Chapter 1
Why astronomy and why its history

This is a story of the oldest of sciences, astronomy. Learning this story will not make you a science wizard. It *will* make you a wizard in the areas of science that are most important: how science works and how science changes the way we think about the world. Astronomy's story -- science's story -- is not just a matter of facts and figures. Science is not a matter of knowing that Mars has two moons and Venus has none. Science is a matter of understanding how we can know that Mars has two moons and Venus has none.

You may be thinking that you are not too excited about this story. If that is the case, good! I am not writing this story for people who love science. I am writing this story for people who don't love science (but if you do love science you will like this story, too). This story is for people who think science is for nerds -- that science is a dull, tedious collection of theories and facts that you memorize to pass a test in school, and then you forget. This story is for people who think science is for heathens -- that science is a machine of the secular world designed to bring down the faith of their family members. This story is for people who think science is for monsters -- that science is a hard-driving, ruthless process sponsored by governments and corporations which has spawned weapons of mass terror and mass destruction, polluted the environment with industrial toxins, poisoned our children with food additives and false vaccines, and ended eons of sustainable human activity.

People who love science will learn science without this story. Most people don't think they love science -- and they haven't learned science, despite school. Here in Kentucky (home of Jefferson Community & Technical College), few people learn much about science (of course that is true for plenty of other places as well). The last decade of the 20th century and the first decades of the 21st saw Kentucky enact big education reforms, saw computers and the Internet become common in schools, saw the message repeatedly promoted that education was the key to economic success (every highway crossing into Kentucky once sported a big "Education Pays" sign). Still, now well into the 21st century, education in Kentucky continues to be plagued with problems. Neither reforms, nor technology, nor P.R. campaigns have fixed Kentucky education -- Kentucky continues to

rank low versus other states in educational attainment.

It is not that people do not want education. People love to learn -- and not because of learning's economic value. People who like fishing, love to learn about fishing (and not because "Fishing Pays"). People who enjoy sewing, love to learn about sewing. Country music fans love to learn about country music. Civil War buffs love to learn about their favorite aspect of that period in time. And so on for cars, boats, basketball, firearms, ice skating, cooking, antiques, etc. We recognize that to care about something is to want to learn about it. Nowhere is this more clear than in sports, where someone who describes himself as a "big Kentucky basketball fan" but knows nothing about the team, the coach, the year's schedule, or how the game is played -- and doesn't care to learn -- is considered a fraud, a fool, and a jerk. A better-told history of science can help to fix education if it can make science have the sort of appeal to ordinary people that fishing, sewing, firearms, and antiques have. This book, *The Known Universe*, is an effort to try something new -- to tell the story of science in a different, better way that changes your view of science.

So what makes the story I am telling different?

For one, I am going to tell you about ideas that were wrong. In fact we are going to learn a *lot* of wrong information. Why? *Because science gets things wrong a lot.* It is important to understand this. We scientists have been wrong a lot in the past. We are probably wrong about many things right now. Being wrong is not being stupid. Most of the times when scientists have been wrong, they have had good reasons for thinking the wrong things they thought. Science is a human endeavor. It is not perfect. It has a human face. We are going to learn that face. Hopefully, by learning what the wrong answers were, and how scientists figured out why they were wrong, you will come to a much better understanding of how science works than you would if you just learned the right answers.

For another, I am going to talk about religion a lot. What is more, I am going to be very respectful of religion. Religion has a big part to play in the story of science. It is unfortunate that there are so many loud voices in the world that wish to portray religion and science as being in some eternal battle with each other.

Seeing the human face will hopefully convince many that science is not just a dull collection of facts and theories figured out by genius nerds and worked into technological monsters, but rather it is the work of real people who get things wrong but learn new things anyway. Education can benefit from the idea that knowledge is not just a matter of being the smart guy with the right answer. Being wrong is part of how we learn. A respectful discussion of religion's role in the history of science will hopefully convince many that science is not just for secular zealots. Education, and particularly education in Kentucky, can benefit from the idea that those who wish to learn need not be forced to make a choice between building knowledge on one hand and maintaining the strength of their faith on the other. If becoming educated about science means that people must abandon their faith (and by extension probably their family and upbringing as well), then many will prefer not to be educated. A respectful discussion can only occur if we accept that being wrong is part of science -- so when science does challenge religion, it does so from the position of knowing that it has often been wrong in the past, and may be wrong now. Similarly, science is often seen as challenging not only religion, but other areas of human thought as well. In education, science-related or "STEM" material is often given priority over subjects like arts and humanities. Again, understanding that science has often been wrong in the past, and may be wrong now, helps us to better appreciate these subjects. In the year 2050 our understanding of, for example, planets orbiting other stars will likely be different from what it is today, and our understanding today is different from what it was in 1990. By contrast, our understanding of Shakespeare's play "Hamlet" as a great work of art remains largely constant. A brilliant astronomer from 2050 and a brilliant astronomer from, say, 1850, will necessarily have many differences when it comes to the science of astronomy -- not so when it comes to "Hamlet".

Our discussion of the science of astronomy will consist of four parts. The first two, *The Center of the Known Universe* and *The Workings of the Known Universe*, will illustrate how science works by telling the story of how scientists brought us to believe that the Earth circles the sun and that the sun is a star. There is no better way to learn how

science works than to learn this story. Many people, including perhaps even you, dear Reader, find certain aspects of science hard to swallow. For example, modern physics tells us that time can run at different rates in different places. You may find that totally absurd. Or, modern biology tells us that all life, including human life, evolved from a common ancestor. You may find that more than absurd -- you may find that offensive. Modern medical science tells us to vaccinate our children. You may find that untrustworthy. Well, the story of how scientists brought us to believe that the Earth circles the sun can tell us a lot about how physics and biology and medical science all work. After all, if you think those ideas are absurd, offensive, or untrustworthy, consider how absurd it is to conclude that the reason the sun rises each morning over the Eastern horizon is not because the sun is rising, but because the Eastern horizon is dropping! Consider whether that conclusion offends you, when religious texts refer to the Earth as being unmoving. Consider whether you trust those scientists who tell you that the Earth moves, even though you cannot verify for yourself that it does.[1] So, is the idea that time runs at different rates in different places really so absurd?

"Wait a minute!" you may say, "I don't want to believe this stuff. I don't want to be convinced that I evolved from a little monkey or an amoeba. I don't want to hear that the medical experts know better than I do about how to care for my kids!" Relax. The story of how scientists brought us to believe that the Earth circles the sun may show you how science works, but it will also show you just how wrong science can be, and how it can go on being wrong for a very long time. The goal of *The Known Universe* is not that you will "believe" in science, but that you will *understand* science. Perhaps when you are finished with this book you will still feel that what modern physics or biology or medical science has to say is unconvincing, and you may still not believe any of it. But you will understand why scientists say what they do.

After you have completed *The Center of the Known Universe* and *The Workings of the Known Universe*, you will not only understand how science works, but you will also understand the basics of modern astronomy so far as that which is visible to the eye is concerned. When you walk outside at night and look up you will know the basics about everything you can see, be it the sun, Jupiter, the moon, or a star. Dear Reader, once you

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1 ...yet. Hopefully you will be able to once you have completed the first two parts of the book.

know how science works, and the basics of astronomy, you can study any astronomical topic you want. There is far too much material in astronomy to cover everything well in one book. Therefore, the rest of this book consists of discussion of two topics that are of wide general interest and that have historical connections to the material covered in the first two parts of this book. Those two topics are the origins of the universe (covered in *The Age of the Known Universe*) and life on other worlds (covered in *The Inhabitants of the Known Universe*). These are both topics about which some people, perhaps even you, have strong opinions. These topics play a role in our society (especially the topic of life on other worlds, as we shall see). A good knowledge of what science has to say about these two topics is probably more valuable to the average person than a good knowledge of what science has to say about, for example, neutron stars, or the details of surface formations on Mars as revealed by the Mars rovers.

At this point you may be wondering to yourself, "How does this Graney guy know what is or is not valuable? What does he know about this stuff? He's a professor at Jefferson Community & Technical College in Louisville, Kentucky, not an expert from Harvard! Why should I believe what he writes? Shouldn't I be reading a book written by someone from some place famous?" Well, just because you aren't at some famous center of learning doesn't mean you can't know something. You can be at a community college in Kentucky and know something, too! Since 2006 Jefferson Community & Technical College's Otter Creek-South Harrison Observatory has sustained an active program of research, focusing on historical astronomy. During that time we have had numerous papers published in academic journals. Our research has twice been the headline item on the web page of the journal *Nature*, one of the world's top science journals. *Scientific American* has published our work. Two books have come out of our work. Some of that research is reflected in this book, so you are going to learn cutting-edge stuff when you read *The Known Universe*. Moreover, that cutting-edge stuff has itself been influenced by you -- or, to be specific, by previous astronomy classes at Jefferson Community & Technical College, whose questions and insights have had a great impact on our astronomy research.

Those questions and insights have also had a great impact on this book (now in its sixth edition). In a real sense, this book is written in part by students. It has been revised six times, not only to keep up with changing knowledge, but also to better address and answer student questions.

So let us begin to learn astronomy's story. We shall begin by forgetting everything we learned in school. We forget about the eight (not nine!) planets. We forget that Saturn has rings and Jupiter has moons. We forget about "My Very Excellent Mother Just Served Us Nine Pizzas".[2] We forget about the Earth turning, about the Apollo missions to the moon, about everything we ever learned in science class or read in any book.

We know nothing about science. We know nothing about astronomy. We just go out and look at the sky, and see what we can see for ourselves....

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2 For those not familiar with that little sentence, it is a common tool for memorizing the planets and their order from the sun. My (Mercury) very (Venus) excellent (Earth) mother (Mars) just (Jupiter) served (Saturn) us (Uranus) nine (Neptune) pizzas (Pluto -- prior to Pluto's demotion to dwarf planet).