

A TEXTBOOK

IN THE

PRINCIPLES OF SCIENCE TEACHING

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TO
MY TEACHERS

**ESPECIALLY THOSE WHO HAVE HELPED ME IN MY THINKING
AND INSPIRED IN ME AN ABIDING ENTHUSIASM FOR
SCIENCE AND THE TEACHING OF SCIENCE, THIS
BOOK IS GRATEFULLY DEDICATED**

PREFACE

THIS book is intended primarily to be used in the instruction of young men and women who are preparing themselves in colleges and normal schools for careers as teachers of one or more of the natural sciences; but it is hoped that it will be scarcely less useful to science teachers now in service and to superintendents of school systems and principals of public and private secondary schools whose duties involve the direction and supervision of science instruction. It is thought also that the book contains much that will be of value to professors of the several natural sciences in colleges and normal schools, in helping them to impart to prospective teachers of their sciences the modern social viewpoint and the true scientific spirit that are so necessary for real success in teaching the sciences to boys and girls of high school age.

The volume is a natural outgrowth of a long career as high school teacher of science, high school inspector, and college teacher of education. It embodies the results of constant study of the natural sciences and of psychology, especially in its applications to science teaching and high school administration, carried on during the course of this career. It attempts to show in a concrete and practical way how the findings of modern experimental and educational psychology may be applied in science teaching. The first eleven chapters and the last one develop and formulate principles that are fundamental to all science training; the others are devoted to the explanation of principles and methods of teaching that are especially applicable to the several sciences of the high school curriculum. They contain also practical hints on the selection and organization of subject matter, the

planning of laboratories, and the choice of equipment in connection with science instruction.

There are several ways in which the book may be used in the instruction of prospective science teachers.

First, it may be used as a text for a broad general course in the fundamental principles of science teaching, intended for all those who are preparing for the teaching of any of the special sciences. In this case the chapters of general interest should receive the most study and attention; and those devoted to the special sciences, Chapters XII to XXIII, should be touched more lightly, being used for the most part as bases for special reports to the class by those most interested in the particular sciences of which these chapters treat.

Second, the book may be used as a text in a special course on the teaching of any one of the sciences. In this case the greater part of the book would be passed over rapidly to develop the general attitude and point of view; and the chapters on Biology or on Geography, Physics, Chemistry, or General Science would be studied intensively and supplemented by copious readings and reports based on references chosen from the book lists appended to the chapters so studied.

Third, in a university where special courses are given on the teaching of all of the several high school sciences this book may be used as a text in each one of these courses in the manner just described. In this case special joint conferences, attended by all these classes combined, may be arranged for. In these general meetings the leading principles brought out in the first eleven chapters and in the last may be made the subjects of general discussion by both instructors and students each from the viewpoint of the science in which he is most interested. By such a plan the courses of instruction in the teaching of all the sciences would be unified, and a common general viewpoint and a common philosophy of science teaching would gradually develop in the institution. This does not mean that such a unified viewpoint and such a com-

mon philosophy of science teaching would necessarily be reached only by adopting the views held by the author of this book, but rather that it would develop out of the discussions that a common study of the book must inevitably provoke.

Besides being employed as a text-book, it is believed that this volume will prove useful as a reference book in connection with more general courses in the principles of teaching or in methods of teaching; for the broader principles developed and formulated in it, and supported by arguments and examples, are those which science shares with all other subjects.

For high school science teachers in service, the book should be useful either for private reading and study or for study in groups such as teachers' meetings, reading circles, and science clubs, or as a text-book in extension or correspondence courses offered by colleges and universities for credit toward a degree.

For the supervisor who is not himself especially well trained in science the book should fill a long-felt want, for he often realizes that something in the science courses or in the way in which they are conducted is unsatisfactory, but does not know just what is wrong or how to go about correcting it. This book may serve to put such a supervisor in possession of principles that will enable him to diagnose the case, prescribe a remedy, and convince the science teacher that he should try the remedy and note the results. On the other hand, if some or all of his science teachers are doing particularly good teaching, a knowledge of the criteria for correctly judging their work will enable the administrator to appreciate its excellence and lead him to use all possible means of providing such equipment and administrative arrangements as are necessary for making it still more effective.

Although in referring to teachers the masculine form of the pronoun is used throughout, it should not be thought that the author wishes to ignore the noble body of science teachers who happen to be women. Let it be understood once for all that the book is addressed no less to women than to men,

and that what is said about teachers is meant to apply to teachers of both sexes.

For whatever there may be of truth or merit in these pages I am indebted largely to many persons. To my father, George H. Twiss, sometime teacher, meteorologist, and the founder and first manager of the Columbus telephone exchange, I owe a lasting debt of gratitude for the influences, brought about me during my boyhood, which first aroused and fed my interests in science. To my science teachers, especially the late Principal Albert N. Ozias, of St. Paul, Minnesota, who was my teacher in the sciences while a student in the old Columbus High School, and to Professors Thomas C. Mendenhall, Albert H. Tuttle, Sidney A. Norton, and the late Stillman W. Robinson, Nathan W. Lord, and Edward Orton, Senior, I am indebted for both my undergraduate training in science and much of what I may possess of skill in experimentation and insight into the scientific method. To them also, as well as to William Morris Davis of Harvard University and Charles Riborg Mann of the University of Chicago, I owe much for their inspiring methods of teaching, and the examples that I have observed through personal contact with them of clear-cut and attractive exposition of scientific facts and theories.

That the writings and teaching of Professors John Dewey and Edward L. Thorndike have had much influence in shaping the lines of thought that are developed in the following pages will be sufficiently evident to those who read them, yet it gives the writer special pleasure to acknowledge it here, and include them among those to whom the dedication of this book is addressed.

In putting the manuscript into final form, and in getting it through the press, I have profited by the criticism of a number of persons to whom my thanks are due, and are gratefully tendered; but I alone am responsible for any errors that may have evaded detection. Professor Paul Monroe

has read the entire work in manuscript and in proof; and Professor E. L. Thorndike has read the greater part of it in manuscript. Professors M. A. Bigelow, R. E. Dodge, and Alexander Smith, of Columbia University, W. W. Charters of the University of Illinois, and W. C. Curtis of the University of Missouri, have read those parts of the manuscript bearing on the subjects in which they are specialists. I am indebted to Professors John H. Woodhull of Columbia University and Fred D. Barber of Normal, Ill., for references and literature on introductory science. My wife, Blanche Olin Twiss, has helped me in the laborious work of verifying the references and book lists and revising the manuscript for the printers. Her criticisms and suggestions also have enabled me to improve the book at many points, both in clearness and in literary form.

Many authors whose books have been consulted in the preparation of this work have received credit in the footnotes; but there are others whose writings have helped indirectly in various ways to make the book what it is. They are too numerous to mention here, but many of them are mentioned in the text or included in the reference lists that are appended to the various chapters, or in the lists of books for high school libraries to be found in the appendix.

These book lists are not intended to be exhaustive bibliographies, nor are the prices appended guaranteed, but they have been selected with much care and labor; and it is thought that they include a sufficient quantity and variety of supplementary material to be of very considerable value, both for special references and general reading.

In the chapters treating of equipment, where prices are given, and where duty-free importations are mentioned, it is to be understood that reference is made to normal conditions, as they existed before August, 1914.

G. R. T.

July 17, 1917.

CONTENTS

CHAPTER I

THE MEANING OF SCIENCE

| | PAGE |
|---|------|
| Nineteenth century science | 1 |
| Twentieth century problems | 1 |
| Relation of science to civilization | 3 |
| Science and inventions | 3 |
| The steam engine and James Watt | 4 |
| The need of research | 5 |
| Science teaching and everyday life | 5 |
| Science as subject matter and as method | 6 |
| The method of science illustrated. Newton | 7 |
| Davy and the composition of water | 10 |
| The meaning of science summarized | 13 |
| Division of the field | 14 |
| Threefold use of the word, science | 16 |
| Questions for further study | 16 |
| References | 17 |

CHAPTER II

THE VIEWPOINT FOR THE SCIENCE TEACHER

| | |
|---|----|
| The humanistic attitude | 18 |
| Aims of instruction in science | 18 |
| Futility of formal and didactic methods | 19 |
| Four guiding principles | 20 |
| Lessons for the teacher from the meaning of science | 21 |
| The fallacy of abstract presentation | 22 |
| Superiority of concrete methods | 23 |
| Questions for further study | 23 |
| References | 24 |

CHAPTER III

THE GENESIS OF SCIENCE

| | PAGE |
|---|------|
| Elementary and concrete thinking | 26 |
| Comparison and classification | 27 |
| The function of language | 28 |
| The empirical method of learning | 29 |
| Constructive thinking | 30 |
| A complete act of thought | 31 |
| Empirical advances | 32 |
| Abstract thought. The Greeks | 33 |
| Facts and hypotheses as related to success in science | 33 |
| The middle ages | 35 |
| The renaissance | 35 |
| From Galileo to Newton | 36 |
| Questions for further study | 37 |
| References | 38 |

CHAPTER IV

SCIENCE AND CHILDREN

| | |
|--|----|
| Race experience and child experience | 39 |
| How young children learn | 40 |
| Empirical thinking by children | 41 |
| Instruction must begin with the child's experience | 42 |
| Rational thinking by children | 43 |
| Scientific thinking | 44 |
| Everyday thinking and scientific thinking | 46 |
| Ability of children to think | 47 |
| Thing thinkers and idea thinkers | 48 |
| Training in the technique of thinking | 49 |
| Motivation necessary | 51 |
| Questions for further study | 52 |
| References | 53 |

CHAPTER V

METHODS OF TEACHING

| | |
|---------------------------|----|
| Lessons on heat | 54 |
| The lesson plan | 54 |

Contents

XV

| | PAGE |
|--|------|
| Advantages of having a plan | 58 |
| The assignment | 60 |
| General preparation | 62 |
| The lesson problem | 68 |
| Specific preparation | 69 |
| The search for fruitful ideas. Reflection | 70 |
| The hypothesis | 71 |
| Developing and testing the hypotheses | 71 |
| Conclusion | 72 |
| Final generalization | 73 |
| Application | 73 |
| Further application and related phenomena. Association | 74 |
| Organizing and systematizing the subject matter | 76 |
| The topical review outline | 78 |
| Danger of over-emphasizing organization | 79 |
| Questions for further study | 80 |
| References | 80 |

CHAPTER VI

EDUCATIONAL FUNCTIONS AND VALUES OF THE SCIENCES

| | |
|---|----|
| What scientific study should do for the pupils | 82 |
| Relation of functions to values | 83 |
| Specific habits | 84 |
| The law of habit formation. Association | 85 |
| Application of the law of association in teaching | 86 |
| Scientific information | 86 |
| Facts, phenomena, and processes | 86 |
| Ideas and meanings. Laws and principles | 88 |
| Hypotheses and theories | 88 |
| Fundamental concepts | 89 |
| The choice of subject matter | 90 |
| Criteria for the choice of subject matter | 91 |
| The mastery of content | 91 |
| Observation, reference reading, and collecting | 92 |
| Inspiration, and scientific ideals | 93 |
| Inspiration from literature | 95 |
| Inspiration and the teacher | 96 |

| | PAGE |
|---|------|
| Inspirational lectures. History and biography | 96 |
| The artistic side of science | 97 |
| Inspiration and the gifted pupil | 98 |
| Questions for further study | 98 |
| References | 99 |

CHAPTER VII

THE DISCIPLINARY AND CULTURE VALUES OF SCIENCE

| | |
|---|-----|
| Mental discipline | 100 |
| Conditions limiting the transfer of training | 102 |
| Applying the principles of transfer | 102 |
| How concepts of method are built up | 102 |
| Ideals as related to transfer of training | 104 |
| Scientific habits of mind | 105 |
| The principles of scientific induction | 105 |
| The method of agreement | 106 |
| The method of difference | 107 |
| The joint method | 108 |
| The method of concomitant variations | 109 |
| The method of residues | 110 |
| Transferable and non-transferable discipline contrasted | 111 |
| The relation of logical methods to science teaching | 111 |
| The modern view of the nature of mental discipline | 112 |
| Precepts for the conduct of transferable training | 112 |
| Developing powers of interpretation | 113 |
| Some basic principles of science teaching | 115 |
| Questions for further study | 117 |
| References | 118 |

CHAPTER VIII

CLASSROOM AND LABORATORY INSTRUCTION

| | |
|--|-----|
| Current methods | 119 |
| The problem as the center of unification | 119 |
| The class conference | 120 |
| Some standards of good class work | 122 |
| The function of the laboratory | 124 |
| The laboratory in teaching | 125 |

| | PAGE |
|---|------|
| Methods of laboratory teaching | 127 |
| Student assistance | 129 |
| Characteristics of a good laboratory exercise | 130 |
| Number of laboratory exercises per year | 132 |
| Size of laboratory divisions | 132 |
| Double periods | 132 |
| Form of notes | 133 |
| Laboratory notebooks | 134 |
| Examination of notes | 135 |
| Questions for further study | 136 |
| References | 137 |

CHAPTER IX

LECTURES, EXCURSIONS, AND REVIEWS

| | |
|--|-----|
| Functions of the lecture-demonstration | 139 |
| The technique of the lecture demonstration | 140 |
| Field observation | 143 |
| Obstacles and how to overcome them | 143 |
| How to conduct excursions | 146 |
| Reviews | 149 |
| Functions of the review lesson | 150 |
| The topical review recitation | 151 |
| Types of topical organization | 152 |
| Written reviews | 153 |
| Association tests as reviews | 155 |
| Review matches | 156 |
| Oral quizzes | 157 |
| Time and opportunity for the teacher | 158 |
| Questions for further study | 159 |
| References | 160 |

CHAPTER X

EQUIPMENT FOR SCIENCE TEACHING

| | |
|--------------------------------------|-----|
| Rooms | 161 |
| Location of rooms | 162 |
| Size of rooms | 164 |
| Planning the science rooms | 166 |

| | PAGE |
|--|------|
| The lighting of rooms. Windows | 168 |
| Shades for stereopticon work | 169 |
| Electric lights | 169 |
| Other artificial illuminants | 170 |
| Electric current for experimental purposes | 171 |
| Water and fuel gas | 171 |
| Students' tables | 172 |
| Demonstration tables | 173 |
| Apparatus cases | 175 |
| Cases for wall maps and charts | 175 |
| Display racks for wall maps and charts | 176 |
| Storage for pictures and lantern slides | 177 |
| Book-cases | 177 |
| Projecting lanterns | 177 |
| The purchasing of apparatus | 180 |
| Questions for further study | 182 |
| References | 182 |
| Dealers in science apparatus and supplies | 184 |

CHAPTER XI

THE SCIENCES AND THE CURRICULUM

| | |
|--|-----|
| College entrance requirements | 187 |
| Results of prescription | 188 |
| Reforms demanded | 189 |
| The program of studies in science | 190 |
| Four years of science study | 194 |
| Curriculum making | 194 |
| Order of studies in the science program | 195 |
| The project teaching plan | 197 |
| Best present order | 199 |
| Future modifications. Junior and senior high schools | 199 |
| Questions for further study | 199 |
| References | 200 |

CHAPTER XII

BIOLOGY

| | |
|--|-----|
| Biological problems | 202 |
| Points of view from biological study | 202 |

Contents

xix

| | PAGE |
|--|------|
| Principles to be observed in a biological course | 204 |
| 1. Development of the type concept | 205 |
| 2. The comparative principle | 206 |
| 3. Classification | 207 |
| 4. Form and structure as related to function | 207 |
| 5. Adjustment, division of labor, and coöperation | 208 |
| 6. Continuity of life. — Life history and race history | 209 |
| 7. The theory of evolution | 209 |
| General method in biological study | 210 |
| Broader aims of the course | 213 |
| Special methods | 213 |
| Correlation of botany, zoölogy, and physiology | 214 |
| Questions for further study | 215 |
| References | 216 |
| Biology | 216 |
| Botany | 219 |
| Physiology | 222 |
| Zoölogy | 223 |

CHAPTER XIII

BIOLOGICAL EQUIPMENT

| | |
|--|-----|
| Method of selection | 225 |
| Student's individual equipment | 226 |
| Dissecting microscopes | 226 |
| Compound microscopes | 226 |
| Homes for living plants and animals | 228 |
| General apparatus and supplies | 229 |
| Wall charts | 229 |
| Models | 230 |
| Animal preparations. Human skeletons | 230 |
| Microscopic slides, and lantern slides | 231 |
| Government publications of interest to schools | 231 |
| Argument for biological equipment | 232 |
| Questions for further study | 233 |
| References | 233 |

CHAPTER XIV

GEOGRAPHY. FUNDAMENTAL PRINCIPLES

| | PAGE |
|--|------|
| The new geography | 234 |
| Changes in subject matter and method | 235 |
| What geographical knowledge is of most worth? | 236 |
| Length of the course, and its place in the curriculum | 236 |
| The teacher's point of view | 237 |
| Relations between peoples and their environment | 237 |
| Physiographic processes and their results | 238 |
| The physiographic cycle | 239 |
| Geographic influences | 240 |
| The type concept and the comparative method in geography | 241 |
| The use of the causal notion | 243 |
| Mental functions in geographical study | 244 |
| Questions for further study | 246 |
| References | 246 |

CHAPTER XV

METHODS IN GEOGRAPHY

| | |
|---|-----|
| Begin with local problems | 247 |
| Textbooks | 249 |
| Field work | 250 |
| Field projects and problems | 252 |
| The pupil's attitude in field work | 253 |
| Laboratory work | 253 |
| Some laboratory projects and problems | 254 |
| The use of the library | 258 |
| Card abstracts | 260 |
| Principles and methods | 260 |
| Order of topics | 261 |
| Questions for further study | 262 |
| References | 263 |

CHAPTER XVI

GEOGRAPHICAL EQUIPMENT

| | |
|-------------------------------------|-----|
| Building up the equipment | 267 |
| Wall maps | 267 |

| | PAGE |
|--|------|
| What maps are necessary | 269 |
| Care in the selection of maps | 270 |
| Methods of displaying maps | 270 |
| Local maps | 271 |
| Blackboard outline maps | 271 |
| Outline seat maps | 272 |
| Government maps | 273 |
| The U. S. Geological Survey Topographic Maps | 273 |
| Mounting and storage of topographic sheets | 274 |
| Mounting grouped sheets | 275 |
| The United States contour map | 276 |
| Physiographic and geologic folios | 276 |
| Coast charts | 276 |
| River and lake maps | 276 |
| Weather maps | 277 |
| Globes | 277 |
| Models and relief maps | 278 |
| Meteorological instruments | 279 |
| Minerals and rocks | 280 |
| Pictures | 280 |
| Lantern slides | 281 |
| Use of blackboard and modeling table | 282 |
| Season apparatus | 285 |
| Helior | 286 |
| Clinometer | 286 |
| Questions for further study | 287 |
| References | 288 |

CHAPTER XVII

PHYSICS. FUNDAMENTAL PRINCIPLES

| | |
|--|-----|
| Common sense notions, and physical principles | 289 |
| Intuitions and the facts of everyday life as starting points | 290 |
| How to associate symbols with things | 291 |
| Concepts, and the symbols that stand for them | 293 |
| Some intuitive notions described | 294 |
| The questions of Tyndall's boys | 297 |
| Economy of time and effort | 299 |

| | PAGE |
|--|------|
| Organization in the study of mechanics | 299 |
| Organization in the study of heat | 300 |
| Organization in the study of electricity | 302 |
| Organization in the study of sound | 305 |
| Organization in the study of light | 306 |
| Organization of the whole body of subject matter | 309 |
| Fundamental concepts of physics | 310 |
| Questions for further study | 310 |
| References | 311 |

CHAPTER XVIII

METHODS IN PHYSICS

| | |
|---|-----|
| Division of the course into two parts | 312 |
| Syllabi | 314 |
| The North Central Association's unit in physics | 314 |
| Library work | 317 |
| Laboratory work | 319 |
| Types of live laboratory problems | 320 |
| Danger in over-emphasis of the practical | 324 |
| Qualitative and quantitative experiments | 324 |
| The progressive program | 325 |
| Questions for further study | 327 |
| References | 327 |

CHAPTER XIX

EQUIPMENT FOR PHYSICS TEACHING

| | |
|--|-----|
| Building up the equipment | 332 |
| How to order | 334 |
| Shop outfit | 335 |
| Home made and improvised apparatus | 335 |
| Apparatus that must be purchased | 337 |
| Economical substitutes | 338 |
| Apparatus that is desirable but more expensive | 339 |
| The Hartl optical disc | 340 |
| Porte lumière | 341 |
| Projecting lantern for artificial radiants | 342 |
| The Von Nardroff color-mixer | 344 |