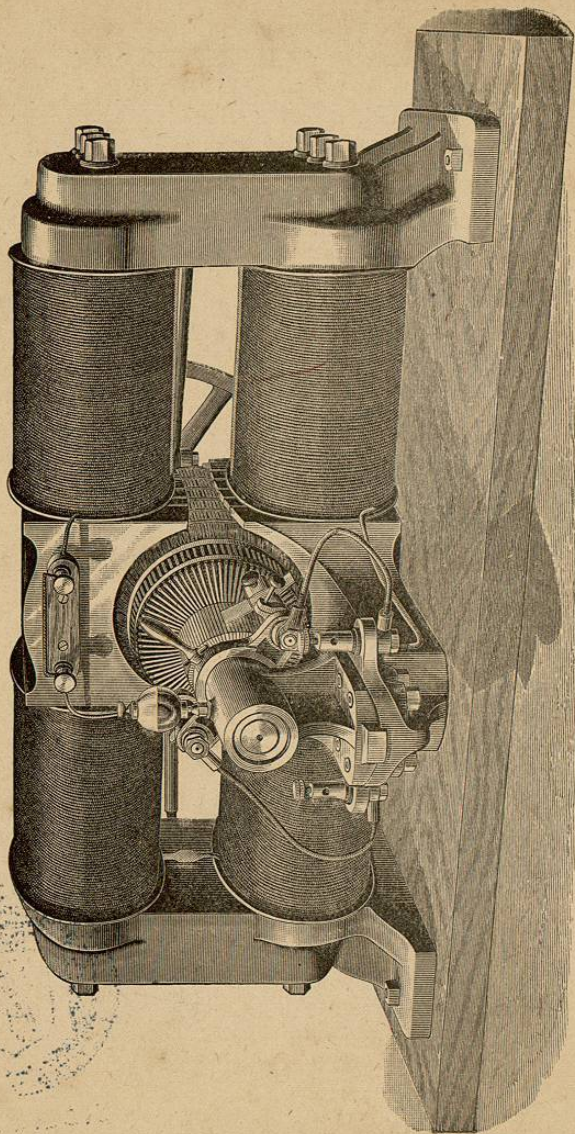


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BY
J. DORMAN STEELE, Ph.D., F.G.S.

AUTHOR OF FOURTEEN-WEEKS SERIES IN NATURAL SCIENCE

*The works of God are fair for naught,
Unless our eyes, in seeing,
See hidden in the thing the thought
That animates its being.*

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AUTHOR'S PREFACE

THIS work has grown up in the class-room. It contains those definitions, illustrations, and applications which seemed at the time to interest and instruct the author's pupils. Whenever any explanations fixed the attention of the learner, it was laid aside for future use. Thus, by steady accretions, the process has gone on until a book is the result.

As Physics is generally the first branch of Natural Science pursued in schools, it is important that the beginner should not be wearied by the abstractions of the subject, and so lose interest in it at the very start. The author has therefore endeavored to use such simple language and practical illustrations as will attract the learner, while he is at once led out into real life. From the multitude of philosophical principles, only those have been selected which are essential to the information of every well-read person. Within the limits of a small text-book, no subject can be exhaustively treated. This is, however, of less importance now, when every teacher feels that he must of necessity be above and beyond any school-work in the fullness of his information. The object of an elementary work is not to advance the peculiar ideas of any person, but simply to state the currently-accepted facts and theories. The time-hon-

ored classifications recognized in all scientific works, have been retained. In order to familiarize the pupil with the metric system, now generally used by scientific men, it is continually employed in the problems. The notes contain many illustrations and additional suggestions, but their great value will appear in the descriptions of simple experiments which are within the reach of any pupil.

New plates being required for this edition, the author has taken the opportunity thoroughly to revise the entire work. By carefully comparing the criticisms of teachers, he has tried to obtain the "parallax" of all its statements and methods, and to eliminate, as far as possible, the errors growing out of his "personal equation." Hearty thanks are tendered to the many friends of the book who, by their suggestions and criticisms, have so greatly added to the value of this revision. To name them all in this Preface would be impossible, and to discriminate would be invidious. The author can not, however, allow the opportunity to pass without expressing his profound sense of obligation. By untiring study and the continued help of his friends, he hopes thus, year by year, to make the series more and more worthy the favor which his fellow-teachers have so abundantly bestowed upon it. Happy indeed will he be if he succeed in leading some young mind to become a lover and an interpreter of Nature, and thus come at last to see that Nature herself is but a "thought of God."

PUBLISHERS' PREFACE.

THE series of elementary text-books in science, written by the late Dr. J. Dorman Steele, attained an extraordinary degree of popularity, due to the author's attractive style, his great skill in the selection of material suited to the demands of the schools for which the books were intended, his sympathetic spirit toward both teachers and pupils, and his earnest Christian character, which was exhibited in all his writing.

Shortly before his death, finding his health too feeble to permit of extra labor, the author requested Dr. W. Le C. Stevens, Professor of Physics in the Packer Collegiate Institute, Brooklyn, to revise the text-book in Physics, as important advances in this department of science had been made since the issue of the edition of 1878. In performing this work, Professor Stevens has endeavored to impose the least possible modification upon the peculiar style of the author. Nevertheless, every chapter has received some alterations and slight enlargement. In a work intended for higher classes, the reviser would naturally make the treatment of every subject more thorough; but this would unfit the present book for the

schools to which it was originally adapted. It is difficult, moreover, to combine a strictly popular style with that precision which is demanded by advanced students in exact science. But although the field in a rudimentary text-book is limited, it is thought that there are no important errors of statement in the present hand-book.

The reviser invites correspondence from all whose practical experience in the class-room or devotion to science may enable them to offer criticisms.

In order to distinguish this revision from the older editions, the name is changed to "Steele's Popular Physics."

PUBLISHERS' NOTICE.

The publishers of this book will still issue the former edition, known as "Steele's Fourteen Weeks in Physics," for classes already organized and for teachers who may prefer to continue its use. Any book-seller can obtain the former edition if requested to do so.

SUGGESTIONS TO TEACHERS.

STUDENTS are expected to obtain information from this book, without the aid of questions, as they must always do in their general reading. When the subject of a paragraph is announced, the pupil should be prepared to tell all he knows about it. He should *never be allowed to answer a question*, except it be a short definition, *in the language of the book*. The diagrams and illustrations, as far as possible, should be drawn upon the blackboard and explained. * Although pupils may, at first, manifest an unwillingness to do this, yet in a little time it will become an interesting feature of the recitation. In his own classes, the author has been accustomed to *place upon the blackboard the analysis of each chapter of the book, and require the pupils to recite from that*, without the interposition of questions, except such as were necessary to bring out the topic more clearly, or to throw a side light upon it. Where the analysis given in the book does not include all the minor points of the lesson, the pupils can easily supply the omission. The "Practical Questions" given at the close of each general subject, have been found a profitable exercise in awakening inquiry and stimulating thought. They may be used at the pleasure of the instructor. The equations contained in the text are designed to be employed in the solution of the problems.

It should constantly be borne in mind that, as far as possible, every question and principle should be submitted to Nature for a direct answer by means of an experiment. Pupils should be encouraged to try the simple illustrations necessary. The student who brings in a bit of apparatus made by himself, does better than if he were merely to memorize pages of text.

The following works, to which the author acknowledges his obligation for valuable material, will be useful to teacher as well as pupil, in furnishing additional illustrations and in elucidating difficult subjects, viz.: Tait's "Recent Advances on Physical Science"; Arnott's "Elements of Physics" (7th ed.); Stewart's "Elementary Physics," also his "Conservation of Energy," and "Treatise on Heat"; Atkinson's "Deschanel's Natural Philosophy"; Lockyer's "Guillemin's Forces of Nature"; Herschel's "Introduction to the Study of Physical Science"; Tomlinson's "Introduction to the Study of Natural Philosophy"; Beale's "How to Work with the Microscope"; Schellen's "Spectrum Analysis"; Roscoe on "Spectrum Analysis"; Lockyer's "The Spectroscope," and "Studies in Spectrum Analysis"; Airy's "Geometrical Optics"; Nugent's "Optics"; "Chevreul on Colors"; Thomson and Tait's "Natural Philosophy"; Maxwell's "Electricity and Magnetism"; Silvanus Thompson's "Lessons in Electricity and Magnetism"; Faraday's "Forces of Matter"; Youmans' "Correlation of Physical Forces"; Maury's "Physical Geography of the Sea"; Atkinson's "Ganot's Physics"; Silliman's "Physics"; Tyndall's Lectures on Light, Heat, Sound, Electricity, also his "Forms of Water"; Snell's "Olmsted's Philosophy" (revised edition); Loomis' "Meteorology"; Miller's "Chemical Physics"; Urbanitzky's "Electricity in the Service of Man"; Cooke's "Religion and Chemistry"; Daniell's "Principles of Physics"; Anthony and Brackett's "Text-book of Physics," and also numerous works named in the "Reading References" at the close of each general division. They may be procured of the publishers of this book. The pupil should continually be impressed with the thought that the text-book only introduces him to a subject, which he should seek every opportunity to pursue in larger works and in treatises on special topics.

The editor will be pleased to correspond with teachers concerning the apparatus for the performance of the experiments, or with reference to any of the "Practical Questions."

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I.

INTRODUCTION.

“We have no reason to believe that the sheep or the dog, or indeed any of the lower animals, feel an interest in the laws by which natural phenomena are regulated. A herd may be terrified by a thunder-storm; birds may go to roost, and cattle return to their stalls during a solar eclipse; but neither birds nor cattle, so far as we know, ever think of inquiring into the causes of these things. It is otherwise with man. The presence of natural objects, the occurrence of natural events, the varied appearances of the universe in which he dwells, penetrate beyond his organs of sense, and appeal to an inner power of which the senses are the mere instruments and excitants. No fact is to him either final or original. He can not limit himself to the contemplation of it alone, but endeavors to ascertain its position in a series to which the constitution of his mind assures him it must belong. He regards all that he witnesses in the present as the afflux and sequence of something that has gone before, and as the source of a system of events which is to follow. The notion of spontaneity, by which in his ruder state he accounted for natural events, is abandoned; the idea that nature is an aggregate of independent parts also disappears, as the connection and mutual dependence of physical powers become more and more manifest; until he is finally led to regard Nature as an organic whole, as a body each of whose members sympathizes with the rest, changing, it is true, from age to age, but without any real break of continuity, or interruption of the fixed relations of cause and effect.”

TYNDALL.