

CLASSIC LIVING BOOK

THE SCIENCES

Edward Singleton Holden

COMPLETE AND UNABRIDGED

This edition published 2025
by Living Book Press
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ISBN: 978-1-76153-817-9 (hardcover)
978-1-76153-792-9 (softcover)

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by

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PREFACE

The object of the present volume is to present chapters to be read in school or at home that shall materially widen the outlook of American school children in the domain of science, and of the applications of science to the arts and to daily life. It is in no sense a textbook, although the fundamental principles underlying the sciences treated are here laid down. Its main object is to help the child to understand the material world about him.

All natural phenomena are orderly; they are governed by law; they are not magical. They are comprehended by someone: why not by the child himself? It is not possible to explain every detail of a locomotive to a young pupil, but it is perfectly practicable to explain its principles so that this machine, like others, becomes a mere special case of certain well-understood general laws.

The general plan of the book is to waken the imagination, to convey useful knowledge, to open the doors towards wisdom. Its special aim is to stimulate observation and to excite a living and lasting interest in the world that lies about us. The sciences of astronomy, physics, chemistry, meteorology, and physiography are treated as fully and as deeply as the conditions permit; and the lessons that they teach are enforced by examples taken from familiar and important things. In astronomy, for example, emphasis is laid upon phenomena that the child himself can observe, and he is instructed how to go about it. The rising and setting of the stars, the phases of the moon, the uses of the telescope, are explained in simple words. The mystery of these and other matters is not magical, as the child at first supposes. It is to deeper mysteries that his attention

is here directed. Mere phenomena are treated as special cases of very general laws. The same process is followed in the exposition of the other sciences.

Familiar phenomena, like those of steam, of shadows, of reflected light, of musical instruments, of echoes, etc., are referred to their fundamental causes. Whenever it is desirable, simple experiments are described and fully illustrated¹, and all such experiments can very well be repeated in the schoolroom.

Finally, the book has been thrown into the form of a conversation between children. It is hoped that this has been accomplished without the pedantry of *Sandford and Merton* (although it must be frankly confessed that the principal interlocutor has his knowledge very well in hand for an undergraduate in vacation time) or the sentimentality of other more modern books which need not be named here. The volume is the result of a sincere belief that much can be done to aid young children to comprehend the material world in which they live, and of a desire to have a part in a work so very well worth doing.

EDWARD S. HOLDEN

THE CENTURY CLUB,
NEW YORK CITY, January 1903.

1 Illustrations have been reproduced from many well-known books, especially from the reading books of Finch and Stickney, Frye's geographies, Davis' physical geography and meteorology, Gage's textbooks of physics, Young's textbooks of astronomy, etc. To the authors of these works, the writer begs to express his sincere thanks.

INTRODUCTORY CHAPTER

(TO BE READ BY THE CHILDREN
WHO OWN THIS BOOK)

LET me tell you how this book came to be written. Once upon a time, not so very long ago, a lot of children were spending the summer together in the country. Tom and Agnes were brother and sister and were together all day long; bicycling or playing golf in the morning, reading or studying in the afternoon. The people who lived in the village used to call them the *inseparables* because they were always seen together during their whole vacation from June to September.

Their cousins Fred and Mary always spent a part of every summer with them, and when they came, there were four inseparables, not two. The children liked the same games, liked to read the same books, to talk about the same kinds of things, and so they got on very well together; though sometimes the two boys would go off by themselves for a hard day's tramp in the hills, or to shoot woodchucks, or for a very long bicycle ride, leaving their sisters at home to play in the garden with dolls, or to do fancywork and embroidery, or to play tennis, or to read a book together. Tom was thirteen years old then, and his sister Agnes was nine; cousin Fred was ten and his sister Mary was twelve.

When the summer afternoons began to get very warm, in July, a rule was made that the children should spend them in the house, or on the wide, shady porch, or else under

the trees on the lawn, or in the garden. Golf, tennis, and wheeling had to be done in the morning; the afternoons were to be spent in something different. Tom's father used to say that the proverb:

*All work and no play
Makes Jack a dull boy*

was only half a proverb. It was just as true, he said, that:

*All play and no work
Makes Jack a sad shirk.*

And so a part of every summer afternoon was given up to reading some good book, or to study, or to work of some sort. The two boys had their guns and wheels to keep thoroughly bright and clean, and a dozen other things of the sort; the two girls had sewing to do; and all of them together agreed to keep the pretty garden free from weeds.

Almost any afternoon, you might see the four inseparables tucked away in a corner of the broad piazza, each one busy about something, and all talking and laughing — except, of course, when one of them was reading, and the others paying good attention. Tom's big brother Jack was at home from college, and in the afternoons he was almost always on the porch reading, or else on the green lawn lying under the trees; and Tom's older sisters, Mabel and Eleanor, were there too, sewing, or embroidering, or reading, or talking together.

So there were two groups: the four children — the inseparables — and the three older ones. When the children came to something in their book that they did not quite understand, Tom would call out to his big brother Jack to explain it to them, and Jack would usually get up



FIG. 1. THE PORCH

and come over to where the children were and tell them what they wanted to know. Almost every day, there were conversations of the sort and explanations by someone older to the four children. All kinds of questions would come up, like these:

“Jack, tell us why a ‘possum pretends to be dead when he is only frightened and wants to get away.”

“Jack, tell us why a rifle shoots so much straighter than a shotgun or a musket.”

“Jack, what’s the reason that a lobster hasn’t red blood?” or else:

“Eleanor, what is the difference between a fern and a tree?”

“Is that coral bead made by an animal or an insect?”

“What is amber, anyway?” And so on.

The children had no end of questions to ask, and Jack or one of the older girls could generally answer them. When they could not give a complete answer, the dic-



FIG. 2. A CELL OF A DRY BATTERY

It costs about \$1.10. The two wires are to be fastened to the two screw posts in the picture - one at the left-hand side, and one in the middle, of the top of the cell.

When the children were talking about electric bells, for instance, they actually strung a wire from one end of the long porch to the other and put a real bell at one end of it and a push button and a battery at the other. In this book, there is a picture showing exactly what they did; but, after all, you cannot understand an electric bell half as well by a picture as you can by the real bell and the real wire². So, when one of the children who is reading this book comes to an experiment, he must read all that

tionary was brought out, and if that was not enough, a volume of the encyclopedia. Sometimes the questions were talked over at the dinner table, and the whole family had something to say. Tom's father had traveled a great deal and could almost always tell the children some real "true" story — something that had happened to him personally, or that he had read.

The chapters in this book are conversations that the children had among themselves or with the older people. They are written down here in fewer words than those actually spoken, but the meaning is the same.

When the children were talking about electric bells, for instance, they actually strung a wire from one end of the long porch to the other and put a real bell at one

2 Children should be careful to read the titles printed under each picture with attention. The titles explain what the picture means.

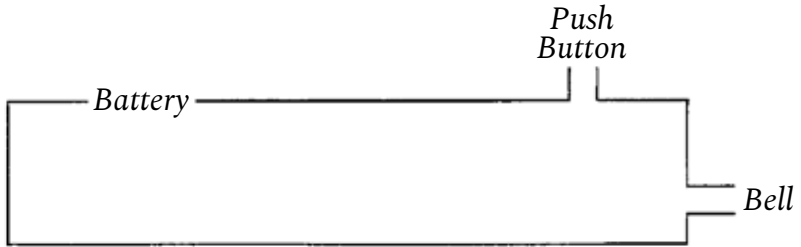


FIG. 3

the book says about it and understand it as well as he can. If he can get an electric battery, a bell, wire, and a push button, then the picture in this book will tell him exactly how to join them together; and when he has done this and actually tried the experiment — and made it succeed — he will know as much about electric bells as he needs to know.

If he cannot get the bell and the wire and so forth, he can probably see a bell of the sort somewhere; and if he keeps his eyes open and thinks about what he has read, he can certainly understand how it works. Here is the battery, always trying to send out a stream of electricity along any wires joined to the two screws at the top. Here is the wire, which is almost a complete loop — almost, but not quite. If the loop were continuous — if the wire were all in one piece — then the stream of electricity would flow along the wire from the battery and would ring the bell.

The use of the push button is to make the wire continuous — to join the two ends of it so that the stream of electricity can pass along it. When you have done this — when you have joined the ends of the loop of wire — the bell rings, and only then, which is just as it should be.

This book gives the pictures and the explanations. They can be understood by paying attention; and when they are once understood, a great number of things will be clear



FIG. 4. AN ELECTRIC BELL

It costs seventy-five cents. The wires are fastened to the two screws at the bottom of the box.

that all children ought to know and that have to be learned sometime. Why not now? The sooner, the better.

If you read what is written in the book and perfectly understand it, that is very well. If there is an experiment to be tried, and you can get the things to try it with, so much the better. If you have any trouble understanding, ask someone — your father, your mother, your teacher — to explain it to you. If you can find another book — a dictionary or an encyclopedia — that describes the same experiment, read that too. Perhaps it will tell you what you want to know better, or more simply, or more fully, or in a different way.



FIG. 5. A PUSH BUTTON

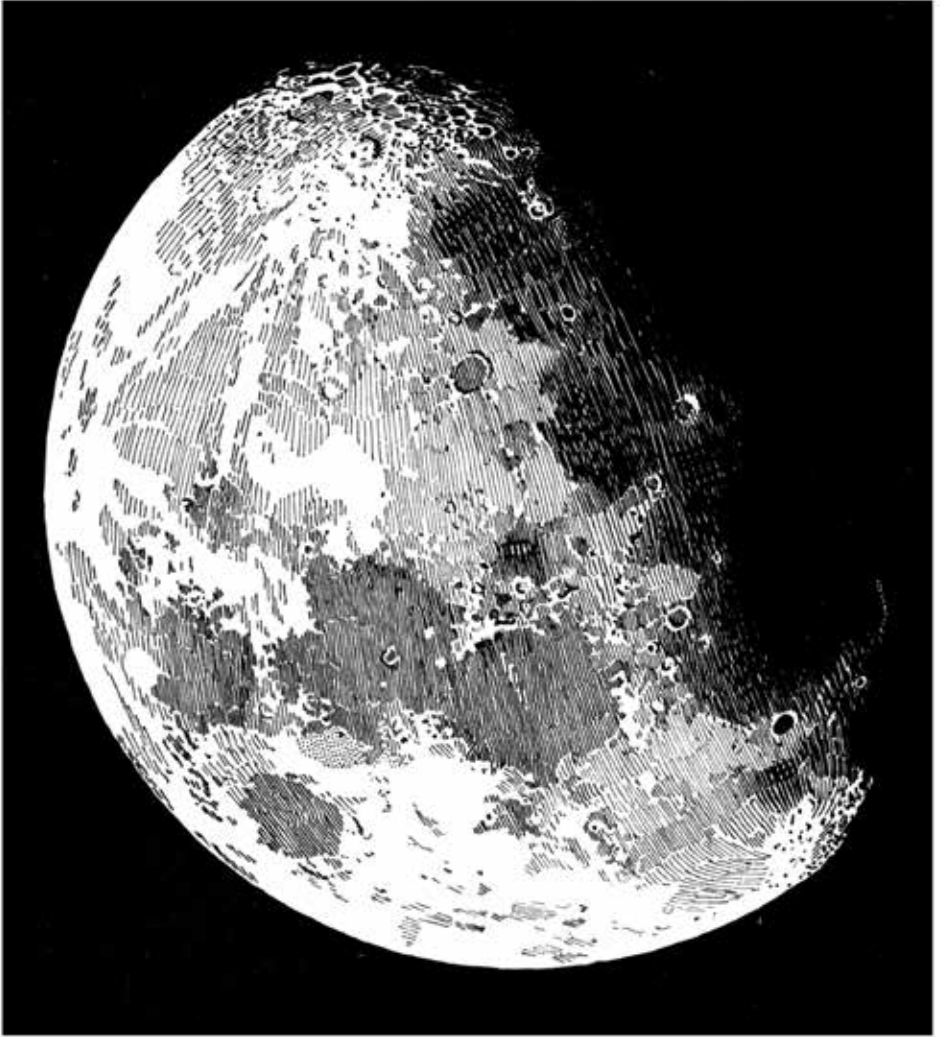
It costs thirty cents.

The two wires are fastened to two screws inside the push button.

Then, finally, keep your eyes open to actually see in the world the things that are talked about in this book. When you see them, try to understand them. Remember what you have read here, and you will find that you understand a good many things that you see about you every day. Somebody understands these things — push buttons, electric

lamps, telescopes, and so forth. Why should not you? You

can if you pay attention enough. The world is, after all, your world. It belongs to you as much as it belongs to anyone. The things in it can all be explained and understood. It is everybody's business to *try* to understand them, at any rate. All these things concern you. The more you know about them, the better citizen you can be — the more useful to your country, to your friends, and to yourself.



The Moon

The moon, from a photograph taken with the great telescope of the Lick Observatory.

BOOK I
ASTRONOMY

THE SCIENCE OF THE SUN, MOON, AND STARS

The Earth as a Planet. - The children were looking at a map of the world one fine afternoon and studying the way the land and water are distributed when Agnes said: "I never knew before how little land there was on the earth. Why, there is *very* much more water than land." "Oh, yes," said Tom, "there's very much more water on the surface, but it's all land at the bottom of the ocean. The sea is about three miles deep, you know, and then you come to the ocean bottom, and that is solid land again. The earth is nearly all rocks and soil—only a little of it is water after all, but that little is on the surface, of course, and that is why it shows."

Agnes: So the earth is almost all land; if you dig down deep enough, you would come to rocks, even below the oceans.

Tom: Yes, and if you went up high enough, you would come to nothing. You would come to air first, and then, by and by, to no air, and then you would come to just nothing — to empty space.

Agnes: Well, it isn't quite empty, as you call it. There are other globes in space. There are other planets, and the sun and the moon, and there are simply thousands of stars. So space isn't empty; it is pretty full!



FIG. 6 AMERICA



FIG. 7 THE OLD WORLD

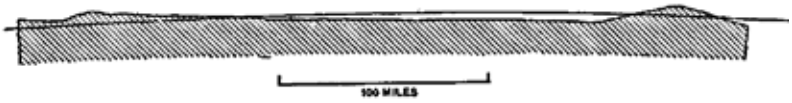


FIG. 8

This picture shows the height of land on the earth compared to the depth of the sea. If you could cut the earth through and through with a knife and look at one part only, it would look something like the picture. All the shaded part is land. The curved line drawn all across the picture, near the top, is the curve of the surface of the oceans. Part of one of the oceans is shown by the white space below this curved line and above the floor of the ocean itself, - the shaded land. The curve of the ocean surface is continued across the picture underneath the mountains. If the surface of the earth were all water, the bounding line would be this curve. From side to side of the picture is about 350 miles. If the whole circle of the earth were drawn, it would be about eight feet in diameter. That is the scale of the drawing.

Distance of the Moon and of the Sun from the Earth.

- Here Tom's big brother, Jack, looked up from his book and said: "Well, that depends on what you call full. It is 240,000 miles from here to the moon, and the moon is the very nearest of all the heavenly bodies to us. There is a good deal of empty space between us and the moon, it seems to me."

Agnes: Two hundred and forty thousand miles! Oh, Jack, is that right?

Jack: Why, that isn't the beginning. How far off do you suppose the sun is? It is 93,000,000 miles — millions this time, not thousands; and some of the planets are much farther off yet, and every one of the stars is farther off still.

Agnes: Jack, tell us about it, will you? We don't know, and you do.

Jack: The very first thing you have to think about is the size of the earth. How far is it through and through the earth, Tom? If you pushed a stick through the earth from New York to China, how long would the stick be?

The Diameter of the Earth. - *Tom:* The geography says that the diameter of the earth is 8,000 miles, so the stick would have to be 8,000 miles long—as long as from Cape Horn to Hudson Bay, my teacher says.



FIG. 9. A BALLOON

Balloons carrying men have gone up more than five miles, and small balloons carrying thermometers, etc., have been sent nearly ten miles high. The atmosphere of the earth extends upwards a hundred miles or so, but beyond this there is no air - nothing but empty space.

Jack: That's about right. Suppose there were a railway from Hudson Bay to Cape Horn, and express trains were running on it at the rate of 40 miles an hour. Let us see how long they would take to go the 8,000 miles. They would go 40 miles in one hour, and 80 miles in two hours, and 960 miles in a day — say 1,000 miles a day. Well, they would take eight days to go the 8,000 miles, then. Now, suppose we could build a railway to the moon. How long would an express train take to go the distance? Take your pencil, Tom, and cipher it out.



FIG 10. THE FULL MOON RISING IN THE EAST

Tom: You said the distance from the earth to the moon was 240,000 miles. If the train goes 1,000 miles a day, it would take 240 days. I don't need any pencil.

Jack: Sure enough; and 240 days is eight months ($8 \times 30 = 240$). It would take the train eight months to go from the earth to the moon, then — eight whole months, traveling night and day at forty miles and more every hour.



FIG. 11. A SCHOOL GLOBE

Agnes: I should be nearly a year older when I got there than when I started, then.

Jack: Yes, and recollect that there are no stations on the railway to the moon. The moon is the heavenly body that is nearest to us, so that space is pretty nearly empty, after all.

Distance of the Sun from the Earth. - *Tom:* How far did you say it was from the earth to the sun — 93,000,000 miles?

Jack: That's right. You will need your pencil to figure out how long the express train would take to go from the earth to the sun, Tom.

Tom: Yes, it is like this, isn't it? The train goes 1,000 miles in a day; then it will take 93,000 days to get to the sun.

$$\begin{array}{r} 30 \overline{)93000} \text{ days} \\ 12 \overline{)3100} \text{ months} \\ \hline 258\frac{1}{3} \text{ years} \end{array}$$

It would take 3,100 months — that is more than 258 years — to get to the sun. That's a long journey! You would have 258 birthdays on the road, Agnes.

Jack: Put it this way, Tom: 258 years ago takes you back to the year 1643 ($1901 - 258 = 1643$). The Pilgrims had been in New England only twenty-three years in 1643, for they came in 1620 ($1643 - 1620 = 23$). Suppose one of those Pilgrims stepped onto the train at Plymouth Rock; he would have been traveling all these years, and he would only have arrived at the sun a few years ago — that is, if he had lived to make the journey.

Tom: Two hundred and fifty-eight years!



FIG. 12. THE PILGRIMS LANDING ON PLYMOUTH ROCK FROM THEIR SHIP, THE "MAYFLOWER", DEC 20, 1620.

The Planets Mercury and Venus. - *Jack:* Yes, and nearly all that space is empty too. There are only two planets between the earth and the sun — Mercury and Venus.

Agnes: Venus, the evening star?

Jack: Yes, Venus is the evening star sometimes. Venus and Mercury are the only planets that the Pilgrim would pass on the road from the earth to the sun. Space is rather empty, isn't it?

Agnes: Aren't there any stars in between the earth and the sun, Jack?

Jack: Not one; the real stars are thousands and thousands of times farther off. We call Venus the "evening star," but Venus is not a star at all, but a planet. Let me tell you, so that you can make a sort of picture of it all in your minds. The sun is there in the middle of space, and all the planets move around him, just as the earth does. Nearest to the sun is the planet Mercury, and then comes the planet Venus, and then the planet Earth.

Agnes: That sounds queerly — "the planet Earth" — though of course we know the Earth is a planet.

The Planets Mars, Jupiter, Saturn, Uranus³, and Neptune. - *Jack:* Yes, exactly so. And then there are other planets farther away from the sun than the earth: Mars for one, and then Jupiter, and then Saturn, and then Uranus, and then Neptune. That is all we know of; there may be more of them. Neptune is thirty times as far from the sun as the earth is. Here is a little table that I will write down for you to keep. You need not memorize it, only recollect that Mercury and Venus are nearer to the sun than we are, and that all the others are farther away.

DISTANCES OF THE PLANETS FROM THE SUN

The planet *Mercury* is 36 million miles from the sun.

The planet *Venus* is 67 million miles from the sun.

The planet *Earth* is 93 million miles from the sun.

The planet *Mars* is 141 million miles from the sun.

The planet *Jupiter* is 483 million miles from the sun.

The planet *Saturn* is 886 million miles from the sun.

The planet *Uranus* is 1,782 million miles from the sun.

The planet *Neptune* is 2,791 million miles from the sun.

Jupiter is five times, and Neptune is thirty times, as far from the sun as the earth is.

Tom: Isn't there a map of all these planets that we can see?

Jack: No, and there's a good reason why. Suppose you tried to make a map of them, and suppose you took the distance from the Sun to the Earth on the map to be an inch. Don't you see that the distance from the Sun to Neptune would have to be thirty times one inch, and the page of your book thirty inches wide — nearly a yard wide?

Tom: Of course, no book has a page as big as that; but you might make little maps.

How to Make a Map that Shows the Sun and Planets.

- *Jack*: You and Agnes can make a map yourselves tomorrow morning if you want to, when you go out for a walk, and I'll tell you how to do it.

Suppose you take the large globe in the library, that you were looking at just now, to stand for the Sun. It is two feet in diameter. Well, the diameter of the real Sun is 870,000 miles, and your map has to be made all to one scale. Every step of yours is about two feet long, isn't it, Tom? Try it.

Tom: Yes, my steps are almost exactly two feet long.

Jack. Well, remember tomorrow that every step you take