CHAPTER 1: WHY SCIENCE MATTERS

In our complicated world, our lives depend on many, many events and decisions outside of our immediate control as well as many within our control. Science as a way of making rational, evidence-based decisions about the natural world offers the best method we have of ensuring those decisions achieve what we want.

Section 1

Society's Responsibilities

Modern society is full of potential hazards. For many of those hazards we need public policies that protect us.

Virtually everything we do to better ourselves has a downside. Industries that make goods cause pollution, whether it be a copper smelter releasing toxic gasses or runoff from a corn field contaminating ground water with pesticides and fertilizer. Consider the innumerable issues we face in our society:

food additives and processed food

medical practices and drugs

agricultural practices: pesticides, fertilizers, genetically modified organisms

pollution: chemical, radioactivity

environmental hazards of consumer products (freon, electromagnetic fields, lead in gasoline)

product safety (autos, electrical appliances, infant seats)

transportation safety

Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

bakery products. We invite your comments and questions.

N85038.0B_MP CHOCOLATE CHIP MINI MUFFINS

INGREDIENTS: SUGAR, ENRICHED BLEACHED WHEAT FLOUR [FLOUR, MALTED BARLEY FLOUR, REDUCED IRON, "B" VITAMINS (NIACIN, THIAMINE MONONITRATE (B1), RIBOFLAVIN (B2), FOLIC ACID)], WHOLE EGGS, CANOLA OIL, WATER, CHOCOLATE LIQUOR, CORN SYRUP, EGG WHITES, COCOA BUTTER, SOY LECITHIN. CONTAINS 2% OR LESS OF: MODIFIED CORN STARCH, MONO AND DIGLYCERIDES, WHEY, SODIUM STEAROYL LACTYLATE, LEAVENINGS (BAKING SODA, SODIUM ALUMINUM PHOSPHATE, ALUMINUM SULFATE), SOYBEAN OIL, SALT, WHEAT GLUTEN, POLYSORBATE 60, GLUCOSE, NATURAL AND ARTIFICIAL FLAVOR, NONFAT MILK SOLIDS, XANTHAN GUM, CALCIUM ACETATE, DEXTROSE, GUAR GUM, CITRIC ACID, SORBIC ACID (TO RETAIN FRESHNESS)
517501
CONTAINS WHEAT, EGG, MILK AND SOY.
MAY CONTAIN WALNUTS
239124F_MP

This list barely scratches the surface of the issues that affect us, and indeed, it only gives broad categories of possible hazards.

Many hazards can only be controlled at the level of society: as individuals, we cannot prevent farmers from using pesticides and fertilizer, prevent other consumers from releasing freon, from using leaded gasoline, etc. Nor is it a good idea to wait to address problems after the fact – when public health has suffered – if we can anticipate and thereby prevent them. We thus expect our government to protect us and to make decisions accordingly.

Our government does make those decisions. From an environmental perspective, we have banned or otherwise curtailed use of DDT, of (some types of) freon, of leaded gasoline, and of some second-hand exposures to tobacco smoke. Yet we continue to use many other things that are potentially harmful: carbon emissions are not taxed or regulated despite evidence of their contribution to global climate change, many other pesticides are still in use, and many aquifers and grasslands vital to the national interest are being exploited beyond their capacity to recharge. Likewise, most attempts by industry to market new drugs are prevented by the government because the drug is deemed harmful.


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People Believe Weird Things

Our perceptions cannot be trusted.

In our society, there is a disconnect between how we expect our government to behave regarding decisions (and how it does behave) relative to how individuals behave. There is a stunning, large fraction of U.S. citizens who say they believe in some aspect of the "paranormal" and other scientifically unfounded ideas.

CONCEPT	% CLAIMING TO BELIEVE IT
Astrology	52%
ESP	46%
Witches	19%
Aliens have landed	22%
Atlantis	33%
Dinosaurs with humans	41%
Communication with dead	42%
Had a psychic experience	67%
Ghosts	35%

(based on a 1991 poll of 1,236 Americans; Gallup, G.H. Jr, and F. Newport. 1991. Skeptical inquirer 15:137-147). Likewise, even many of us in this class at least suspect there is some validity to several of these ideas (our first-day survey).

Belief in magic, aliens, and recent dinosaurs is undoubtedly harmless in most cases and can even be entertaining – people rarely carry such beliefs to extremes that might harm themselves, and believing in astrology can take some of the dullness out of life, just as most of us read the fortune in our fortune cookie. There could be many social repercussions when a large fraction of a population does not know how to decide what is real -- wholesale criminal convictions of innocent people, failures to make medical and technical advances, failures to make other improvements in the standard of living, a decay in education systems, and much more. To a large extent, however, we do not expect the government to follow such beliefs.

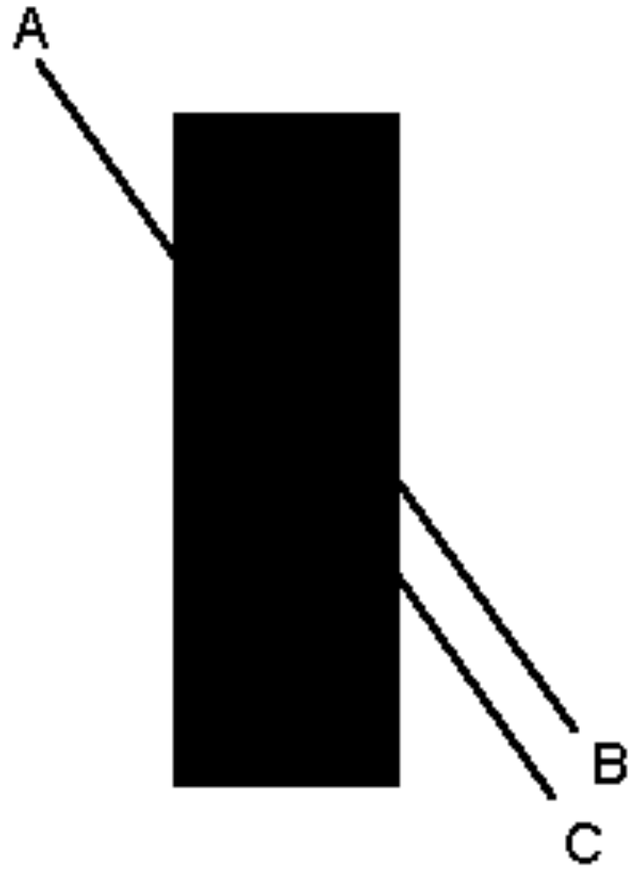
Our Brains are Inherently Flawed

It is perhaps not our fault that we don't automatically know how to interpret Nature. There has been a moderate flood of books recently on the many fallacies of our brains:

TITLE	AUTHOR
Predictably Irrational	Dan Ariely
Thinking Fast and Slow	Daniel Kahneman
The Folly of Fools	Robert Trivers
The Myth of Repressed Memory	Elizabeth Loftus

These books offer many examples of fallacies in our thinking, most of which we are not aware of when we commit them. Some of the examples are stunning if not frightening: judges exhibiting a profoundly higher rate of granting paroles immediately after lunch, and advertisers exploiting our subconscious tendencies to be swayed in predictable directions by the choices offered – merely adding an unattractive choice can drive us to prefer the more expensive options. Loftus has researched for years the fallibilities of our memories, especially its impact on eyewitness testimony. Trivers argues that our brains have in fact been evolved to deceive us, rather than convey an unbiased perception of our world.

One of the easiest and most convincing demonstrations of the hard-wired imperfections of our brains is optical illusions. The figure below is easily displayed on a black and white page. The straight line appears to be AB but is really AC. Magic tricks often rely on illusions of sorts. Lecture will offer others.



Understanding Nature

is not about being clever, it is about evidence.

To an outsider, this point is perhaps counter-intuitive, yet it defines the essence of the scientific method. Humans have a long history of failing to explain or predict Nature from first principles. The central pillar of science is that we need to observe Nature to know Nature – we need to look at the evidence. In mathematics, it is possible to prove result: a proof begins with a set of assumptions that defines the rules, and from those it becomes possible to define strict outcomes. In the real world, we never know the rules that bound a problem. So we make up approximate rules, work out the consequences and see if Nature fits. And it never fits perfectly, only approximately. When Nature actually does appear to fit, however, it does not mean that the rules are true or complete. At best it means that the rules are approximately true for that circumstance, but when we move to a new problem, the set of rules may be somewhat different. Science is like a patchwork quilt of evidence and the stories we have built to explain that evidence.

Thus with respect to science, it does not actually matter that our brains are flawed. Our perceptions could be accurate, and understanding Nature would still not be automatic. Our logic could be perfect and that would not be enough. We would still need a methodology for comparing our guesses and ideas to the evidence and then deciding whether an imperfect match between them is close enough.

Decisions Involve More Than Just Evidence

All of us exhibit a range of beliefs – how strongly we accept something differs from one subject to another and from person to person. Our individual beliefs typically depend on a combination of factors, including but not limited to the following

1. the evidence – what you know about the issue
2. compatibility with your world view
3. reliability of the source
4. consequences of accepting/doubting

As these factors will usually vary from person to person, we can easily understand how two people will differ in their belief on any topic. Furthermore, it may often be appropriate that personal decisions be influenced by a variety of factors. Yet when the chosen option needs to be the one that lies closest to the natural truth, we want to go with the evidence – the one supported by science.

SECTION 6

What follows in this book

This book is about a method that empowers people and institutions achieve their specific goals. This method is widely known as the scientific method, though this term is a misnomer. Not only do scientists solve problems using this method, but it is also the mainstay of improvement in business and industry, and it provides a unique perspective on social institutions. Our goal in this class is to teach you how to use the scientific method and apply it to everyday health and social issues both for personal matters and to be informed about decisions made by our government. If your career is one in which you will be called on to solve problems, whether in business, law, or government, this style of thinking should be helpful in those areas as well.

However, because of this goal, the class emphasizes critical thinking rather than memorization of facts. In teaching you to tackle novel situations, we will teach you to analyze arguments and descriptions of new findings. For example, you will be given short news articles and asked to interpret the articles and to identify whether the research has certain features. So if your goal in taking a nonmajors biology class is to obtain an encyclopedic knowledge of biological facts, this class is not for you. But if you want to know how to identify weaknesses of a study or how to identify potential science frauds and cons, then this class should serve that purpose. Below, we list a few more examples of the ways that this class might help you as a nonscientist to think about everyday problems.

EXAMPLE	ISSUE
Being tested for illegal drugs	Do you know what testing practices best ensure your civil rights against erroneous test results?
A new study claiming that modest alcohol consumption improves longevity	Could you tell whether this study indicates that you should drink alcohol?
A 3-year study showing that 1 of every 200 university students caries HIV (the AIDS virus)	What does this number indicate about the chance that your partner is infected?
A juror being asked to decide the guilt of a rape suspect based on DNA evidence	How might the prosecution and defense each present a biased appraisal of the evidence?