CHAPTER 1

SCIENCE IS AN ELF

Evidence, Logic, and Falsification as the criterion for scientific decision-making. A question beginning with the interrogative “Why” is not a good scientific question. The art of structuring a question so that it can be tested. The controlled experiment

WHY BOTHER WITH SCIENCE?

This book has several goals. In the first instance it is about how scientists evaluate information and draw conclusions. Understanding this process is a requirement for modern life and it is an important aspect of every part of our lives. Thomas Jefferson is reputed to have said, “An informed citizenry is the bulwark of a democracy…” Today, to be a participant in the community of “informed citizenry,” one must be able to interpret scientific information. It is difficult if not impossible to function effectively in society without some knowledge of the scientific process.

Every day the newspaper or television brings forth a large issue of some concern to each of us, but how prepared are you, really, to evaluate the arguments that global warming is real, will affect your way of life, will threaten coastlines, is responsible for severe hurricanes? Can you truly compare moral vs scientific arguments concerning stem cells, correction of genetic defects, medical manipulation of fertility (to achieve conception or prevent it), or maintenance of life by use of machines? Should you vote to protect wetlands, to prevent future floods, to maintain a fishing industry, or to allow resting places for migratory birds? Or are wetlands simply breeders for mosquitoes and places that could be profitably developed for housing or commercial purposes? Can you participate in a meaningful discussion of the dangers of nuclear reactors, or the merits or disadvantages of genetically engineered foods? On a more personal level, can you evaluate different potential diets, or interpret an advertisement for a medication? Can you read and understand the information inserts in medicine?

Ultimately, each of these discussions, and many more, depend on highly technical details that are not readily presented to the non-scientist. On the other hand, all scientists are expected to present their data in a manner that a layman can understand. Much scientific research is supported by your tax dollars through government-sponsored research programs. Each proposal for research is presented to a scientific
board for evaluation, but the proposal typically also contains a summary that is 
expected to be meaningful to a congressman or congresswoman who will vote 
on the subsidy for the overall program, and meaningful to interested citizens who 
would like to know how their money is spent. That means you.

The goal of the scientist in this abstract is not to teach a lay audience the highly 
technical details of a complex proposal but to make the goals, limitations, and 
potential of the proposed research clear enough that you will understand the purpose 
and agree that it is a good idea and has the potential of producing knowledge of 
interest and value to you. Thus the first goal of this book and this course is to 
prepare you for this role as a citizen. What we hope to achieve is to give you a 

EVOLUTION

We have chosen the approach of illustrating the scientific method through the study 
of evolution. We have chosen evolution for several reasons. First and foremost, 
evolution is the most important idea of the 19th Century and the most influential of 
the 20th Century. (Scientists almost never speak in absolutes, and almost inevitably 
qualify or restrict any statement that they make. I was therefore tempted to state, 
“evolution is arguably the most important idea…” but in this case there seems to 
be little reason to deny these claims.) Second, unlike, for instance, astrophysics or 
molecular biology, one needs relatively little technical background or familiarity 
with very abstruse and abstract topics to understand what is going on. For these 
reasons the topic seemed a logical choice.

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Evolution, like astrophysics, lacks one essential of laboratory science, the ability to 
readily design and carry out experiments. It is possible to make predictions, which 
are in a sense thought experiments, and in some instances it is possible to design 
and conduct experiments, and we will address these issues as best we can. In all 
other senses, evolution is in every way a full science and illustrates the logic and 
construction of scientific thinking. That is, it depends fully on three elements that 
I define as an “ELF” principle: Evidence, Logic, and Falsification. A scientific 
idea must be based on evidence, whether obtained by observation or experiment. 
The evidence suggests a link between two phenomena. A scientist will attempt to 
understand the link by establishing that one phenomenon causes another, or in other 
words he or she will form a hypothesis of cause and result. For instance, every 
year as spring approaches the sun gets higher in the sky and the days get longer. 
This is the evidence—both the length of the day and the mean temperature—that 
we can observe and measure. A reasonable hypothesis would be that the increased 
sunlight warmed the earth, rather than that the warming of the earth caused the