In short, the public has grown distrustful of scientific predictions of gloom and doom. Gee, I wonder why? Could it be because, historically, scientists have always been wrong about these predictions? Hmmm.

"But doesn't science tell us how things work?" you might ask. Well, yes and no. The disciplined practice of scientific investigation will usually give us a better idea of how the natural world works than, say, making something up. (You might have noticed from media reports that scientists are sometimes caught doing this, too.) Unfortunately, a variety of practical problems leads to much less confidence in some scientific conclusions than others. And this brings us to a startling fact that you might not be aware of: *science is not truth.*

While experts remain at odds over the issue of when life begins, most agree it's sometime after work

Chapter 2: Science Isn't Truth

THE WORD "SCIENCE" comes from the Latin *scio*, "to know." So, science is *knowledge*. And as most of us older than thirty can attest, what we know isn't necessarily so. In order to begin to understand why there is so much debate about manmade global warming in the science community, you need to first accept that science doesn't provide us with truth. The practice of scientific investigation involves tools to help us explain how the physical world *might* work. The explanation doesn't have to be true to be useful, just consistent with most of the evidence.

In our technologically driven age, people want to believe that all of life's questions will eventually be answered through science. After all, our lives have been made so much healthier and more enjoyable through the inventions and discoveries that the application of scientific investigation has brought us. But there are some areas of scientific study for which it is particularly difficult, if not impossible, to get hard answers.

When science tries to explain what happened long ago, when no eyewitnesses were available to make measurements, I do not consider that to be a "hard" science. Even though paleoclimatologists try to reconstruct the climates of past centuries or millennia though proxy measurements such as tree rings, there is no way to verify how accurate those interpretations are. A very weak relationship that is found between tree rings and temperature over the last hundred years is extrapolated back 2,000 years, and the result is called "science."

Much more confidence can be placed in actual human observations. For instance, the written records of the Vikings who colonized and farmed Greenland during the Medieval Warm Period are pretty indisputable. Similarly, their gradual migration out of Greenland when colder weather ruined crops, and when icebergs began to appear and threaten safe passage of their boats, are also part of the historical record. They may not be quantifiable in terms of a precise temperature, but then neither are 1,000-year-old tree rings.

Scientific progress requires quantitative measurements that can be verified, testing of alternative hypotheses (possible explanations of how things work), and experimentation. But while science deals with observed facts or measurements, scientific debate usually does not arise over the existence of those measurements. Instead, most of the debate usually centers on differing opinions about what the measurements mean, what they are telling us about the way nature works.

And that part of science is the interesting part. Scientists like to figure out the significance of our observations, and what they are telling us about our world. Unfortunately, not all areas of scientific study are created equal; some sciences are blessed with an abundance of ways to test theories, while other sciences do not have this advantage.

While the interpretations from study of past climates might well be true, there is no way to know for sure. No matter how long and how hard science analyzes a problem, the answers might simply be unknowable. As I said, not all areas of scientific study are created equal.

In the case of global warming, we really don't know how warm the Earth is relative to past centuries, millennia, or eons. Furthermore, as I will explore in the coming chapters, even though warming is actually occurring today, science still does not have a way to reliably discriminate between manmade warming and natural warming processes. We cannot put the Earth in a laboratory and carry out experiments on it. There is only one global warming experiment, and we are all participating in it right now.

Nevertheless, for reasons ranging from economic to human survival, mankind still needs answers about future levels of warming. Science must do what it can to provide some of these answers as best it can. Scientific uncertainty will always exist, and so policy decisions will have to be made in the face of scientific doubt.

But as is often the case with fields of study that have such strong political, economic, and even religious connotations, our emotions can lead us to overstate the ability of science to provide the answers that we are so desperately seeking. People start to misuse scientific research results as an excuse to facilitate social or political changes that they wanted to see happen anyway. I guess this is just human nature, even for scientists.

THE HUMAN SCIENTIST THEORY

My wife does not agree with me on this, but I have a theory that scientists are human. Scientists have the need to believe that the research they are doing is important. They have religious, economic, and political biases and opinions—their own worldview. Scientists can get emotional and defensive when their research is challenged. That, in fact, is pretty common.

We scientists can usually be divided into two main camps—male and female. We also have a wide variety of other characteristics in common with regular humans. But in contrast to most humans, who must provide useful goods and services in their jobs in order to earn a living, the government-funded scientist's job is to spend your money. As I will explore in Chapter 6, this tends to make most scientists relatively clueless about basic economics.

Some of them then make stupid pronouncements about what should be done about this or that problem that society is presented with.

There are some subjects that are sure to cause an argument: religion, politics, war, money. Science doesn't seem like it would be one of them. But just as the subject of evolution will cause two people who normally see eye to eye to start arguing, tempers also flare when global warming is brought up in conversation. I have participated in several internet forums that have nothing to do with climate or global warming. As soon as the topic of discussion strays into global warming territory, it is almost guaranteed an argument will ensue. And just like these heated disagreements between humans, scientists also get hot under the collar on the subject of global warming. See? Even more evidence to support my human scientist theory.

But shouldn't scientific inquiry be dispassionate and objective? After all, science doesn't really care what the answer is to a scientific question; it just provides tools for us to try to find the answer. Yes, that's the way it should work, but it seldom does. So, when scientists become emotionally attached to a specific theory, you know that more than science is involved.

Like most other people, scientists don't know as much as they pretend to know. Scientists generally don't like to reveal to the public the uncertainties that are associated with their research. It might make them look less expert. Sometimes it is just too complicated to explain all of the uncertainties. Whatever the reason, claims that scientists make are usually more dramatic and confident than can be defended with the science alone.

Furthermore, since it is only a relatively few scientists who are willing to speak out publicly about global warming, these tend to be the ones that make the more dramatic claims. If they didn't, most reporters wouldn't give them the time of day. And guess which researchers have the most influence on government funding managers and members of congress?

Scientists' personal biases inevitably lead to friction and divisions in the scientific community. As a result, one scientist who researches the effects of warming on hurricanes has accused an older, more famous hurricane researcher of having "brain fossilization." Another climate scientist refused to present a talk after learning that a scientist with whom he disagreed would also be giving a talk in the same conference session. One very famous global warming scientist refused to testify in a congressional hearing when he found out that a global warming skeptic would also be testifying.

Furthermore, every scientist likes to think that the problem that he or she is working on is important to humanity. Who wants to devote their life's work to something that no one cares about?

> *Scientist:* Honey, I'm home!
>
> *Spouse:* Hi, dear. Did you discover anything exciting today?
>
> *Scientist:* Oh, yeah! I found that the tsetse fly actually does a little dance before mating! I can't wait to tell everyone at our next international conference!
>
> *Spouse:* That's nice, dear.

This leads to a tendency for scientists to exaggerate the certainty and importance of their conclusions:

> *Reporter:* So, Dr. Scientist, what are the implications of this finding about the behavior of the tsetse fly?
>
> *Scientist:* Well, by understanding what behaviors lead to mating in the fly, we hope to better understand the original human evolutionary process, how the first male and female humans ended up "getting together," as it were.

The final result is then the news story written by the reporter in the *Daily Rag*:

> *Headline:* "Mating Behavior in First Humans Revealed by Fly's Dance"

And if the behavior of flies is newsworthy, what could be more important than Saving the Earth? Even if a particular scientist's research has not been particularly Earth-shaking, they will typically allow themselves to be prodded by a reporter into overstating their conclusions. As a result, the "truth" of global warming then gets so repeated, mutually supported, and inbred between the media and the global warming pessimists that increasingly bold claims appear in the news.

It has now reached the point where you will hear claims like these: "all reputable scientists agree," "skeptics are like those who would deny the Holocaust or the dangers of smoking," or "skeptics only take their position because they are funded by Big Oil." Some climate scientists would have you believe that manmade global warming is more than just a theory—it is a fact. This is a dead giveaway that those scientists have an emotional attachment to the issue—yet another indication that they are human. While actual thermometer-measured global warming might indeed be considered an observational "fact," *manmade* global warming is far from it.

In their efforts to convince you that manmade global warming is serious, some scientists will even appeal to the public's love of animals—at least the cute ones. When a TV special or movie on global warming suggests that global warming is causing polar bears to drown, our emotions overcome our sensibilities. (I haven't heard yet whether global warming threatens slugs.) Most reporters fail to mention the fact that the total polar bear population has grown dramatically in recent decades. Even Al Gore's movie couldn't find real video of a polar bear threatened by a lack of ice—they had to create a computer animation of a poor bear swimming in an ice-free sea.

This appeal to our emotions is part of what constitutes news today, and for many issues it doesn't matter a whole lot whether the problem we choose to believe in is real or imaginary. But when it comes to a subject as important as global warming, we need to separate our emotional attachment to an idea from what we know (or don't know) based upon the science.

UNCERTAINTY IN SCIENCE

Nothing has ever been proved for sure in science. Most scientists don't even realize that science itself involves some basic assumptions (postulates) that cannot be proved, only assumed. Yet these postulates are necessary for science to progress. One is that the universe is real, and that humans are capable of discerning its real nature. Another assumption is that nature is "unified," that is, that the physics we measure here and now are the same as the physics operating at other locations and at other times. These are things we assume to be true when carrying out our science, but there is no way to prove them to be true.

A very common trap that scientists tend to fall into is forgetting all about their assumptions. In order to address any problem quantitatively, the scientist must first make simplifying assumptions. If assumptions aren't made, it is usually too difficult to analyze most physical problems. By the time the research is completed and the conclusions are finally made, though, the scientist typically forgets all about his original assumptions. This is probably the biggest single source of the scientist's overconfidence in his conclusions. It is also the first startling discovery I made as a fresh young researcher about other scientists that eventually led to my theory that scientists are human.

This is not to say that uncertain scientific research results are not valuable. While the scientific method is not strictly applicable to every kind of research, it does represent a series of steps that the researcher should take to minimize the chance that he or she will come to the wrong conclusion. Formulate a hypothesis of the way things work. Devise an experiment to test your theory. Make measurements, and analyze the data to see if they support your theory. Our methods of scientific inquiry are pretty good at improving our chances of not falling for logical fallacies or happenstance while trying to discern how nature works.

But scientific inquiry isn't foolproof. Even if the data happen to support your theory, it could be that they support someone else's theory even better. Not even scientific "laws" have been proven to be true. A physical law is simply a theory which scientists have grown tired of trying to disprove. As an example, there used to be a law in nuclear physics called the "Law of Parity" that involved the weak atomic force. It was a law, at least, until some clever researchers disproved it in 1956.

As another example, a 2005 Nobel Prize was awarded to Australians Barry Marshall and Robin Warren for their discovery of the bacterial basis for peptic ulcers. The consensus of medical opinion used to be that stomach ulcers were the result of a stressful lifestyle or too much spicy food. Marshall had the audacity to suggest at a 1983 conference in Brussels, Belgium, that ulcers might instead be caused by a bacterial infection. As Marshall recounts, this was widely considered to be "the most preposterous thing ever heard." It is not easy to overturn scientific "truths," and it took more than two decades before this startling claim led to the highest honor a researcher in any field can receive.

One of the nagging uncertainties that science always has to deal with is that of attributing causes to observed effects. This is true in all scientific fields, especially medical research. Performing science usually entails making numerical measurements of some sort, which are then analyzed for statistical relationships.

It is relatively easy to establish whether a relationship exists or not, but the difficulty comes when we try to explain why it exists. For instance, a researcher might find that, out of a study of 10,000 adult alcoholics, 97 percent of them drank milk as a child. The researcher might then hypothesize that the drinking of milk as a child leads to alcoholism later in life. But as you might suspect, there are alternative explanations as well. It could have been the cookies that were eaten with the milk.

Peptic ulcers are hardly a contentious philosophical, political, or economic issue. They are carried around by millions of people, so we know they are real, that they exist. They can be seen, through optical instrumentation, by the human eye. In contrast, manmade global warming is a mental construct. There is only one possible case of it on the Earth, and the observational evidence for it is obscured by all of the other chaos that the climate system is creating at any given time.

The best way to build confidence in a scientific theory is to test the predictions of that theory against measurements. The trouble with global warming theory is that we cannot test it in the laboratory. What we want to know is how the climate system will respond to increasing levels of greenhouse gases. There is only one experiment going on, and we cannot prove that the warming we have been experiencing has been due to those greenhouse gases or some natural change in the climate system.

The closest thing to a natural climate experiment that we have been able to measure was the 1991 eruption of the Mount Pinatubo volcano in the Philippines. The millions of tons of sulfur it spewed into the stratosphere caused a 2 percent to 4 percent reduction in solar radiation in the Northern Hemisphere. This was followed by one to two years of cooler than normal temperatures. This is viewed by some as providing a quantifiable example of how the climate might respond to more greenhouse gases. But sunlight is the source of energy for the climate system, while greenhouse gases (which we will discuss in more detail in Chapter 3) determine how energy is redistributed in the system.

Yes, there has been globally averaged warming in the last thirty years. Yes, greenhouse gas concentrations in the atmosphere have increased in the same period of time. But this does not prove that drinking milk as a child causes alcoholism later in life.

Certainly a majority of climate scientists would agree that global warming is a potential problem in the coming century. But when you hear the phrase "all reputable scientists now agree," then you can be pretty sure we're not talking about something that has in any way been "proved." Very little global warming research actually results in a conclusion that the evidence supports mankind as the cause of current global warmth, rather than some natural process. Instead, most published research on manmade global warming simply assumes that it exists—not that it doesn't exist. As a result, that research appears to "support" manmade global warming. But that is what the research was funded to study.

A widely publicized study by Naomi Oreskes in 2004 claimed that of 928 abstracts of published research articles dealing with "climate change," none were found that disputed the scientific consensus that recent global warming can be attributed to humans. Aside from the fact that I have a stack of such papers in my office, I would wager that neither did any of those 928 articles demonstrate that our current global warmth is not due to natural causes. Manmade global warming is simply assumed to be true because we have no reliable way of observationally separating natural sources of global warming from human sources.

Maybe the "fact" that the Earth has warmed can be considered to be "truth." *Why* the Earth has warmed, though, is another matter entirely. If you want possible physical explanations for what we observe in nature, go to science. If you want truth, go to church.

Next, I would like to give you a crash course, Weather & Climate 101. Don't worry, there are no tests, and I will keep it as simple as possible. Just bear with me, and by the end you will have a better appreciation for just how complex the climate system is. Then, you can judge for yourself whether science knows enough to claim that "the science is settled" on manmade global warming.

. . . now I'll pointlessly show the isobar map as usual

Chapter 3: How Weather Works

WHILE MOST BOOKS on global warming try to convince you that this or that scientific study shows evidence for or against manmade global warming, that feels too much like a contest to me. It's as if whoever can list the most published research findings supporting their side wins. But science isn't about winning debates, or taking a vote, or forming a consensus. The climate system is, or is not, sensitive to mankind's greenhouse gas emissions.

So, rather than covering an endless list of specific scientific papers and what they claim to have discovered about climate change, I instead want to equip you with a basic understanding of how weather, and thus climate, works. I want you to appreciate how complex the climate system is, how little we really know about it, and what its most fundamental purpose is: to get rid of excess heat. Finally, I will describe what I believe to be the thermostatic control mechanism that will limit the amount of climate change we will experience from human activities.

By teaching you the basics of how weather operates, I hope to make you informed enough so that you can think about the