

Claude Phipps

NO WONDER YOU WONDER!

Great Inventions
and
Scientific Mysteries



 Springer

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Claude Phipps
Illustrations by Friedelwolf Wicke

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*This book is dedicated to Dr. Ray Kidder,
who taught me that complex science can be
expressed simply as he explained inertial
confinement fusion with a few equations on
the whiteboard, during my first week on the
job at Livermore.*

Sorèze, May 11, 2015

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In Praise of *No Wonder You Wonder!*

“From beginning to end, and with laugh after laugh, I enjoyed every single word of this remarkable book. Phipps is a hell of a good writer, and the kind of physics teacher that I would have loved as a young student. *No Wonder You Wonder* can be engrossing for anyone with a bit of curiosity, not just the scientific minded.”
– Christophe Bonnal, Chief Engineer, CNES (French Space Agency)

“*No Wonder You Wonder* is a fantastic book. Covering topics such as space, matter, and the energy within the universe, this book does an excellent job of clarifying these topics. It’s a great read for young scientists and aspiring physicists.” – August R., high school freshman

“*No Wonder You Wonder* is an utter joy to read! Phipps is able to delve deep into the depths of black holes, the algorithms of time, or the construction of a jet engine while carrying you along on an informative and exciting ride... a ‘must read’ for anyone interested in a deeper understanding of the world around us.” – Jonah Cohen, Sound Engineer, Musician, Entrepreneur

“This book is like a conversation with a favorite uncle who opens doors to secret places we have wondered about, or never knew were out there waiting for us. Phipps is a guide who clearly loves mystery and discovery. He democratizes science by inviting readers to become citizen scientists with agency, awe, and a sense of responsibility.” – Garry Hesser, Martin Olav Sabo Professor of Citizenship and Democracy Emeritus, Augsburg College, Minneapolis, MN

“Claude Phipps takes us on a whirlwind tour of the science and technology behind the perennial question, “How does that work?” We learn how science has shaped society from ancient China to the modern day. Phipps emphasizes understanding and working with numbers as a central theme, but in a delightfully conversational tone that teaches and entertains. This whimsically illustrated book is written by one of science’s most creative minds whose joy in wondering about the world around him shines through every page.” – Mick Shaw, Formerly Director, Krypton Fluoride Laser Programme, Rutherford Appleton Laboratory, UK

“Claude Phipps in *No Wonder You Wonder* is a modern Plinius the elder summarizing human knowledge up to his time. His book examines math and science in an

informative and entertaining way to both those who love math and science and those who don't. You don't know what you didn't know until you've read this book." – Mary Sisk, Retired Procter & Gamble Manufacturing Engineer

"Claude Phipps has written a book that makes science learning fun. He is fascinated and excited by the subject, and it shows in his writing. While exploring a variety of science subjects, he inserts his colorful opinions and anecdotes while properly labeling them as such. He is very careful to avoid burdening the reader with a lot of difficult material, but the reader cannot just breeze through the contents like a novel. It takes time to go over the science and check out the underlying explanations. I recommend this book both for youth and for adults. It is an eye-opener and a mind-opener." – David K. Reynolds, Ph.D., Constructive Living

"I read this book with delight and was fascinated by Phipps' approach! No Wonder You Wonder will be captivating for teachers and their students - and for anyone with a sense of wonder." – Ray Kidder, Laser Research Program Leader, Lawrence Livermore National Laboratory (Ret.)

"Dr. Phipps has written a book as entertaining as it is enlightening. His brilliant scientific mind and playful writing style come together in a fun and fascinating read that will provide endless "ah-ha" moments for anyone who has ever wondered about the many mysteries of our world." – Jerry Jerome, an educator

Part I

Basics

Preface

Lots of scientists can write equations. I can, too! But, as a way of communicating, they are off-putting to anyone who didn't go flying through Algebra II and Calculus, let alone Differential Equations. My goal here is to make the complex simple, instead of the other way round. There is *nothing* you have to read first in this book. You may want to glance at the *Numbers* and *Metric System* chapters first, if you're not comfortable with those things. But you can start anywhere that interests you and read backwards and forwards. That's my kind of book!

Who Am I?

I'm a "retired" scientist in Santa Fe, New Mexico. My expertise is in the physics of pulsed lasers interacting with materials. I have a Ph.D. in plasmas from Stanford, and a Master's from MIT. I worked at the Livermore and Los Alamos labs for many years. So far as I know, I never worked on anything that would hurt someone. I have run a conference called High Power Laser Ablation in Santa Fe every two years since 1998. I still work 50 h a week. Even in science, my intention has always been to make the complex simple. I'm also a poet and writer, and history is one of my favorite things.

When I look out my window at the world, I see an infinitely complex place full of interrelated things. Poke it anywhere, ask a question like "why is the sky blue?," and that question will bore down and branch out into a thousand more questions which are all part of physics. That's why it's such a great field. I don't want to be a narrow expert in anything, but rather knowledgeable about it all. *It is still possible!* That's one reason I wrote this book. I know there are a lot of you out there, who are curious but are not encouraged by the way science is usually taught. You will notice it's written here in a personal, narrative way, and that the same topic shows up in

various ways in several chapters, rather than being organized in some hierarchy. For that reason, I've put in links connecting discussions of the same thing. You *can* understand it without getting a degree in it.

The second reason for the book will become more clear in the very first chapter, where I insist that you're not entitled to your own facts. The Internet is a tremendous resource, but it has no filtering mechanism and it's easy for one person's particular opinion to become what "Einstein said."

What is Science and What is Not?

Here's a bit of philosophy: What is science anyway? Is it Francis Bacon's "scientific method," which you may have learned in school: "First, form a hypothesis..."? Of course not! Those ideas were written by Lit and History Majors! Few scientists do science that way. Scientists are human. Science starts in the belly with a hunch, a wish to leave a mark on the world, a sudden crazy thought in a conference, a vision of the benzene molecule in a dream. After I make my theory and think I've proved it, does a contrary result cause me to abandon it? Of course not! All this work was worthwhile after all! If others try to prove me wrong, I'll fight like hell until I *have* to admit they're right!

But, the results of science are not just belief or faith. They're not arbitrary. Science is a reality-based community. Do you follow me? Any good scientific result must tie into reality.

By "reality," I mean this: if there is an agent here *that I can identify and measure, and it acts in the same measurable way everywhere for everyone*, then it's a scientific fact, part of reality. Whether I as a scientist understand it, or not, doesn't matter. It's a gift if I don't: a new relationship to figure out and then tie into the rest of them.

The squishy things happen when I try to explain a scientific fact with a theory about why it happened, because that depends on my imagination and training, and on the state of science in my time. But the foundation of facts is not so squishy. A good scientist is ready to admit that a new and better explanation of things than she learned is possible. After a thousand years of pretty good science, we start from an agreed set of basic ideas ("force is mass times acceleration") that have been proven so often we don't give them a second thought. Why is that? Because experimental scientists have proved these basic theories so many times, in so many different ways, in the lab, some of them out to dozens of decimal places. My theory is no longer squishy when it's proven.

I don't have a right to make up my own facts. Others have to agree.

Science is a continuing process of finding where basic ideas break down and discovering new and better ideas to explain what you can see. For example: you can weigh something and find its mass, and the tick of a clock is the tick of a clock. Yet, as Einstein realized just a century ago, while we can all agree on what we mean by "mass," "speed," "lifetime," and "length" in our own backyards, we will not agree even approximately when I'm going at 90 % of the speed of light away from you! This does not mean, as you may have heard, that "Einstein said everything is relative."

He didn't. His theories of relativity have been proven to microseconds for clocks on satellites circling the Earth, and for multiply extended lifetimes of fast atomic particles that ought not to live as long as they do.

The thrilling part of science is discovering brand new things, like the Higgs boson, which Peter Higgs actually lived to see, or in doing brand new things like landing on the Moon.

It's been a pretty rapid change. Three hundred years ago, you couldn't have bought a battery (although those clever Arabs may have made a few for electroplating 2000 years ago!), and electric lights of any sort were not known until about 1800. Two centuries ago, people were just finding out about electric currents and magnetic and electric fields and how they can produce each other. Electric street and house lights required generators, and these were not perfected until the time of Lincoln. Nobody knew how far away the stars really were until a hundred years ago. Now, the set of scientific facts you will learn in school changes dramatically in one human lifetime. And that is why school takes a long time.

Science is a strong belief system for me. My "belief" is that science is the best way to approach reality.

"Belief" is a funny word. It all comes down to what I think is true. Miracles and magical outcomes are strong belief systems for many, many people. Garcia Marquez got a Nobel prize for stories about that kind of reality and I find his stories beautiful, but that world is a different one from the scientific one.

My observation is that 30–50 % of people believe things that have no scientific basis, and call it "science." If it works for them it would be cruel as well as hopeless to try to disprove their beliefs. Lord knows, at least that fraction of the U.S. population believes the world was made 6000 years ago. Nikita Khrushchev once said, "If the people believe there's a river over there, don't tell them there's no river. Make an imaginary bridge over the imaginary river!" And that is good advice for all of us.

I cannot measure "energy," as that word is used colloquially. People see and feel auras or they don't, and that's anecdotal, not reproducible. Energy, in my field, is measured in joules. The energy of a blue photon is always the same. When those guys at CERN fired two proton beams at each other and found the Higgs boson resonance at 125 billion volts of energy, after millions and millions of shots, to me, it was justified and even a holy event to play the "Ode to Joy" from Beethoven's ninth in the movie "Particle Fever." If you haven't seen that movie, go do it!

There's a deeper fear for me, and that's what this preface is about: when it appears the majority of people in general (not you, dear reader!) are starting to doubt that there is a factual reality and prefer the reality on their favorite blog or hearsay from a friend—"of course, we know that...", "Einstein said that..." (poor Einstein, he said so *many* things)—the entire Enlightenment Experiment, the basis of Modern Civilization is doomed. Yes, I know I already ranted about that in Chap. 1!

I also "believe in" the power of prayer. I cannot measure it, it is certainly anecdotal, and what it is that I am praying to, or how it acts, is a mystery. This is in that other world, that I *believe in but cannot measure, and have no need to measure*. It's not true that I don't believe in anything I cannot measure. I believe in love, in beauty, in honesty and so on. I'm sure you do too! But, I also believe in science and repeatable scientific results.

I admit there are many things in the scientific world that nobody understands. And that makes it so interesting. There's *so much* left for your generation to find out! But there *are* things we do understand.

That's why I'm writing this book for you, to help you keep these things separate! It's not just a matter of belief, what is science and what is not. The world of belief and the world of science do *not* contradict each other, although religions have often claimed that they did.

So: onward and upward! Enjoy!

Einstein Said ...

And now, as the Monty Python folks used to say, “for something completely different!” Poor Einstein! He said so many things! Many of these are examples of how people like to buttress their own opinions, or, which is better, enhance a story. Glenn Hodges, on his sounding line blog puts it succinctly: “Einstein is the victim of interminable New Agey quote chains that seem to revel in the notion that the greatest scientific mind of the twentieth century believed the same things Oprah does.” This is why I’m writing this chapter.

1. “Everything is Relative.” He didn’t say that. As we say in *Modern Science*, when you come back from a very fast trip, some things—like the age of your friends—are irreversibly changed.
2. One day, someone saw a horseshoe hanging above his door and asked him if he really believed this brought him luck. “I don’t believe in it! But it works anyway!” he is supposed to have said.
Nope. The truth is: Niels Bohr was visiting a friend, saw the horseshoe and asked “Do you really believe in this?” to which his friend replied “Oh, I don’t believe in it. But I am told it works even if you don’t believe in it.” The truth is often *much* less dramatic.
3. “Genius is ten percent inspiration, ninety percent perspiration.” Actually, it was Edison, and what he said was “Genius is one percent inspiration, ninety nine percent perspiration,” a little bit more boring. But then, he may have put out too much indiscriminate effort in developing light bulbs—scientists sometimes ridicule indiscriminating industry by saying someone’s efforts are “Edisonian.”
4. “If you can’t explain your physics to a barmaid it is probably not very good physics.” That’s a good one, and I believe it. But it was Ernest Rutherford who said it.
5. “The definition of insanity is doing the same thing over and over and expecting different results.” We don’t know who said it, but it’s probably very old. And it’s not a definition of insanity. Maybe of stupidity.

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