

**EXPERIMENTAL SCIENCE SERIES; I.
INDUCTIVE ELEMENTARY PHYSICAL
SCIENCE WITH INEXPENSIVE
APPARATUS, AND WITHOUT
LABORATORY EQUIPMENT**

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Experimental Science Series; I. Inductive Elementary Physical Science with Inexpensive Apparatus, and without Laboratory Equipment by F. H. Bailey

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F. H. BAILEY

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Experimental Science Series

I.

INDUCTIVE
ELEMENTARY PHYSICAL SCIENCE

WITH

INEXPENSIVE APPARATUS, AND WITHOUT
LABORATORY EQUIPMENT

BY

F. H. BAILEY, A.M.

AUTHOR OF "PRIMARY PHENOMENAL ASTRONOMY," INVENTOR OF THE "ASTRAL
LANTERN, OR PANORAMA OF THE HEAVENS," THE "COSMOSPHERE,"
"100 IN 1 PHYSICAL SCIENCE APPARATUS," ETC.

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PREFACE.

THE course in Elementary Physical Science, of which these pages form the first instalment, is the outgrowth of various experiments made first in the public schools of Michigan, later in Dr. Felix Adler's Workingmen's School in New York City, and finally, during the past four years, in the private school of Mrs. Quincy A. Shaw in Boston, — a school founded by Mrs. Shaw, the daughter of the great naturalist, Professor Louis Agassiz, for the purpose of developing methods of nature study that will secure to the young student the best preparation for holding through life intimate converse with nature.

The endless source of happiness which this gives is a heritage that Mrs. Shaw has believed will come always to all students who are introduced to the study of the earth by the natural method. The author's educational views were so fully in accord with her own, that she gave him perfect liberty in laying out the work in the Physical Science branches of nature study for pupils from twelve to eighteen years of age. The results reached have been such that many of the best educators of Boston and vicinity have recommended and urged that the course be given a wider field of usefulness.

While this work has been largely the result of classroom experiment, indebtedness is freely acknowledged to

various sources, especially to the excellent little manual on "Home-made Apparatus," by Professor John F. Woodhull, of the New York Teachers' College.

For any testimony that may be wished in regard to the merit of the course, the following are referred to: Mrs. Quincy A. Shaw, Boston, Mass.; E. Bentley Young, Master of the Prince School, Boston; Charles F. King, Master of the Dearborn School, Boston; W. A. Mowry, President of Martha's Vineyard Summer School; S. T. Dutton, Superintendent of Brookline Schools; Larkin Dunton, Head Master of Boston Normal School; A. E. Winship, Editor of *The Journal of Education*; and Frank A. Hill, Secretary of Massachusetts Board of Education.

F. H. B.

6 MARLBORO STREET, BOSTON, MASS.
January, 1895.

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TO THE TEACHER.

No previous knowledge of physics is absolutely necessary; but a clear conception of the *object* aimed at is imperative, in order that the work may be done in a scientific manner, and the highest success attained. That object is not primarily to give the pupil a few physical facts out of the great abundance of truth, a few essentials of which is all that is possible in any course, but to cultivate his powers of observation and independent thought. Every young child possesses these powers, and is eager to use them; but a system exclusively of book-education tends to destroy them. Some one has truthfully said, "No injustice would be done to a teacher if his skill and the educative value of his lessons were measured by his success in making children reason out conclusions from observed or stated facts;" and we may add that for the best discipline those facts should be observed, not stated. *That* education is of the most value in every walk of life which not only enables its possessor to reason correctly upon facts possessed, but which gives him the power of keen and accurate observation by means of which to collect the facts for himself. Seeing is not so simple an act as many suppose. Every scientist knows that it is one thing to turn the eyes towards an object, but quite another thing to see what is there. Every one's observational powers need cultivating, and

“*Observation Lessons*” are of value for this purpose, but doubly valuable when so arranged as to become an incentive to logical reasoning.

In planning this course these two objects have been kept in view, and they should be continually before the teacher in charge. If the course is properly taught, pupils who have been in the habit of learning, or trying to learn, without independent thought, find that it is impossible to do so in this work. They are compelled to use their eyes in collecting facts, to put these facts together, and to draw conclusions from them. These processes at their command, they are then prepared for the great school of life; but without having acquired these processes, no amount of accumulated facts are of much value. Teachers who have never tried this method will be astonished at the ease with which children adopt it. At first, if their previous instruction has been entirely by the memory method, this one seems to fail completely. The pupils can use neither hands, eyes, nor minds. They cannot experiment successfully, nor see more than a small part of what happens when the experiment is done, to say nothing of thinking out what it all means. But I have not yet had a pupil whose habit of leaning upon book or teacher was so strong that it did not give way, within a brief space of time, and let some degree of self-activity show itself. In training the pupil to self-reliance, it is at the very beginning that the skilful teacher has the opportunity of doing his best work. I have tried several methods: one extreme is to assist the pupils in every step at the beginning, and wean them gradually; the other, to throw them entirely upon their own resources from the very beginning. Of the two extreme