for a period of one year of each of the following magazines: Ladies Home Journal, Saturday Evening Post, Good Housekeeping Magazine, Life, and Time. The circulation of these magazines for the March-June period, 1940 was as follows:[5]

Ladies Home Journal	3,547,652
Saturday Evening Post	3,321,496
Good Housekeeping Magazine	2,308,598
Life	2,860,484
Time	777,688

An effort was made to examine one issue a month for the year 1940. This was accomplished without difficulty so far as the two monthly magazines were concerned. The issues of Good Housekeeping Magazine and Ladies Home Journal for the months January through December, 1940, were investigated.

In dealing with the weekly magazines one issue a month

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[4] "Physical science" as used in this study includes physics, chemistry, astronomy, mineralogy, and geology; and excludes the biological sciences.

[5] N. W. Ayr & Sons, Directory of Newspapers & Periodicals, 1941.

was also examined. The particular weekly issues chosen to be used in the investigation were taken at random without any effort on the part of the investigator. In some cases, however, the contents of each of the weekly issues for a month were glanced at and the issue chosen for examination was the one containing the most scientific material. This procedure seemed acceptable to the investigator because the purpose of the study was to determine what science these periodicals contain rather than how much science.

The weekly magazines examined are listed below:

Saturday Evening Post.

January 27, 1940
February 10, 1940
March 30, 1940
April 6, 1940
May 4, 1940
June 1, 1940
July 6, 1940
August 24, 1940
September 28, 1940
October 26, 1940
November 16, 1940
December 28, 1940

Life.

December 26, 1938
January 30, 1939
April 29, 1940
January 6, 1941
February 3, 1941
February 10, 1941
May 19, 1941
June 30, 1941
July 28, 1941
August 18, 1941
September 22, 1941
October 6, 1941

Time.

October 16, 1939	April 8, 1940
November 20, 1939	May 13, 1940
December 18, 1939	June 10, 1940
January 1, 1940	July 8, 1940
February 5, 1940	August 12, 1940
March 4, 1940	September 9, 1940

The copies of Life magazine used in this study were not for the year 1940 as was true of other magazines examined. The Life magazines used were spread over a period of time from December, 1938, to October, 1941. This spread was due to difficulty in securing the periodicals. The Indiana State Teachers College Library does not keep this magazine in bound volumes. The magazines used were secured from the Fairbanks Library. However, this library did not have all the issues, and in an effort to secure one issue for each month, it was necessary to include issues over a period of three years. Even with this spread, issues for November and March were not found. Life magazine, as a rule, devotes once a month a section to science. The issues chosen for examination in this study were issues containing these "science sections." Scientific material was also found in Life in the section "speaking of pictures."

Time magazine devotes a section in each issue to science and most of the data gathered from this periodical were found in these sections. However, the entire magazine was leafed

through and any random articles concerning science were included. The issues of Time were for the year 1940 with the exception of October, November, and December. The bound volume containing these issues was not in the library at the time the study was made. The issues for the same months for 1939 were used instead.

Procedure used. A list of three hundred fifty physical science terms was prepared from the index of a modern physical science text. Ample space was left throughout the list for the addition of other terms that might be found. Each magazine issue was leafed through from cover to cover and every article of a scientific nature was carefully read. All physical science terms, an understanding of which was necessary to grasp the full meaning of the article, were tallied on the list of terms. A few examples are given below:

"The acetic acid in vinegar can be satisfactorily handled by the digestive organs." (Good Housekeeping Magazine, October, 1940, p. 107). Knowledge of the term "acetic acid" was considered necessary for an intelligent reading of the article in which this statement appeared.

"Now let us see what sixty grams of protein mean in terms of milk, eggs, fish, cheese, or other foods." (Ladies Home Journal, November, 1940, p. 94). Knowledge of the terms "gram" and "protein" were considered essential for an understanding of the article. In fact, the magazine used a foot-

note in which the gram was explained in relation to ounces.

"A high-pressure area sweeping southeast from the frozen Mackenzie Basin of northern Canada brought in a week of sleet and rain..." (Time, February 5, 1940, p. 16). Knowledge of the term "high-pressure area" was considered essential for an understanding of the article.

Only one tally was given to the same term in any one article, although the term may have been used repeatedly.

Summary of Study. Table I shows the frequency and percentage of the forty-two scientific terms which were found in the greatest number of articles. Tables II and III give information concerning the total number of terms which relate to each of the topics discussed in the average physics and chemistry textbooks.

This study shows that articles concerning foods appear in periodicals far more frequently than articles of any other scientific topic. Plastics have recently come into the picture, and there is an increasing number of articles concerning organic chemistry. Articles dealing with X rays, atoms, and topics relating to the so-called "modern physics" are decidedly on the increase, while light has maintained its place at the top of the list of frequently appearing topics. Many of the topics to which traditional physics and chemistry textbooks gave considerable emphasis are seldom, if ever, mentioned in laymen's periodicals. These topics include the

Table I

FORTY-TWO MOST COMMON PHYSICAL SCIENCE TERMS
and
NUMBER AND PERCENTAGE OF ARTICLES IN WHICH EACH APPEARED

Scientific Term	Frequency	Percentage
Vitamins	32	13.3
Protein	16	6.6
Acids	15	6.2
X Ray	10	4.2
Calcium	8	3.3
Plastics	8	3.3
Radio	7	2.9
Weather	7	2.9
Calorie	6	2.5
Frequency Modulation	6	2.5
Phosphorus	6	2.5
Oil	6	2.5
Airplane	5	2.1
Electron	5	2.1
Iron	5	2.1
Lens	5	2.1
Minerals	5	2.1
Velocity	4	1.7
Temperature	4	1.7
Pectin	4	1.7
Magnetism	4	1.7
Horsepower	4	1.7
Hydrogen	4	1.7
Gelatin	4	1.7
Fats	4	1.7
Energy	4	1.7
Carbohydrate	4	1.7
Atoms	4	1.7
Photography	4	1.7
Atmosphere	4	1.7
Air	4	1.7
Acceleration	3	1.2
Alloys	3	1.2
Diesel	3	1.2
Fabrics	3	1.2
Humidity	3	1.2
Oxygen	3	1.2
Rayon	3	1.2
Sun	3	1.2
Television	3	1.2
Voltage	3	1.2
Water	3	1.2

Table II

PER CENT OF PHYSICAL SCIENCE TERMS FOUND IN MAGAZINE ARTICLES THAT RELATE TO MAJOR TOPICS IN HIGH SCHOOL PHYSICS TEXTS

Topic	Frequency	Per Cent
Light	49	25.3
Mechanics & Work	24	12.4
Modern Physics	22	10.8
Heat	21	10.8
Radio & Television	20	10.3
Mechanics of gases	16	8.2
Matter & Measurement	8	4.1
Energy	6	3.1
Sound	6	3.1
Mechanics of liquids	5	2.6
Electric Current	4	2.1
Dynamoes & Machines	4	2.1
Mechanics of Solids	3	1.6
Electrostatics	2	1.0
Electric Induction	2	1.0
Men	2	1.0

Table III

PER CENT OF PHYSICAL SCIENCE TERMS FOUND IN MAGAZINE ARTICLES THAT RELATE TO MAJOR TOPICS IN HIGH SCHOOL CHEMISTRY TEXTS

Topic	Frequency	Per Cent
Foods	66	33.7
Organic Chemistry	33	16.8
Processes	15	7.7
Acids	15	7.7
Metals	14	7.1
Plastics	8	4.1
Calcium	8	4.1
Phosphorus	6	3.1
Gases	6	3.1
Miscellaneous	6	3.1
Atoms	5	2.5
Salts	5	2.5
Synthesis	3	1.5
Fabrics	3	1.5
Alloys	3	1.5

following: Boyle's law, Newton's laws of motion, Ohm's law, valence, and chemical equations.

From this study, it would seem that such topics as the function and utilization of foods, contributions of organic chemistry to our civilization, and modern physics should be given much consideration in an up-to-date physical science course.

Comparison with Previous Studies. Table IV gives the forty-four physical science terms which appeared in the greatest number of articles according to Curtis' study. In the parentheses preceding each term is the percentage of the total number of articles in which the term appeared more than one time in the original study. The sum of these percentages, however, is 76.7, instead of 100. The other 23.3 percent consisted of biological terms. For the sake of comparison, it seemed advisible to make the sum of the percentages of the physical science terms total approximately 100. This was accomplished by multiplying the percentages in parentheses by four-thirds. The numbers following each term are the modified percentages.

Table V is a comparison of the writer's study and Curtis' study. The terms in the vertical list were taken from Table I. The names of the two studies were placed across the top of the table, and check marks were used to indicate the relative positions of the term in each study. (x) indi-

Table IV

PER CENT OF PHYSICAL SCIENCE TERMS
WHICH APPEARED IN
GREATEST NUMBER OF DIFFERENT ARTICLES
ACCORDING TO CURTIS' STUDY

	Scientific Term	Per Cent*
(6.5)	Weather	8.7
(4.0)	Airplane	5.3
(3.2)	Power	4.3
(3.1)	Weather bureau	4.1
(2.9)	Earth quake	3.9
(2.4)	Engine	3.2
(2.4)	Gas	3.2
(2.2)	Degree	2.9
(2.2)	Pole	2.9
(2.2)	Temperature	2.9
(2.2)	Turbine	2.9
(2.1)	Storage battery	2.8
(2.1)	Wave	2.8
(1.9)	Wavelength	2.5
(1.7)	Wind	2.3
(1.6)	Explosion	2.1
(1.6)	Gale	2.1
(1.6)	Horsepower	2.1
(1.6)	Motor	2.1
(1.6)	Pressure	2.1
(1.4)	Blizzard	1.9
(1.4)	Boiler	1.9
(1.4)	Electrical	1.9
(1.4)	Fertilizer	1.9
(1.3)	Energy	1.7
(1.3)	Gasoline	1.7
(1.3)	Mercury boiler	1.7
(1.3)	Steel	1.7
(1.3)	Vapor	1.7
(1.1)	Alcohol	1.5
(1.1)	Circuit	1.5
(1.1)	Inch (of rain)	1.5
(1.1)	Mineral	1.5
(1.1)	Snow	1.5
(1.0)	Coal	1.3
(1.0)	Crystal	1.3
(1.0)	Dirigible	1.3
(1.0)	Frost	1.3
(1.0)	Mercury	1.3
(1.0)	Nitrate	1.3
(1.0)	Star	1.3
(1.0)	Storm	1.3
(1.0)	Ventilation	1.3
(1.0)	X Ray	1.3

*Adjusted values

Table V

COMPARISON OF STUDIES
OF PHYSICAL SCIENCE TERMS
APPEARING IN SCIENCE ARTICLES

Scientific Term	Writer	Curtis
Vitamins	x	
Protein	x	
Acids	x	
X Ray	x	*
Calcium	x	
Plastics	x	
Radio	x	
Weather	x	x
Calorie	x	
Frequency Modulation	x	
Phosphorus	x	
Oil	x	
Airplane	x	x
Electron	x	
Iron	x	
Lens	x	
Mineral	x	*
Velocity	*	
Temperature	*	x
Pectin	*	
Magnetism	*	
Horsepower	*	
Hydrogen	*	
Gelatin	*	
Fats	*	
Energy	*	*
Carbohydrates	*	
Atoms	*	
Photography	*	
Atmosphere	*	
Air	*	
Acceleration	*	
Alloys	*	
Diesel	*	
Fabrics	*	
Humidity	*	
Oxygen	*	
Rayon	*	
Sun	*	
Television	*	
Voltage	*	
Water	*	

cates that the term appeared in two per cent or more of all scientific articles. (*) indicates that the term appeared in less than two per cent of all articles. A blank indicates that the term was not among the forty-four most common physical science terms found by Curtis.

It is at once apparent that the two studies gave quite different results. Only three terms -- weather, airplane, and energy showed the same relative positions in the two lists. Thirty-five of the forty-two most frequently used physical science terms in the writer's study were not among the forty-four most frequently used physical science terms in Curtis' study. This does not mean that all of these thirty-five terms did not appear in periodical literature at the time the earlier study was made, but it does indicate they are of greater importance now than they were at that time. However, it is true that some of the terms such as plastics and vitamins which ranked high in the recent study, seldom, if ever, appeared in periodical literature sixteen years earlier.

The results of Searle's study are shown in Tables VI and VII. Table VIII is a comparison of the per cent of physical science terms found in magazine articles that relate to major topics in high school physics texts as reported by Searle and the writer. The topics are listed in the order of the sum of their percentages in the two studies. These sums are shown after each term. The names of the authors of the two studies

Table VI

PER CENT OF PHYSICAL SCIENCE TERMS FOUND IN MAGAZINE ARTICLES THAT RELATE TO MAJOR TOPICS IN HIGH SCHOOL PHYSICS TEXTS AS REPORTED BY SEARLE

Topic	Per Cent
Light	18.2
Dynamoes and Machines	16.5
Matter	10.5
Mechanics and Work	8.9
Heat	8.2
Mechanics of Solids	6.6
Molecules	5.1
Men	5.0
Mechanics of Liquids	4.9
Magnetism	3.8
Sound	3.3
Gravity	2.6
Electrostatics	2.4
Energy	1.7
Electric Induction	1.2
Electric Current	1.1

Table VII

PER CENT OF PHYSICAL SCIENCE TERMS FOUND IN MAGAZINE ARTICLES THAT RELATE TO MAJOR TOPICS IN HIGH SCHOOL CHEMISTRY TEXTS AS REPORTED BY SEARLE

Topic	Per Cent
Processes	14.9
Discoveries	12.9
Gases	12.8
Synthesis	11.2
Atomic Weight	7.4
Analysis	6.9
Sodium	6.6
Nitrogen	4.5
Radium	3.9
Laws	3.8
Oxygen	2.7
Acids	2.6
Colloids	2.2
Men	2.1
Crystals	1.2
Salts	1.2
Periodic System	.8
Organic Chemistry	.5
Sulphur	.5
Symbols	.5
Calcium	.4
Halogens	.3

Table VIII

COMPARISON OF STUDIES OF PHYSICAL SCIENCE TERMS FOUND IN MAGAZINE ARTICLES THAT RELATE TO MAJOR TOPICS IN HIGH SCHOOL PHYSICS TEXTS

Topic	Total Percentage	Writer	Searle
Light	43.5	x	x
Mechanics & Work	21.3	x	x
Heat	19.0	x	x
Dynamoes & Machines	18.6	*	x
Matter & Measurement	14.6	x	x
Modern Physics	11.3	x	
Radio & Television	10.3	x	
Mechanics of Gases	8.2	x	
Mechanics of Solids	8.2	*	x
Mechanics of Liquids	7.5	*	*
Men	6.0	x	*
Sound	6.4	*	*
Molecules	5.1		x
Energy	4.8	*	*
Magnetism	3.8		*
Electrostatics	3.4	*	*
Electric Circuit	3.2	*	*
Gravity	2.6		*
Electric Induction	2.2	*	*

appear at the top of the Table, and check marks were used to indicate the relative positions of the term in each study. (x) indicates that the terms relating to this topic were five per cent or more of all terms relating to physics. (*) indicates that the terms relating to this topic consist of less than five per cent of all terms relating to physics. Ten of the nineteen topics relating to physics received the same relative ranking in both studies. Both studies showed that magazines contain more terms classified under the heading "light" than under any other heading so far as physics is concerned. Scientific terms dealing with modern physics and radio and television now show prominent percentages, although they did not appear in the earlier study.

Table IX is a comparison of the per cent of science terms found in magazine articles which relate to major topics in high school chemistry texts. The plan of Table IX is the same as that of Table VIII. Only two of the thirty topics received the same relative positions in both studies. Fourteen topics mentioned in the earlier study were not once encountered in the recent investigation. "Foods," which heads the list in the recent study, was not even mentioned in the earlier one, while organic chemistry, which ranked second in the former, ranked eighteenth in the latter. "Processes," which headed the list in Searle's study, still holds an important rank, maintaining third place in the present summary.

Table IX

COMPARISON OF STUDIES OF PHYSICAL SCIENCE TERMS FOUND IN MAGAZINE ARTICLES THAT RELATE TO MAJOR TOPICS IN HIGH SCHOOL CHEMISTRY TEXTS

Topic	Total Percentage.	Writer	Searle
Foods	33.7	x	
Processes	22.6	x	x
Organic Chemistry	17.3	x	*
Gases	15.9	*	x
Discoveries	12.9		x
Synthesis	12.7	*	x
Acids	10.3	x	*
Atomic Weight	7.4		x
Metals	7.1	x	
Analysis	6.9		x
Sodium	6.6		x
Calcium	4.5	*	*
Nitrogen	4.5		*
Plastics	4.1	*	
Radium	3.9		*
Laws	3.8		*
Salts	3.7	*	*
Phosphorus	3.1	*	
Miscellaneous	3.1	*	
Oxygen	2.7		*
Atoms	2.5	*	
Colloids	2.2		*
Men	2.1		*
Fabrics	1.5	*	
Alloys	1.5	*	
Crystals	1.2		*
Periodic System	.8		*
Sulphur	.5		*
Symbols	.5		*
Halogens	.3		*

CHAPTER III

STUDENTS' SCIENCE INTERESTS

In an effort to reach some conclusion concerning students' science interests, three separate studies were investigated. Those of Pollock[1] and Curtis[2] were made in 1924. Zim's[3] study, which is far more comprehensive than either of these, was completed in 1940. Most research studies of science interests have been conducted with children below the junior high school. However, the above mentioned studies were made with older children, and Curtis obtained questions from parents as well.

Table X shows the frequency and percentage of junior high school students' science interests according to Pollock's study. It might be pointed out here that the percentages shown in Tables X to XVI were computed for use in this study and did not appear in the original works. Tables XI and XII show the frequency and percentage of the scientific interests

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[1] C. A. Pollock, "Children's Interests as a Basis of What to Teach in General Science," Educational Research Bulletin, Ohio State University, 3:1.

[2] F. D. Curtis, "Some values of Extensive Reading in General Science," Contributions to Education, Number 163, (New York: Teachers College, Columbia University, 1924).

[3] H. S. Zim, Science Interests and Activities of Adolescents, (New York: Ethical Culture Schools, 1940).

Table X

PHYSICAL SCIENCE INTERESTS
OF CHILDREN
ACCORDING TO POLLOCK'S STUDY

Scientific Term	Frequency	Per Cent*
Electricity	349	12.8
Stars	253	9.3
Radio	243	8.9
Heat	181	6.6
Lightning	157	5.7
Planets	146	5.3
Moon	120	4.4
Sun	98	3.6
Mars	97	3.6
Wind	86	3.1
Gravity	83	3.0
Air	82	3.0
Airplane	81	3.0
Earth	72	2.6
Light	57	2.1
Sound	51	1.9
Gas	50	1.8
Rotation	46	1.7
Clouds	40	1.5
Volcanoes	38	1.4
Machinery	36	1.3
Water-supply	36	1.3
Sea	31	1.1
Earthquake	30	1.1
Snow	30	1.1
Nature	27	1.0
Radium	27	1.0
Food	25	.9
Stones	25	.9
Telephone	25	.9
Engine	24	.9
Rain	24	.9
Photography	21	.8
Seasons	21	.8
Coal	20	.7

*Not given in original study

Table XI

PHYSICAL SCIENCE INTERESTS
OF BOYS AND GIRLS
ACCORDING TO CURTIS' STUDY

Scientific Term	Frequency	Per Cent*
Stars	194	10.7
Electricity	106	5.8
Planets	94	5.2
Moon	91	5.0
Earth	89	4.9
Gravity	81	4.5
Earthquakes	79	4.4
Volcanoes	75	4.1
Sun	69	3.8
Radio	67	3.7
Smoke	57	3.1
Mars	54	3.0
Lightning	51	2.8
Ocean	43	2.4
Air	36	2.0
Light	35	1.9
Wind	33	1.8
Astronomy	31	1.7
Clouds	31	1.7
Crude-oil	31	1.7
Meteors	31	1.7
Solar system	30	1.7
Aurora Borealis	29	1.6
Rain	28	1.5
Thunder	28	1.5
Geysers	27	1.5
Tides	27	1.5
Sound	26	1.4
Evolution (cosmic)	22	1.2
Eclipses	21	1.2
Mechanics	21	1.2
Gases	20	1.1
Sky	20	1.1
Combustion	19	1.0
Comets	18	1.0
Geology	18	1.0
History of science	18	1.0
Rainbows	18	1.0
Snow	18	1.0

*Not given in original study

Table XII

PHYSICAL SCIENCE INTERESTS
OF MEN AND WOMEN
ACCORDING TO CURTIS' STUDY

Scientific Term	Frequency	Per Cent*
Radio	90	8.2
Stars	74	6.8
Electricity	54	4.9
Crude-oil	48	4.4
Earth	47	4.3
Moon	43	3.9
Volcanoes	39	3.6
Sun	38	3.5
Tides	38	3.5
Earthquakes	37	3.4
Gravity	33	3.0
Ocean	32	2.9
History of science	31	2.8
Mars	30	2.7
Air	29	2.6
Astronomy	29	2.6
Solar system	29	2.6
Sound	29	2.6
Planets	27	2.5
Diet	25	2.3
Wind	24	2.2
Light	24	2.2
Lightning	24	2.2
Chemistry (household)	23	2.1
Meteors	23	2.1
Clouds	22	2.0
Automobile mechanics	21	1.9
Radium	21	1.9
Geology	17	1.6
Rain	17	1.6
Stain removal	16	1.4
Coal	15	1.4
Geysers	15	1.4
Seasons	15	1.4
Thunder	15	1.4

*Not given in original study

of boys and girls and of men and women, respectively, as determined by Curtis. It is interesting to note that in all three of the tables stars, electricity, and radio are near the top. The correlation of Curtis' study as a whole with that of Pollock is .69 ± .04.

Pollock and Curtis used some form of questionnaire as their main source of data, and the questionnaire was the first device used by Zim. However, Zim's study is different from the above mentioned studies in that Zim did not stop with the questionnaire. He used six different techniques, three of which are discussed in this study. It did not seem necessary to discuss all six techniques, because the results were similar in each. In this connection Zim says, "Thus for both boys and girls the questions about which they wonder reflect the same interests as shown by the science exhibits, film choice, etc."[4]

The replies to the question, "What part of science ever studied did you find most interesting?" are shown in Table XIII. Zim points out that the grouping of the topics as shown in Table XIII is arbitrary and covers up many of the specific interests reported by the students; e.g., "Six separate entries--airplanes, lighter-than-air craft, aeronautics, balloons, stratasphere ships, and aviation were combined under

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[4] Zim, op. cit., p. 93.

Table XIII

COMBINED REPLIES IN THE PHYSICAL SCIENCES
TO THE QUESTION
"WHAT PART OF SCIENCE EVER STUDIED DID YOU FIND MOST INTERESTING?"

Physics

Topic	Total Responses[x]	Per Cent*
Electricity	22.7	29.2
Engines and Machines	13.2	16.9
Miscellaneous	11.3	14.5
Air and Water	10.1	13.0
Radio	7.0	9.0
Airplanes	6.0	7.7
Radiant Energy	5.7	7.3
Sound	1.9	2.4

Chemistry

General	25.3	75.7
Burning	4.5	13.5
Photography	2.3	6.9
Theoretical	1.3	3.9

*Not given in original study

[x]Fractions indicate divided choices. Answers varied from a single word to several sentences. Frequently the subject wrote about two or three areas of science which impressed him.

the heading airplanes."[5] With the foregoing thought in mind, we shall consider the number of responses given various areas of science. "The grouped items occurring most frequently under the heading of physics were electricity, radio, airplanes, engines and machines, air, and weather. In the chemical area, general responses were most frequent (chemicals, chemical experiments, etc.). Burning and oxidation was the only topic with an outstanding number of responses."[6] In studying the results of Table XIII, it must also be remembered that this study included students in grades seven to nine inclusive and asked their interest in science studied.

Table XIV shows the combined replies to the question, "What things would you like best to find out in science?" As in the previous study, physics was again outstanding. Under this division, electricity and radio dominate, with airplanes and engines following. General chemistry and photography seem most important under the heading of chemistry.

Data obtained from the analysis of compositions are shown in Table XV. These findings are similar to those of the questionnaire. Electricity, radio, and transportation are the outstanding groups in which students express their interest in physical science.

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[5] Ibid., p. 22

[6] Zim, Loc. cit.

Table XIV

COMBINED REPLIES IN THE PHYSICAL SCIENCES
TO THE QUESTION
"WHAT THINGS WOULD YOU LIKE BEST TO FIND OUT IN SCIENCE?"

Physics

Topic	Total Responses	Per Cent
Electricity	18.3	32.7
Radio	11.4	20.4
Engines and Machines	10.8	19.3
Airplanes	6.8	12.1
Radiant Energy	3.6	6.4
Applied Physics	2.4	4.3
Miscellaneous	2.2	3.9
Sound	.5	.9

Chemistry

General	16.2	73.3
Miscellaneous	3.3	14.9
Photography	2.6	11.8

Table XV

COMPOSITION TOPICS RELATED TO PHYSICAL SCIENCE

Physics

Topic	Total Responses	Per Cent
Transportation	54.9	29.1
Electricity and Radio	79.4	42.0
Miscellaneous	22.7	12.0
Machines and Mechanics	13.1	6.9
Light and Heat	11.4	6.0
Air	7.4	3.9

Chemistry

General	82.0	75.7
Miscellaneous	15.7	14.5
Explosives and Fire	5.5	5.1
Air and gases	5.1	4.7

Acting on the assumption that interests may best be measured by the way they modify the activities of the interested person, Zim made a study of the entries at the Children's Science Fair,[7] which is conducted by The American Institute of the City of New York. Table XVI shows the distribution of individual entries in physics and chemistry for the Children's Science Fair for the years 1936 and 1937. "In the chemistry grouping, most of the exhibits are models illustrating processes. An important percentage of the exhibits pertains to dyestuffs and to the use of chemicals. The Physics grouping is large. In this area, electricity, radio and other radiations account for about 45 per cent of the entries. Air and airplanes and light account for about 15 per cent each; engines and machines for another 10 per cent."[8] It is interesting to note that "other radiation," which is usually referred to as "modern physics," received a prominent position in the realm of students' interests. "The exhibits entered in the Children's Science Fair are the results of voluntary participation of boys and girls in various areas of science. Since the Fair is open to all pupils from all schools in New York, it is evident that the interests

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[7] Morris Meister, Children's Science Fair of the American Institute, (New York: The American Institute, 1932)

[8] Zim, op. cit., pp. 106-107.

Table XVI

ANALYSIS OF 506 INDIVIDUAL ENTRIES IN CHILDREN'S SCIENCE FAIR 1936-37

Physics

Topic	Total Entries	Per Cent
Electricity	39	25.7
Air and airplanes	24	15.8
Radio	20	13.2
Light	20	13.2
Engines and machines	16	10.5
Missing exhibits	14	9.2
Other radiation	9	5.9
Miscellaneous	4	2.6
Heat	3	1.9
Water	3	1.9

Chemistry

Models of processes	16	39.0
Uses of chemicals	6	14.6
Missing exhibits	6	14.6
Dyes and textiles	5	12.2
Miscellaneous	5	12.2
Photography	2	4.9
Chemical tests	1	2.4

of pupils as shown by this study are typical of those of pupils of the entire metropolitan area."[9]

Zim summarizes his study by saying, "This research on science interests finds that problems of health, growth, and physiological processes are of great concern to many pupils. Living things, the mechanics of transportation and communication are also important centers of interest. A tentative, flexible curriculum may be developed in these areas of content realizing constantly that teaching the content is not an end in itself but is a means of developing the objectives in science teaching."[10]

Comparison of Studies. Table XVII is a comparison of two studies of science articles described in Chapter II with two studies of science interests described in Chapter III. The list of scientific terms shown in Table XVII were taken from Table I. The column headings refer to the various studies as follows: W--the writer's study of science articles (see Table I); C_1--Curtis study of science articles (see Table IV); C_2--Curtis study of science interests of boys and girls (see Table XI); C_3--Curtis study of science interests of men and women (see Table XII); P--Pollick's study of science interests of junior high school students (see Table X). A check (x) under the column heading indicates that the

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[9] Ibid., p. 111.

[10] Ibid., p. 217.

Table XVII

COMPARISON OF STUDIES
OF
SCIENCE ARTICLES AND SCIENCE INTERESTS

Scientific Term	W	C_1	C_2	C_3	P
Vitamins	x				
Protein	x				
Acids	x				
X ray	x	*			
Calcium	x				
Plastics	x				
Radio	x		x	x	x
Weather	x	x			
Calorie	x				
Frequency Modulation	x				
Phosphorus	x				
Oil	x		*	x	
Airplane	x	x			x
Electron	x				
Iron	x				
Lens	x				
Mineral	x	*			
Velocity	*				
Temperature	*	x			
Pectin	*				
Magnetism	*				
Horsepower	*				
Hydrogen	*				
Gelatin	*				
Fats	*				
Energy	*	*			
Carbohydrates	*				
Atoms	*				
Photography	*				
Atmosphere	*				
Air	*		x	x	
Acceleration	*				
Alloys	*				
Diesel	*				
Fabrics	*				
Humidity	*				
Oxygen	*				
Rayon	*				
Sun	*		x	x	x
Television	*				
Voltage (electricity)	*	*	x	x	x
Water	*				*

frequency of the corresponding scientific term was two per cent or more of the total frequencies in the respective study. A check (*) under the column heading indicates that the frequency of the corresponding scientific term was less than two per cent of the total frequencies of the study.

The plan and purpose of Table XVIII is the same as that of Table XVII. However, the basic list of scientific terms in Table XVIII was taken from Curtis' study of science articles, see Table IV.

Neither table shows impressive agreement. The agreement in Table XVIII is only slightly better than that of Table XVII. This is an interesting fact, because in the former table, the science interests found by Curtis and Pollock were compared with the scientific terms found in Curtis' study of science articles--all of these studies were made at approximately the same time. In Table XVII the interest studies of Curtis and Pollock, and Curtis' study of science articles were compared with the writer's study of science articles which was made approximately fifteen years later.

From these tables, it seems that students' and adults' scientific needs and interests center primarily around radio, oil, airplanes, air, sun, electricity, earthquakes, gas, wind, rain and snow, and stars. Other needs and interests worthy of mention seem to be X ray, weather, mineral, temperature, energy, water, coal.

Table XVIII

COMPARISON OF STUDIES
OF
SCIENCE ARTICLES AND SCIENCE INTERESTS

Scientific Term	W	C_1	C_2	C	P
Weather	x	x			
Airplane	x	x			x
Power		x			
Weather bureau		x			
Earthquake		x	x	x	
Engine		x			*
Gas		x	*		*
Degree		x			
Pole		x			
Temperature	x	x			
Turbine		x			
Storage battery		x			
Wave		x			
Wave length		*			
Wind		*	*	x	x
Explosion		*			
Gale		*			
Horse-power		*			
Motor		*			
Pressure		*			
Blizzard		*			
Boiler		*			
Electrical	*	*	x	x	x
Fertilizer		*			
Energy	*	*			
Gasoline		*			
Mercury boiler		*			
Steel		*			
Vapor		*			
Alcohol		*			
Circuit		*			
Inch (of rain)		*	*	*	*
Mineral	*	*			
Snow		*	*		*
Coal		*			*
Crystal		*			
Dirigible		*			
Frost		*			
Mercury		*			
Nitrate		*			
Star		*	x	x	x
Storm		*			
Ventilation		*			
X ray	*	*			

Table XIX

COMPARISON OF ZIM'S INTEREST STUDIES

Physics

Topic	Q_1	Q_2	C	F
Electricity	x	x	x	x
Radio	*	x	x	x
Miscellaneous	x	*	x	*
Engine and Machines	x	x	*	x
Radiant Energy	*	*	*	x
Airplane	*	x		x
Air and Water	x		*	*
Sound	*	*		
Applied Physics		*		
Transportation			x	

Chemistry

General	x	x	x	
Miscellaneous		x	x	x
Photography	*	x		*
Burning	x		*	
Theoretical	*			
Air and gases			*	
Models of Processes				x
Chemical Tests				*
Dyes and Textiles				x

Table XIX is a comparison of Zim's interest studies (see Tables XIII to XVI). The column headings refer to the following: Q_1--"What part of science ever studied did you find most interesting?" Q_2--"What things would you like best to find out in science?" C--composition topics; F--science fair entries.

Good agreement is shown between Zim's studies. Due to the fact that Zim's data were published in "bunches," it was felt that there was no basis on which to compare Zim's study with other studies. However, it is now obvious that five of Zim's ten "bunches" in physics, viz., electricity, radio, radiant energy, airplane, air and water are among the most important of students' scientific needs and interests according to the conclusions drawn from the two preceding comparative tables.

The chemistry phase of Zim's study is not very conclusive. The headings "general" and miscellaneous hide a multitude of interests. It is evident, however, that students are interested in photography and enjoy working with dyes, textiles, chemical tests, and models of processes.

CHAPTER IV

EVALUATION OF OBJECTIVES

The objectives to be evaluated are listed in Chapter I. It did not seem necessary to treat each objective separately; therefore, only those generalizations which have been added to or taken from the list are evaluated here.

Additions: It seems that the following generalizations should be incorporated in the modern science curriculum:

1. Foods are transformed into energy by chemical processes in the body.

2. Chemistry's conquest of nature's secrets has revolutionized man's clothing.

3. Plastics and alloys have replaced natural products as servants in home and industry.

4. Water is the most common chemical compound.

The first objective is not only justified but practically demanded by both the interest study and the magazine analysis. "It would seem that such topics as the function and utilization of foods,...should be given much consideration in an up-to-date physical science course." (Chapter II, page 16.) "...problems of health, growth, and physiological processes are of great concern to many pupils..." (Chapter III, page 36.)

The second objective relates almost entirely to organic chemistry, to which an increasing number of scientific articles in magazines are being devoted. While "fabrics" did not rank high in the list of scientific terms found in magazine articles, it must be remembered that the term never appeared in previous lists and it had to make great gains to receive the recognition it did in the writer's study. The coal tar products, dyes, and textiles are of interest to students as shown by Science Fair entries.

The writer's analysis of magazine articles makes the third objective seem necessary. Table I shows that the term "plastics" appeared in eight articles, while the term "alloys" appeared in three. Neither of these terms appeared in Curtis' study. The writer found that four percent of all physical science terms found in magazine articles (see Table III) relate to plastics, and one and one-half percent relate to alloys. Neither of these were given any rating by Searle (see Table VII).

The three comparative tables at the end of Chapter III give water considerable emphasis. "From these tables, it seems that students' and adults' scientific needs and interests center primarily around radio...rain... Other needs and interests worthy of mention seem to be...water..." (Chapter III, page 38). "However, it is now obvious that five of Zim's ten 'bunches' in physics, viz., ...air and water are among the

most important students' scientific needs and interests... (Chapter III, page 41). The foregoing conclusions seem to demand the addition of the fourth fundamental concept.

Subtractions: All interest studies, both old and new, seem to justify those objectives which relate to astronomy. However, the writer's study did not find astronomical terms among the forty-two most common physical science terms appearing in periodicals. Furthermore, in adapting this list of objectives to the Laboratory School physical science course, it was considered advisible not to include those which relate to astronomy or geology for two reasons:

1. It would be difficult to do four sciences justice in a one-year course.

2. Those students who have received their elementary and junior high school science at the Laboratory School will have had a good elementary course in astronomy before entering this class.

In the light of the foregoing, objectives number 3, 4, 5, 6, 7, 8, and 14 (see page 3) will not be included. The revised set of general objectives arranged as they will be taken up in the course are shown below:

UNIT I: WATER

1. Water is the most common chemical compound.
2. There are fewer than one hundred chemical elements.

3. Every substance is one of the following: (a) a chemical element, (b) a chemical compound, (c) a mechanical mixture.

UNIT II: THE ATMOSPHERE

4. The gravitational attraction between the earth and a mass of unconfined gas or liquid causes the pressure of the liquid or gas on the surface of the earth.
5. Liquid or gas pressure is exerted equally in all directions.

UNIT III: TEXTILES

6. Chemistry's conquest of nature's secrets has revolutionized man's clothing.

UNIT IV: FOODS

7. Foods are transformed into energy by chemical processes in the body.
8. The sun is the chief source of energy for the earth.
9. Chemical changes are accompanied by energy changes.

UNIT V: BUILDING MATERIALS

10. Plastics and alloys have replaced many natural products as servants in industry and home.

UNIT VI: HEAT, A FORM OF ENERGY

11. Matter and energy cannot be created or destroyed, but may be changed from one form to another.

12. The kinetic energy of the molecules determines the physical states of matter.
13. Chemical and physical changes are manifestations of energy changes.
14. Chemical changes are accompanied by energy changes.
15. In a chemical change a quantitative relationship exists between the amounts of the substances reacting and the amounts of the substances that are the products of the reaction.

UNIT VII: ENERGY APPLIED TO MACHINES

16. Machines are devices for accomplishing useful transformations of energy.
17. Any machine, no matter how complicated, may be analyzed into a few simple types.
18. A change in rate or direction of motion of an object requires application of external force.

UNIT VIII: ENERGY AND ITS RELATION TO SOUND

19. Sound is caused by waves which are produced by a vibrating body and which can affect the auditory nerves of the ear.

UNIT IX: ENERGY MANIFESTED AS LIGHT

20. Light is a limiting factor to life.
21. Radiant energy travels in straight lines through a uniform medium.

UNIT X: ELECTRICITY

22. The applications of electricity and magnetism in the home and in industry have revolutionized the methods of living of many people.

23. Electricity is a form of energy that results from disturbing the position of the regular paths of electrons.

24. All matter is probably electrical in structure.

Understanding and enlargement of these objectives will constitute the contribution of physical science teaching to the ultimate aim of education.

CHAPTER V

UNITS FOR A PHYSICAL SCIENCE COURSE

The first four chapters represented an attempt to determine, by scientific means, what to teach in a physical science course. This chapter consists of suggestions on how to teach, and suggests materials to be used in teaching.

Each of the ten units which follow consists of seven parts:

First, the fundamental concepts to be developed in the unit. These concepts need not be mentioned at any specific time or place in the teaching of the unit, but should be referred to at every opportune moment, so that, by the end of the unit, every student will have heard, read, and vocalized the concepts several times.

Second, a list of specific objectives. While the specific objectives in the following units were carefully selected, they are by no means the only specific objectives that might be used, nor are they necessarily the best. The specific objectives should be called to the students' attention at the beginning of the unit, and throughout the teaching of the same, the students, as well as the teacher, should feel that they are driving toward specific goals. It has been recommended that the students and teacher plan the specific objectives together. This method was used to a certain

extent in the preparation of the units in this work. The plan is very satisfactory when an effective overview is given by the teacher, and a general spirit of cooperation and earnestness exists among the students.

Third, science experiences for entire group. These are elementary and instructive laboratory exercises performed by each member of the class under the direction of the instructor. Activities of this nature are valuable because they give the students scientific experiences on which to base science learnings. Since this course is intended primarily for non-college students, these science experiences seem highly desirable because they give the student an opportunity to learn by working with his hands.

Fourth, teacher demonstrations. Little need be said on this point because the value of effective demonstrations has long been recognized. It is advisable that the teacher perform all demonstrations where expensive or dangerous apparatus and chemicals are used.

Fifth, individual projects and reports. Out of the science experiences and demonstrations will grow suggestions for individual projects and reports. These projects and reports will help motivate the course and assist the instructor in making allowances for individual differences in the class.

Sixth, enrichment. Enrichment includes field trips,

exhibits, and visual aids. While these are listed last in the units, they should be used at the appropriate time during the process of the unit and should not be held until the end.

Seventh, materials. In some instances, the exact materials to be used in the science experiences are listed. In general, however, a reference is made to a science book or laboratory manual which contains a list of appropriate materials and some information concerning the demonstration. In making reference to the above sources, only the author's name and page number is given unless two books by the same author were used. This the case with Lynde's books, and, in such a situation, an appropriate notation is made to distinguish one book from the other. Complete reference to all materials will be found in the bibliography.

UNIT I

WATER, ITS USES AND PROPERTIES

Fundamental concepts to be developed:

I. Water is the most common chemical compound.

II. There are fewer than one hundred chemical elements.

III. Every substance is one of the following: (a) a chemical element, (b) a chemical compound, (c) a mechanical mixture.

Specific Objectives:

A. Appreciations
1. Appreciation of the importance of water in our daily lives.
2. Appreciation of chemists' ability to discover impurities in water.
3. Appreciation of present day methods of water softening.
4. Appreciation of present day soap industry.
5. Appreciation of modern methods of refrigeration.
6. Appreciation of chemists' ability to decompose substances into elements.
7. Appreciation of scientists' discoveries of the ninety-two elements.

B. Understandings
1. Knowledge of the process by which the city water works makes water fit for drinking purposes.
2. Knowledge of the essential chemicals used in making soaps, and of methods of making soaps different.
3. Knowledge of the science back of modern refrigerator and general understanding of its operation.
4. Knowledge of peculiar properties of water.
5. Knowledge of surface tension phenomena.
6. Knowledge of the chemical composition of water.
7. Knowledge of characteristics, and difference between (a) chemical element, (b) chemical compound, (c) mechanical mixture.

SCIENCE EXPERIENCES FOR ENTIRE CLASS	MATERIALS
Water tests	
a. Soap test to distinguish hard water from soft water.	Hard water, soft water, soap solution.
b. Test for organic materials.	Collins, pp. 71-2.
c. Test for water acidity or alkalinity.	" 73.
d. Test for gases in water.	" 73.
Water purification	
a. Distil $CuSO_4$ solution	Dull, pp. 241-2.
b. Build model water purification plant.	Sch. Sci. & Math. 38:454
Water softening	
a. Build a model water softener.	Permutite, salt, glass tubing, wide mouth bottles.
Soaps	
a. Literature on soap history and present industry.	P & G The Story of Soap
b. Make hard soap.	Collins pp. 145
c. Make soft soap.	" 146
d. Make toilet soap.	" 263
e. Make colored soap.	" 264
f. Make perfumed soap.	" 264
Refrigeration	
a. Make diagram of commercial ice plant.	Dull, p. 245
b. Make diagrams of mechanical refrigerators--gas type and electric type.	" 247
Surface tension	
a. A list of experiences from which students and teacher may choose those which seem most interesting.	Lynde, pp. 90-122 (brown book)
Water pressure	
a. A list of experiences from which the students and teacher may choose those which best suit the situation.	Lynde, pp. 92-106 (blue book)

SCIENCE EXPERIENCES FOR ENTIRE CLASS	MATERIALS
Elements and compounds	
a. Mechanically mix elements iron (filings) and sulfur, separate with magnet.	Collins, p. 22
b. Remix iron filings and sulfur, heat, try to separate.	" 23
c. On a large map of the world locate, if possible, deposits of each of the ninety-two elements either in free or combined state.	Encyclopedia Britannica Chemistry textbooks World Map

TEACHER DEMONSTRATIONS	MATERIALS
Water and its constitutents	
a. Electrolyze water	Electrolysis apparatus
b. Synthesize water	Source of hydrogen
c. Prepare and study hydrogen	Mossy zinc, sulphuric acid generating bottle, delivery tube, wood splints.
d. Prepare and lecture on oxygen	$KClO_3$, MnO_2, ignition tube, wide mouth bottles.

INDIVIDUAL PROJECTS AND REPORTS	MATERIALS
Mineral waters	
a. Location of important mineral water springs in Indiana and U. S.	Crook, pp. 231-5
b. Determine as nearly as possible common chemicals in mineral waters.	U. S. Bulletin #91, Bureau of chemistry.
c. Collect samples of mineral waters sold to public.	
Density and specific gravity	
a. Determine specific weights of metals.	Henderson, pp. 65-7
b. Study principle and uses of hydrometers.	Dull, pp. 43-5

Solutions

a. Read about acids and bases, test them with litmus paper.	Hopkins, pp. 193-4
b. Note the boiling and freezing points of solutions as compared with distilled H_2O	Black, pp. 376-7

ENRICHMENT

A. Field Trips
- Field trip to city water works
- Field trip to ice plant
- Field trip to local refrigerator sales

B. Visual Aids

"Purifying Water"	Ohio Department of Education
"Soap"	Eastman Kodak Company
"Refrigeration"	Indiana University

UNIT II

THE ATMOSPHERE

Fundamental concepts to be developed:

I. The gravitational attraction between the earth and a mass of unconfined gas or liquid causes the pressure of the gas or liquid on the surface of the earth.

II. Gas or liquid pressure is exerted equally in all directions.

Specific Objectives:

A. Appreciations
   1. Appreciation of modern air conditioning.
   2. Appreciation of service rendered by government weather bureau.
   3. Appreciation of scientific basis of weather forecasting.
   4. Appreciation of forecasting instruments.
   5. Appreciation of U. S. Civil Service.

B. Knowledge
   1. Knowledge of the fact that our atmosphere has weight and exerts pressure.
   2. Knowledge of some of the common applications of the gas laws such as are found in the submarine, blood pressure gauges, balloons, siphons, pumps, etc.
   3. Knowledge of weather forecasting instruments.
   4. Understanding of scientific observations back of the daily weather forecast.
   5. Understanding of the weather map.
   6. Knowledge of qualifications and salaries of government meteorologists.
   7. Understanding of fundamentals of modern air conditioning.
   8. Knowledge of gases of which atmosphere is composed.
   9. Knowledge of properties of these gases.
   10. Knowledge of uses of these gases.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Atmospheric pressure a. A list of science experiences from which students and instructor may choose those which seem most interesting and helpful in developing fundamental concepts of unit.	Lynde, pp. 2-30 (brown book) Lynde, pp. 107-126. (blue book)
Air compression and expansion a. A list of science experiences from which students and instructor may choose those which seem most interesting and helpful in developing fundamental concepts of unit. b. Make a list of pneumatic appliances used in your home.	Lynde, pp. 50-61 (brown book) Lynde, pp. 141-160 (blue book)
Weather forecasting a. Note daily weather forecasts in local paper for two weeks.	

SPECIAL PROJECTS AND REPORTS	MATERIALS
Air compression and expansion a. Explain the operation of any of the following: atomizer, paint sprayer, windshield wiper, caisson, submarine, blood pressure gauges, balloons, siphons, pumps (exhaust and compression), vacuum sweeper. b. Prepare diagrams of any of the above.	Any physics text will give information; real articles should be used for demonstration if possible.
Air conditioning a. Articles to read; these contain photographs which might be reproduced.	Scientific American 155:80-83, Aug., 1936 149:62 , Aug., 1933 150:66 , Feb., 1934

SPECIAL PROJECTS AND REPORTS	MATERIALS
Weather forecasting	
a. Look up weather lore; try to find scientific argument for them.	Van Cleef, pp. 75-80.
b. Collect weather forecasting gadgets, study principles of operation.	
c. Prepare list of Civil Service positions in field of meteorology with salaries. Study examination announcements.	Available at General Delivery Window at Post Office.

TEACHER DEMONSTRATIONS

Weather forecasting:	
a. Discuss weather forecasting instruments. Demonstrate with as many as are available.	Any good physics text. Barometer, thermometer, aneometer, hygrometer, rain guage, weather vane.
b. Explain science back of weather forecasting; explain weather map; give students data to put on weather maps.	Weather maps for every student. "Weather Forecasting," a pamphlet published by the U. S. Government.
c. Composition of atmosphere.	Chart showing proportions of each gas found in atmosphere.

ENRICHMENT

Field trip:
Journey to local weather bureau.

Films:

"Atmospheric Pressure"	Eastman Kodak Company
"The work of the Atmosphere"	Indiana University

UNIT III

TEXTILES

Fundamental concept to be developed:

I. Chemistry's conquest of nature's secrets has revolutionized man's clothing.

Specific Objectives:

A. Appreciations
   1. Appreciation of the changes of man's clothing brought about by scientific advances.
   2. Appreciation of the properties of synthetic fabrics which make them superior to natural ones.
   3. Appreciation of the scientific research behind these advances.
   4. Appreciation of the cost of producing synthetic fibers.
   5. Appreciation of chemical processes used in textile industry, viz., bleaching, mercerization, worsting, dyeing.
   6. Appreciation of chemists' ability to make better dyes than nature provides.

B. Knowledges
   1. Knowledge of the important physical and chemical properties of common fabrics, both natural and synthetic; and understanding of different fabrics for different garments.
   2. Knowledge of the relative cost of the different fabrics.
   3. Knowledge of dyes.
   4. Knowledge of the fundamental chemicals used in manufacture of synthetic fabrics and some understanding of chemical processes involved.

C. Skills
   1. Ability to remove common stains from fabrics.
   2. Ability to identify common fabrics.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Properties of fabrics: a. Perform physical tests for the different fibers. b. Chemical tests for different fibers. c. Study the effect of solvents such as acetone, acids, bases, and water on different fibers. d. Determine the thread count of fabrics. e. Change appearance of fabrics by chemical processes. f. Test the color-fastness of different samples of cloth.	Samples of cotton, linen, wool, silk, rayon, vinyon, fiberglas, lanital. Directions for all these tests will be found in Tuleen, et al., pp. 151-166.
Treatment of fabrics a. Remove some common stains from fabrics.	Tuleen, et al., p. 160.

SPECIAL PROJECTS AND REPORTS	
Report on silk.	"Silk," a special booklet and silk sample sent by the Real Silk Company of Indianapolis, Indiana.
Report on nylon.	"Nylon tells a Story" The DuPont Magazine, Sept., 1941, pp. 1-4. Oct., 1941, pp. 17-20.
Report on leather.	"The Story of Leather," an illustrated booklet of sixty pages giving a concise history of leather. The Ohio Leather Co.

ENRICHMENT

Exhibit:

Prepare an exhibit of fabrics.

Films:

"The Story of Leather"	Tanner's Council of America, 100 Gold Street, New York.
"Cotton Goods"	Eastman Kodak Company
"Woolen Goods"	Indiana University
"Silk"	Eastman Kodak Company
"From Flax to Linen"	Eastman Kodak Company
"Romance of Rayon"	Eastman Kodak Company

UNIT IV

FOODS

Fundamental concepts to be developed:

I. Foods are transformed into energy by chemical processes in the body.

II. The sun is the chief source of energy for the earth.

III. Chemical changes are accompanied by energy changes.

Specific Objectives:

A. Appreciations
   1. Appreciation of service rendered by U. S. Government in inspection of foods.
   2. Appreciation of modern food markets and foods.
   3. Appreciation of scientists ability to distinguish different foods.
   4. Appreciation of the chemistry of our bodies.

B. Knowledges
   1. Knowledge of five classes of foods.
   2. Knowledge of function of each class.
   3. Knowledge of important sources of each class.
   4. Knowledge of bodily secretion and processes involved in digestion of foods.
   5. Knowledge of the chemical process of photosynthesis.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Food tests	
a. Test foods for starch.	All food tests will be found in "Test It Yourself" by Tuleen and others, pp. 62-4.
b. Test candies for glucose.	
c. Test sucrose for glucose.	
d. Change sucrose to glucose.	
e. Test starch for glucose.	
f. Change starch to sugar with saliva; then test.	Iodine solution, Fehling's solutions A & B, HCl, NaOH, white paper, bunsen burner, HNO_3, NH_4OH.
g. Test foods for fats and oils.	
h. Test foods for proteins.	

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Food values a. Prepare food chart showing results of food tests b. Study pamphlet, "Food Values in Diet"	Bush, "Guided Activities" p. 86. Swift & Co. will gladly send a copy of "Food Values in Diet" for every member of the class.
Test foods for acids a. With litmus paper b. With baking soda	Bush, "Guided Activities" p. 98.
Baking powders a. Test solutions of cream of tartar and baking soda with litmus. b. Mix these solutions. Prepare solutions of baking powder. Compare results.	Tuleen and others, p. 33.
Test green leaves for food substances.	Osterhout, pp. 164-181.

SPECIAL REPORTS AND PROJECTS	
Vitamins a. Laboratory experiment with white rats to demonstrate the effect of a lack of Vitamin D. (This would have to be carried out over a period of time).	Turtox Service Leaflet #49.
Prepare menu for week of suitable amount of five essential foods.	
Experiments on photosynthesis a. A group from which students and instructor may select those which seem most valuable.	Osterhout, pp. 182-203.

TEACHER LECTURE AND DEMONSTRATION	MATERIALS
Lecture and demonstration on photosynthesis.	Set of slides prepared by W. H. Woodrow.

ENRICHMENT

Strip film: "Life of Louis Pasteur"	Metropolitan Life Insurance Company, (the Laboratory School Library has this film).
16mm. films: "Digestion"	Indiana University
"Food and Growth"	Eastman Kodak Company

UNIT V

PRODUCTS OF CHEMISTRY IN HOME AND INDUSTRY

Fundamental concepts to be developed:

I. Ceramics, plastics, and alloys have replaced natural products as servants in home and industry.

Specific Objectives:

A. Appreciations
   1. Appreciation of the beauty, safety, and convenience that chemistry has contributed to our present day life.
   2. Development of an interest in, and an ability to recognize, the different classes of substances in our surroundings.
   3. Appreciation of the promise in theoretical and applied chemistry of further benefits to our civilization.
   4. Appreciation of the fact that chemistry today plays a leading part in the production of most of the materials we use.

B. Knowledges
   1. Knowledge of the composition of some common alloys, such as brass, solder, type, and bell metal.
   2. Understanding of the fact that the composition of alloys can be purposefully controlled to produce desired qualities for a specific use.
   3. Knowledge of the methods, purposes, and significance of scientific research in its relation to our everyday life.
   4. Knowledge of some "waste" materials that chemistry has utilized.

SPECIAL PROJECTS AND REPORTS	MATERIALS

(While many of the following activities could be done as group experiences, The Laboratory School set-up made it more appropriate to handle them as special projects and reports).

Ceramics	
a. Make sample of cement and prepare report.	Pamphlet published by Louisville Cement Company. Hodgson, pp. 16-25.
b. How to make and use brick.	
c. Report on glass.	
d. Report on paint.	
e. Report on stone.	
Plastics	
a. Reports on plastics.	Bell, entire book. Mansperger, pp. 1-17.
Alloys	
a. Report on steel.	Any high school chemistry text.
b. Make samples of solder, rose and Wood metals. Determine the melting point by placing the metal in cold water then heating it and noting the temperature at which it melts.	
c. Prepare reports on above alloys.	Any modern high school chemistry text or laboratory manual will give considerable information about the alloys.
d. Prepare reports on the following alloys; samples of some of them might be made:	
Brass	Encyclopaedia Britannica is also an excellent source of material in this field.
Bronze	
Duralumin	
Pewter	
German Silver	
Sterling Silver	
Type metal	
Gun metal	

SPECIAL PROJECTS AND REPORTS	MATERIALS
Metals a. While working with alloys, students become interested in the metals in their pure state. Reports may be prepared on any or all of the following metals: Aluminum Copper Iron Magnesium Nickel Platinum Beryllium Vanadium Lead Tin Cobalt Bismuth Silver Gold	Any modern high school chemistry text and Encyclopaedia Britannica will furnish information on these metals.

ENRICHMENT

Field trip:

Tour to local brick plant.

Exhibits:

Make a collection of metals for permanent display. List them with their characteristic properties and uses.

Make a collection of the more important alloys, such as brass, bronze, gun metal, type metal, etc.

Secure samples of iron ores, copper ores.

Prepare a display of various kinds of bricks.

UNIT VI

HEAT, A FORM OF ENERGY

Fundamental concepts to be developed:

I. Matter and energy cannot be created or destroyed, but may be changed from one form to another.

II. The kinetic energy of the molecules determines the physical states of matter.

III. Chemical changes are accompanied by energy changes.

IV. Chemical and physical changes are manifestations of energy changes.

V. In a chemical change a quantative relationship exists between the amounts of the substances reacting and the amounts of the substances that are the products of the reaction.

Specific Objectives:

A. Appreciations
1. Appreciation of our civilization's dependence upon heat engines--steam engine, gas engine, and Diesel engine.
2. Appreciation of man's ability to control fire.
3. Appreciation of modern heating systems in our homes.

B. Knowledges
1. Knowledge of kindling temperature and nature of burning.
2. Understanding of laws of conservation of energy and conservation of matter.
3. Knowledge of the law of definite composition.
4. Knowledge of the fact that heat is really energy.
5. Knowledge of molecular physics.
6. Understanding of difference between heat and temperature.
7. Knowledge of heat units--calorie, B.T.U.
8. Knowledge of economical firing methods and heat value of coal.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Nature of burning	
a. Prepare oxygen, study properties.	Any high school chemistry text or manual.
b. Examine Bunsen burner, adjust, make diagram showing parts and operation of same.	
Fuels	
a. Make coal gas, coal tar, and coke.	Lynde, (brown) p. 187.
b. Do experiment on destructive distillation of wood.	
Conductivity	
a. Boil water in paper.	Lynde, (brown) p. 190.
b. Study principle of Davey safety lamp with Bunsen burner and wire gauze.	Any physics text.
Heat measurement	
a. Test your neighbor's temperature sense.	Bush, Guided Activities, p. 36.
b. Work problems dealing with thermometers.	Any physics text.
Fire control	
a. Make a fire extinguisher.	Lynde, (blue) pp. 161-163.
TEACHER DEMONSTRATIONS	
Spontaneous combustion	
a. Start fire with piece of ice.	Bush, p. 141.
b. Start fire with phosphorus and disulfide.	McGill, Chemistry Guide, p. 226.
Conductivity	
a. Demonstrate speeds at which different metals conduct heat.	Conductometer, ignition solution.

TEACHER DEMONSTRATIONS	MATERIALS
Fire control	
a. Foamite fire extinguisher demonstration.	Sch. Sci. & Math. 36:71.
Convection	
a. "Genie" demonstration.	Lynde, (brown) p. 192.
b. Coffee percolator principle.	Lynde, (brown) p. 193.
Radiation	
a. Heat radiation and absorption.	Leslie's cube and differential thermometer are best to demonstrate this. If they are not available, see Lynde, (blue) p. 86.

SPECIAL PROJECTS AND REPORTS	MATERIALS
Explosions	
a. Demonstrate a gas explosion.	Lynde, (blue) p. 194-196.
b. Demonstrate a dust explosion.	Lynde, (blue) p. 194-196.
c. Demonstrate gasoline engine power stroke.	Lynde, (blue) p. 78.
Expansion	
a. Demonstrate principle of bimetal.	Thermostat of an old automatic electric iron is excellent for this purpose.
Heating systems	
a. Demonstrate hot air convection.	Lynde, (blue) p. 84.
b. Make a diagram of heating system in your home.	
c. Make diagram of heating system of your school.	
d. Build a model steam heating plant.	Sch. Sci. & Math. 32:1018.
Insulation	
a. Report on insulation	Pamphlet published by Celotex Company.

ENRICHMENT

Field trip:

Tour of local coke plant.

Exhibit:

Collection of fireproof materials.

Films:

"Firemaking"	Indiana University
"Fire Prevention"	Indiana University
"Fire Safety"	Eastman Kodak Company

UNIT VII

ENERGY APPLIED TO MACHINES

Fundamental concepts to be developed:

I. Machines are devices for accomplishing useful transformations of energy.

II. Any machine, no matter how complicated, may be analyzed into a few simple types.

III. A change in rate or direction of motion of an object requires application of external force.

Specific Objectives:

A. Appreciations
   1. Appreciation of modern transportation systems.
   2. Appreciation of some of the simple machines which have been developed for the purpose of doing away with human drudgery.

B. Knowledges
   1. Knowledge of operation of some of the common types of heat engines.
   2. Knowledge of the fact that force and acceleration are inseparable, that one cannot exist without the other.
   3. Understanding of the meaning of the physical concepts, work, energy, velocity, acceleration, momentum, and force.
   4. Understanding of the fact that nothing is ever gained from nature without effort and that it is never possible by any kind of machine to get more energy out of the machine than is put into it.
   5. Knowledge of the fact that all machines are combinations of six simple machines.

C. Skills
   1. Ability to fix simple difficulties of home equipment.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Work, power, energy	
a. Find your own horsepower.	Williard, p. 195.
Machines	
a. Experiences with levers.	Williard, p. 205. (This experience will require a number of meter sticks).
b. Experiences with wedge.	Williard, p. 207.
c. Experiences with inclined plane.	Williard, p. 212.
d. Experience with pulley.	Williard, p. 207.
e. Experience with wheel and axle.	Williard, p. 210.

TEACHER DEMONSTRATION	
Automobile	
a. Show and discuss the transmission system of an automobile.	If the school does not have these articles they can be secured from any junk yard at a nominal cost. A student may be happy to furnish them for you.
b. Explain the steering gear of an automobile.	
c. Explain the transmission of an automobile.	

SPECIAL PROJECTS AND REPORTS	
Levers	
a. Examine the type bar system of any typewriter. Make sketch of lever system.	Henderson, Physics Guide, p. 137.
b. Measure the diameters of the different sprocket wheels on a bicycle and determine the M.A.	Hausrath, p. 80.
Automobile	
a. "Evolution of the Ford Car."	Pamphlet may be secured from Ford Motor Company.
b. "An Outline History of Transportation from 1400 B.C."	Pamphlet published by General Motors Corporation.

SPECIAL PROJECTS AND REPORTS	MATERIALS
c. "Transportation Progress"	Pamphlet published by General Motors Corporation.
Airplane a. If there is a student in the class who has a hobby building model airplanes, let him explain the same to the class.	The pamphlet "Aviation" published by Boy Scouts of America contains excellent material on the types of aircraft, tools, and materials for model aircraft construction, etc.
b. "The Story of the Airship."	Pamphlet published by Goodyear Tire and Rubber Company.

ENRICHMENT

Films:	
"Machines"	Eastman Kodak Company
"Energy and its Transformations"	University of Chicago

UNIT VIII

ENERGY AND ITS RELATION TO SOUND

Fundamental concept to be developed:

I. Sound is caused by waves which are produced by a vibrating body and which can affect the auditory nerves of the ear.

Specific Objectives:

A. Appreciations
   1. Appreciation of the physical basis of music.
   2. Appreciation of our auditory sense.
   3. Appreciation of the science of acoustics used in constructing modern auditoriums.

B. Knowledges
   1. Knowledge of the fact that a vibratory body is necessary for the existence of physical sounds.
   2. Knowledge of the fact that sound requires a real medium for its transmission.
   3. Understanding of resonance and beats.
   4. Understanding of the terms pitch, volume, quality.
   5. Understanding of difference between noise and music.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Sound phenomena a. A series of experiences on sound which may be either group or individual depending on available equipment.	Williard, pp. 366-390.
TEACHER DEMONSTRATIONS	
Nature of sound a. Origin of sound.	Williard, pp. 367-368.
Transmission of sound a. In air and in vacuum.	Eckles, p. 562.
Pitch a. Demonstration with sound disk.	Sound disk, rotator.
Ear a. Explain with the aid of a chart the workings of the ear.	Chart can be secured from school health or physiology department.
SPECIAL PROJECTS AND REPORTS	
Look up information on the following: a. Limits of audibility. b. Sound insulation. c. Velocity of sound. d. Echoes. e. Whispering galleries. f. Pitch. g. Intensity. h. Quality. i. Resonance.	High school physics; Encyclopaedia Britannica.

ENRICHMENT

Field trip:

Take tour to Indiana State Teachers College Union Building Auditorium or other acoustically designed building.

Films:

"Fundamentals of Acoustics"	University of Chicago
"Sound waves and their sources"	University of Chicago

Slides:

"Sound"	Keystone View Company

UNIT IX

ENERGY MANIFESTED AS LIGHT

Fundamental concepts to be developed:

I. Light is a limiting factor in life.

II. Radiant energy travels in straight lines through a uniform medium.

Specific Objectives:

A. Appreciations
1. Appreciation of the fact that light is necessary for life.
2. Appreciation of the optics of the human eye.
3. Appreciation of science of optics. (Instruments which have greatly promoted the search for knowledge and which have opened up new worlds for man to conquer).
4. Appreciation of science of photography.
5. Appreciation of life and work of Michelson and Huyghens.
6. Appreciation of modern lighting in home and industry.

B. Knowledges
1. Knowledge of the fact that light decreases as the square of the distance from the source.
2. Knowledge of light cost and measurement.
3. Knowledge of the physical properties of the human eye, its possible defects and their remedies.
4. Understanding of image formation in such common optical instruments as the camera, stereopticon, microscope, and the human eye.
5. Understanding of the cause of dispersion by a prism.
6. Understanding of nature of pure color.
7. Knowledge of cause of rainbow and related phenomena.
8. Knowledge of light polarization.
9. Knowledge of the entire group of electromagnetic radiations.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Experience with transparent, translucent, and opaque objects.	Williard, p. 398.
Experience to show that light travels in straight lines.	Williard, p. 400.
Illumination a. Experience with home-made Bunsen photometer.	Williard, p. 407.
Mirrors a. Construct the image of an object as formed by a plane mirror.	Dull, p. 340.
b. Show that angle of incidence equals angle of reflection.	Dull, (physics workbook) p. 159.
Lenses a. Make diagrams of compound microscope and refracting telescope.	Dull, pp. 370-1.
Eye a. Make diagram of eye and study its physical properties.	Dull, pp. 362-3.
b. Experience with optical illusions.	Williard, p. 451.
Color a. Use plate glass mirror and lighted candle to show multiple images.	Dull, (physics workbook) p. 176.
b. Look at U. S. Flag and pieces of colored yarn through different colored glass.	Dull, (physics workbook) p. 84.

TEACHER DEMONSTRATIONS	MATERIALS
Illumination	
a. Show charts on illumination.	These may be secured from research laboratories such as Edison Laboratory.
b. Demonstration with light meter. Measure the intensity of illumination at various locations in school room and building.	A foot-candle meter is necessary for this demonstration.
Mirrors and lenses	
a. Demonstration showing total internal reflection.	Sch. Sci. & Math., 35:577.
b. Show charts and diagrams of optical instruments.	These may be secured from any optical company such as Bausch & Lomb.
Eye	
a. Explain parts of eye from charts.	Charts prepared by Better Vision Institute, Suite 2020, 30 Rockefeller Plaza, New York City, are of value in discussion of eye, color, lighting conditions, etc. Booklets for each student may be obtained at small cost.
Color	
a. Show additive properties of color.	Eckles, p. 207.
b. Experiments on complimentary colors.	Williard, p. 469.
c. Lantern slide showing the rainbow.	Slide prepared by W. H. Woodrow.
Polarization	
a. Demonstrate polarization of light.	Tourmaline tongs or a pair of polaroid discs.

SPECIAL PROJECTS AND REPORTS	MATERIALS
Photography.	
a. Chemistry of photography	Collins, pp. 215-220.
b. Demonstrate action of camera	Let member of class who has a camera bring it and describe its action.
c. Students who have not already done so, should make a pin-hole camera.	Williard, p. 401. A good pin-hole camera can be secured from Eastman Kodak Company for twenty-five cents.
Illumination	
a. Determine the candle power of several lamps.	Dull, (Workbook) p. 157.
Mirrors and lenses	
a. Make a small periscope.	Dull, (Workbook) p. 176.
b. Determine focal length and power of some spectacle lenses.	Dull, (Workbook) pp. 165-68.
c. Construct simple microscope and telescope and find their magnification.	Dull, (Workbook) pp. 169-70.
d. Construct an amateur telescope.	Sch. Sci. & Math. 37:643.
Report on flourescent lighting.	

ENRICHMENT

Field trip:

Trip to American Optical Company Laboratory, Swope Block, Terre Haute.

Films:

"Illumination"	Eastman Kodak Company
"Optical Instruments"	Eastman Kodak Company
"The Behavior of Light"	Eastman Kodak Company

Outside speakers:

Speaker from local store that deals in photographic supplies.

Have a physician speak on care of eye.

UNIT X

ELECTRICITY, RADIO, MODERN PHYSICS

Fundamental concepts to be developed:

I. The applications of electricity and magnetism in the home and in industry have revolutionized the methods of living of many people.

II. Electricity is a form of energy that results from disturbing the position of the regular paths of electrons.

III. All matter is probably electrical in structure.

Specific Objectives:

A. Appreciations
   1. Appreciation of dependence of modern communication on electricity.
   2. Realization of the dependence of modern transportation upon electrical energy.
   3. Appreciation of the value of electricity in lightening the drudgery of household tasks.
   4. Appreciation of work of Faraday and Edison.
   5. Appreciation of work of such great physicists as Millikan, Marconi, Einstein, Compton.
   6. Appreciation of the important economic and political problems arising from the widespread use of electricity.

B. Knowledges
   1. Knowledge of the fact that the earth acts like a large magnet.
   2. Knowledge of various ways of producing static electricity on bodies.
   3. Understanding of the fact that current electricity is but a charge in motion.
   4. Understanding of the relations between magnetism and electricity.
   5. Knowledge of the meaning of electrical conductors and non-conductors.
   6. Knowledge of the factors which determine the amount of current flow of electricity.

7. Knowledge of units used in measuring electricity and their inter-relationship.
8. Knowledge of chemical effects accompanying current flow through liquids.
9. Knowledge of some of the discoveries of modern physics.
10. A general understanding of the working principles of radio.

C. Skills
1. Ability to read simple electric meters and understand these readings.
2. Ability to calculate electrical costs for different-sized lamps and other equipment.
3. Ability to interpret the diagrams of simple electrical circuits.
4. Ability to make simple repairs on household fixtures.

SCIENCE EXPERIENCES FOR ENTIRE GROUP	MATERIALS
Magnetism	
a. Experience with magnetic poles.	Fuller, et al., p. 523.
b. Study properties of lines of force around magnets.	Lunt, pp. 10-11. (This experience will require a magnet for at least every two members of the class.)
c. Experiences with magnetic induction.	Fuller, et al., p. 526.
d. Study magnetic induction and lines of force.	Collins, p. 161.
e. Make a magnet.	Fuller, et al., p. 528.
Static electricity	
a. Produce static electricity with a clothes brush.	Morgan, p. 14.
b. Electrified balloons.	Morgan, p. 11.
c. Moving toy.	Morgan, p. 16.
d. Charging by contact.	Fuller, et al., p. 576.
e. Action of opposite charges.	Spinney, p. 274.
Current electricity	
a. Produce a current of electricity.	Collins, p. 170.
b. Make an electric cell.	Williard, pp. 553-554.
c. Study the Voltaic cell.	" pp. 554-556.
d. Tear up an old dry cell, study its parts.	" pp. 556-558.
Electrical measurements	
a. A series of experiences that may be either group or individual depending upon available equipment.	Williard, pp. 525-554.
b. Every student should learn to read a wattmeter and should calculate the light bill of his home.	Williard, pp. 525-543.
TEACHER DEMONSTRATION	
Magnetism	
a. Lecture demonstration on earth's magnetic field.	Fuller, et al., p. 537.

TEACHER DEMONSTRATION	MATERIALS
Static electricity	
a. Lecture demonstration with electrophorous and static machine.	Morgan, p. 22. Williard, p. 513.
b. Principle of condenser.	Williard, p. 517.
Current electricity	
a. Water analogy of electricity, Ohm's law.	Dull, p. 443.
b. Explanation of operation of all kinds of motors available and electrical appliances around the home.	Let students furnish material for teacher to explain.
c. Operation of telephone.	Any physics text.
d. Study of storage battery.	
Radio	
a. Lecture and demonstration on simple principles of radio.	Williard, pp. 621-633.
Modern physics	
a. Demonstrations with photo-electric cell if one is available.	
b. Show X ray pictures of teeth, lungs, or bones.	These can be secured from dentists or doctors.

SPECIAL PROJECTS AND REPORTS	MATERIALS
Magnetism	
a. Discovery of magnetism.	Electricity and Wheels (pamphlet)
b. Report on permeability.	Fuller, et al., p. 534.
Static electricity	
a. Report on lightning rods.	Encyclopedia Britannica.
b. Make a working model of a Cottrell precipitator.	Eckles, et al., p. 271.
Current electricity	
a. Make a Daniel cell and a gravity cell. Discuss properties, advantages, and disadvantages.	Any physics text.

SPECIAL PROJECTS AND REPORTS	MATERIALS
b. Demonstrate operation of small transformer; measure voltage of primary and secondary circuits.	Some member of the class can usually furnish a transformer from a toy electric train.
c. Project on electroplating.	
d. Principle of electric motor.	Williard, pp. 601-606.
e. Heating effect of an electric current.	Williard, pp. 585-589.

ENRICHMENT

Field Trip:
Tour of the Indiana State Teachers College Union Building basement to see air purification apparatus.

Films:

"Electrostatics"	University of Chicago
"Magnetic Effects of Electricity"	Eastman Kodak Company
"Chemical Effects of Electricity"	Eastman Kodak Company
"Heat and Light from Electricity"	Eastman Kodak Company

Slides:

Production and transmission of electricity.	Set of slides prepared by V. C. O'Leary.

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A. BOOKS

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