CHAPTER 3

WHAT IS PSEUDOSCIENCE?

Metaphysical claims involving things like the "Law of Attraction" (Byrne, 2006), astrology, or homeopathy all share at least two features, both of which were identified as a problem in Chapter 2: it's very easy to find evidence for those claims, and any claims made can typically not be falsified. The broad set of fields for which this holds true are often collected under the terms *pseudoscience* or *junk science*.

Pseudoscientific claims make predictions or offer explanations, just as scientific claims do, and so can be difficult to distinguish from "proper" scientific claims. Where they differ is in the scaffolding for the claims made: Pseudoscientific theories fail to offer a robust set of underlying laws, or even hypotheses, that can be empirically shown to justify the predictions or explanations generated by those theories. Pseudoscience is often taken seriously, and thought to correspond to reality, for quite mundane reasons—our gullibility and will to believe. Consider astrology, which claims that the zodiac sign under which you are born influences your personality and can even help to foretell your future.

A psychologist named Bertram Forer showed how easy it is to tap into the human frailties of wanting to believe and gullibility in a landmark experiment some 70 years ago. Forer administered a personality test to his undergraduate students in one class period and promised to give them personalized feedback during the next class. But rather than giving them individual assessments, he copied a few descriptive sentences from a newspaper astrology column and gave all the students the exact same "profile" (Forer, 1949, p. 120), reproduced as follows:

> You have a great need for other people to like and admire you. You have a tendency to be critical of yourself. You have a great deal of unused capacity which you have not turned to your advantage. While you have some personality weaknesses, you are generally able to compensate for them. Your sexual adjustment has presented problems for you. Disciplined and self-controlled outside, you tend to be worrisome and insecure inside. At times you have serious doubts as to whether you have made the right decision or done

> the right thing. You prefer a certain amount of change and variety and become dissatisfied when hemmed in by restrictions and limitations. You pride yourself as an independent thinker and do not accept others' statements without satisfactory proof. You have found it unwise to be too frank in revealing yourself to others. At times you are extroverted, affable, sociable, while at other times you are introverted, wary, reserved. Some of your aspirations tend to be pretty unrealistic. Security is one of your major goals in life.

When the students were asked to evaluate the accuracy of the character traits identified in their horoscope on a scale of 0 (least accurate) to 5 (most accurate), an average result of 4.26 was obtained. This result has proved to be replicable across various cultures and hundreds of repetitions in other classrooms since Forer ran the experiment. The average score remains at around 4.2 across these different contexts (Dickson & Kelly, 1985). What the Forer effect (also sometimes referred to as the Barnum effect, after the circus showman P. T. Barnum) shows is that we tend to accept highly generalized descriptions of this sort as accurate. We take notice of, and overvalue, apparently confirming instances of apparently plausible hypotheses, and discount or ignore evidence that runs contrary to what we're invested in believing.

WHY IS THIS A PROBLEM?

Although some versions of pseudoscience, mysticism, and general quackery are fairly constant insults to our sensibilities (as we will see in Chapter 11, some forms of alternative medicine have been around for hundreds of years), others, such as those magic holographic bracelets that promise you increased balance and strength, seem to go in and out of fashion like pop stars and children's toys. Although it is not always clear that these fashions cause direct harm to our health, they often cause at least two sorts of indirect harm. The first sort of harm occurs through quackery taking the place of effective medical interventions, thereby allowing people to suffer needlessly. Sometimes, people even die, as was the case with 9-month-old Gloria Sam, an Australian infant whose (treatable) eczema became chronic and—through infection—deadly after her homeopath father chose to "treat" her with water instead of medicine (Associated Press, 2009).

The second sort of harm is to our wallets, in that mystical interventions always come at a price. Sometimes you might consider investments worthwhile even if they are for things that are not directly tangible or to your benefit—the 10% that some religious folk tithe to their churches does at least support various forms of communal activity, regardless of the truth or falsity of the religious beliefs. It's perhaps true that the gullible don't always deserve protection from their poor judgment—if it comforts you to build an

airport for aliens, as the town council of Arès in France did in 1976 (*Daily Telegraph*, 2010), the ensuing merriment for the rest of us could well be worth the cost, assuming the money should not instead have been spent on basic sanitation or other needs.

But not everyone has money to waste on such follies. For every person with more dollars than sense, there will be plenty who might instead believe that some mass-marketed trinket can bring them increased health, wealth, or happiness, and who then proceed to allocate resources they cannot afford to purchasing those trinkets. Instead of choosing to take (expensive) medication, those suffering from bursitis or arthritis could choose to buy a Power Balance bracelet at a relatively cheap price (of roughly \$30)—a one-off expense instead of a lifetime of medication.[1]

The claims made on behalf of these bracelets are absurd, and create a clear (yet misleading) impression that it's more than simply a placebo effect at work in referring to "Eastern philosophies [that] contain ideas related to energy. These are commonly referenced as Chi or Chakras. There are a number of well known practices like acupuncture, meditation and Feng Shui, which are believed to affect these energies" (Power Balance, n.d.-a).

Power Balance—similarly to all manufacturers of such products—does cover its legal bases while making vague concessions to the fact that they know they are simply selling a more modern form of snake oil—this time in colorful silicone form. In answer to the question "How do I know it is working?" for example, they say, "Wear the product throughout your day, whether exercising or not. While we have received testimonials and responses from around the world about how Power Balance has helped people of all ages and physical abilities, there is no assurance it can work for everyone" (Power Balance, n.d.-b). Given the short memories people seem to have of these sorts of exploitation, this strategy should work for long enough to make a fair amount of money. They surely know, for example, that the manufacturers of the Q-Ray bracelet in the United States lost a class-action suit in 2006, and that the judge forced them to pay back \$22.5 million of their "ill-gotten gains" (Federal Trade Commission, 2008). And that Power Balance in Australia was required to publish "corrective advertising" and refund all customers who asked for their money back (Australian Competition and Consumer Commission, 2010).

But our memories are short indeed, and we also often fail to do our homework when something new and apparently wonderful comes along. We forget, or never learned, that the demonstration a Power Balance salesperson will perform for a prospective buyer is a simple variant of what is

[1] Well, perhaps once-off: some of these magical bracelets, even the "quantum" sort, apparently need occasional recharging to replenish their powers.

known as "applied kinesiology," (Schwartz et al., 2014) frequently used by stage magicians to produce entirely subjective perceptions of increased strength and balance. We allow ourselves to forget—in the hope of finding some magic bullet for health and happiness—that we have no evidence for the existence of an "energy field" in humans that can be affected by negative ions or biofeedback (see Chapter 12 for more on that topic). We allow ourselves to ignore the fact that we don't know whether holograms can be "imprinted" with frequencies, how this might be done, and, if it can be done, on what principles the manufacturers choose the frequencies or amount of mysticism to cram into their bracelets. Most of all, we allow ourselves to forget that if you think about it for a moment, all of these possibilities seem vanishingly unlikely to be an accurate description of what's going on.

If you take a look at the "research" described on the web pages of the manufacturers of these products, you'll quickly notice that none of them conform to the commonly understood gold standard for scientific research, namely, the double-blind controlled trial (discussed in detail in Chapter 11). Instead, they consist of strings of meaningless technobabble and fancy words like "quantum," along with user testimonials. But user testimonials are no more than anecdotes, and no matter how many anecdotes you might accumulate, they do not add up to scientific data.

The increased wealth of these snake-oil peddlers comes at a broader cost than simply offering false hope to a few, and the waste of money that buying these bracelets entails. They contribute to us not doing our homework, and perhaps becoming more gullible and more ignorant. They tap into the absurd deference we afford to celebrities and their product endorsements, regardless of the fact that many of these celebrities have no relevant expertise (and that they often seem no more successful for wearing magic bracelets themselves).

This general "climate of unreason" is a dangerous thing in itself, regardless of the triviality of any particular *instance* of unreason. Power Balance, T4ProBalance, Quantum Leap, and all the other variants of these pyritic placebos can assist in raising our tolerance for quackery in general, and quackery comes in forms far more dangerous than a hologram. It was quack science that led to years of HIV/AIDS denialism in countries like South Africa, and quack science that supported, and still supports, conspiracy theories about vaccines causing autism (Harris, 2010).

It would be foolish to make any claims for a causal link between our tolerating relatively benign forms of pseudoscience and the more dangerous ones described previously. But it is in environments where we refrain from being critical of nonsense that people develop misguided ideas, and it is therefore not implausible to suggest that we should take care to foster a more critical environment, even in cases like these, by applying scientific modes of thought and inquiry. This can help us to distinguish between

pseudoscience and real science, regardless of the varying degrees of pseudo in some "science."[2]

THE DEMARCATION PROBLEM

Finding the boundary or differentiating criteria between science and pseudoscience is known as the demarcation problem, and, as is often the case in the philosophy of science, this problem has proven to be a thorny issue, with no clear consensus emerging despite years of debate. As Lakatos (1980, p. 1) reminds us, strength of conviction is no help at all:

> But the history of thought shows us that many people were totally committed to absurd beliefs. If the strengths of beliefs were a hallmark of knowledge, we should have to rank some tales about demons, angels, devils, and of heaven and hell as knowledge. Scientists, on the other hand, are very skeptical even of their best theories. Newton's is the most powerful theory science has yet produced, but Newton himself never believed that bodies attract each other at a distance. So no degree of commitment to beliefs makes them knowledge. Indeed, the hallmark of scientific behavior is a certain skepticism even towards one's most cherished theories. Blind commitment to a theory is not an intellectual virtue: it is an intellectual crime.

Despite the demarcation problem, a common-sense definition of pseudoscience is perhaps fairly easy to agree on—it's in the detail, especially in terms of what sciences fall into which category, that disagreements are likely to arise. A starting point for a definition would, we propose, look something like this:

> Any claim, hypothesis, or theory that is presented in the language and manner typical of scientific claims, but that fails to conform to accepted standards in science regarding openness to peer review, replicability, transparent methodology, and the potential for falsifiability is highly likely to be a pseudoscientific claim, hypothesis, or theory.

To put it another way, we are making the point that the *absence* of the hallmarks of good science, as described in Chapter 2, are a clear warning sign for the presence of pseudoscience. With pseudoscientific claims, anecdotes might be allowed to trump evidence, or confirmation (rather than falsification) might be given undue weight. Most important, perhaps,

[2] Much of the discussion here regarding Power Balance bracelets previously appeared in my (JR) column in the Daily Maverick of January 27, 2011.

the communal nature of the scientific endeavor is perverted—instead of making data, findings, and methodology open for all to scrutinize and attempt to replicate, pseudoscientific claims tend to rely on fringe data, published by fringe scientists, in low-quality journals, thereby creating an impression of scientific controversy where none actually exists. At the conclusion of Chapter 2, we presented a flowchart of science, showing, ideally, how it works. Figure 3.1 shows the analogous flowchart for pseudoscience.

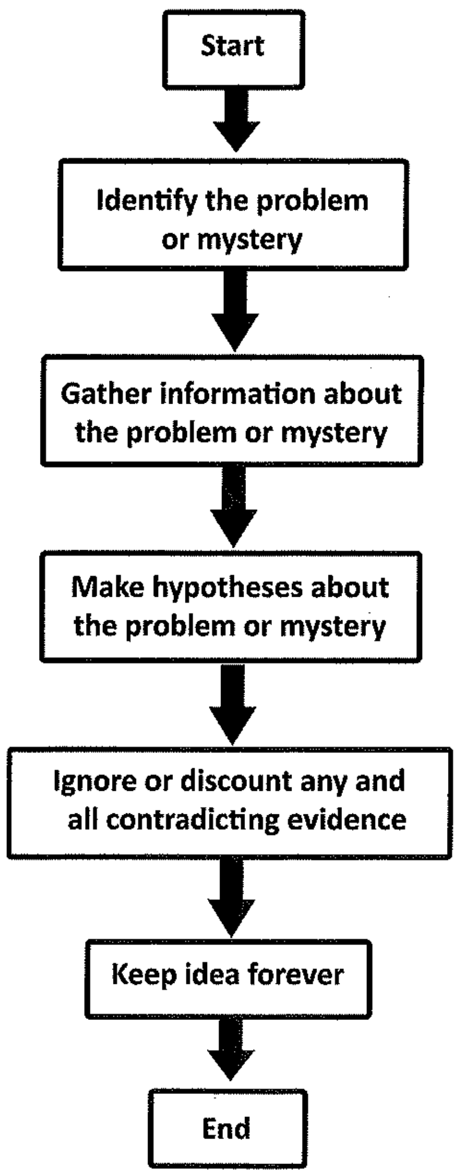

FIGURE 3.1 Pseudoscience flowchart.

Although slightly tongue-in-cheek, this flowchart shows how pseudoscience lacks the deductive, replicative, and corrective mechanisms that make science such a powerful explanatory force for finding out how the world works. In the real world, making the distinction between science and a pseudoscience can involve a difficult, and sometimes subjective, judgment. But even though it can be difficult, it's a judgment we should attempt to make whenever possible, as certain fields—perhaps particularly health care—are very prone to abuse by quack science, and real harms can result from public misunderstanding of the proper scientific method (Sagan, 1996).

Two final confounds need to be addressed before we take a closer look at some strategies for how to navigate (even if not completely resolve) the demarcation problem. First, it's not reliably the case that pseudoscientists or quacks are *intending* to deceive. In fact, a large number, maybe even the majority, might be utterly sincere rather than simply attempting to make some easy money off our gullibility. So as much as we might decry the *effects* of pseudoscience in terms of the harms it can do to people's wallets or, more worryingly, their health, we should remember to separate the issue of the scientific errors from our analysis of moral culpability and guilt. Although we might be able to be sure that the quack is wrong, we can't always be sure that he *knows* this, and intends to deceive. This would of course not make him right—but in one sense, it might make him (slightly) less wrong.

Second, there's a difference between pseudoscience or quackery and science simply done badly, or communicated incompetently. Take addiction as an example: Since 2007 or so numerous articles in the popular media have asserted that sugar is "addictive," that rats prefer it to cocaine, and so forth. The claim has been repeated so often that many people now uncritically accept it as true that sugar is in fact "addictive" (Kirkpatrick, 2013) rather than simply something we like the taste of, sometimes eat too much of, yet are able to stop eating too much of with a little more self-discipline (just like, say, watching TV or playing video games).

We'll look at this example in greater detail in Chapter 6, but for now, consider a recent newspaper article warning of the "hidden sugar in sauces" (Koen, 2015). For the sake of the example, just imagine we are agreed (a) that added sugar is something that should be consumed in moderation, if at all and (b) that accurate food labeling is a good thing, in that we want to know what we are eating. Even so, some things make for illegitimate comparison. Noting that a particular chili sauce contains four times the amount of sugar per 100 grams than a tin of Coca-Cola is profoundly misleading, thanks to the fact that a typical portion of the sauce might be something like 20 milliliters whereas a typical portion of the soda would be at least 10 times that amount, and usually more than 20 times that amount.

This is not an example of pseudoscience in the sense that something mystical is being measured, or weird and wonderful effects are alleged to result from some particular intervention. It is nevertheless misleading, and troubling as a result, but mostly as an index of a media and society that are attuned to taking scare stories more seriously than they should.

TIPS FOR IDENTIFYING PSEUDOSCIENCE

There are no hard-and-fast rules for distinguishing science from pseudoscience. In fact, one key problem in this regard is that pseudoscience trades exactly on these ambiguities and difficulties. Because many of us aren't comfortable with uncertainty, pseudoscience has a certain allure in presenting unambiguous "truths" or guidance to an audience. But as we argued in Chapter 2, the world of empirical data is messy, and the language of certainty will typically involve at least some misrepresentation of a more complex picture. But although assessing whether science is credible or not does involve a certain amount of subjective judgment—and making these judgments is a skill that can be exercised and refined—there are some rules of thumb that we hope you will find useful. The features highlighted next tend to be associated with pseudoscience more often than they are associated with good science, and that allows us to treat them as warning signs for claims that we are justifiably suspicious of.

Sensationalism and Oversimplification

Your first and most general clue involves encountering research that is presented in a sensationalistic or overly simplistic sort of way. You'll often encounter this right in the headline, where it might appear that a complex scientific story is being summarized in the form of "clickbait"—in other words, phrased in such a way that you're more likely to read it, whether or not it's accurate. "Shocking findings reveal that your shampoo is giving you cancer!" would be the sort of thing to watch out for, in that even if you know nothing about the study in question, you do know enough about the scientific method that (at the very least) you'd expect to read that your shampoo *might be* giving you cancer. Even this more modest claim is probably false, but at least the headline builds in some acknowledgment of the probabilistic nature of inductive reasoning, as well as the possibility of later falsification.

To return briefly to the earlier "sugar addiction" conversation: It merits highlighting here that even though our previous treatment of the topic presented it as poor communication of scientific activity rather than as pseudoscience, it does present a good example of how those boundaries can easily blur. If you, as a health care practitioner, present as axiomatic the claim that sugar is *known* to be toxic and/or addictive, and base your treatments

on that "knowledge," it would certainly be reasonable to wonder whether misrepresenting the scientific consensus to such an extent that charges of making pseudoscientific (rather than merely exaggerated) claims might be a reasonable accusation.

Press Releases, Jargon, and "Churnalism"

Beware of "scientific" language or excessive jargon. We've recently seen a large upturn in the use of what has been described as "neurobabble" (or "neurobollocks"), which refers to the trend of presenting any human activity as being describable in terms of the brain and fMRI data (Poole, 2012). Although brain science holds enormous potential for answering some very important questions around things like addiction, it also allows us to escape personal responsibility—we might be encouraged to start thinking, "It wasn't me, it was my brain!" (Satel & Lilienfeld, 2013).

In an effort to sound impressive, press releases will often bombard readers with technical jargon because it instantly creates the impression that some smart people have done some very important work that you're unlikely to ever understand, so you basically just have to trust them. But this isn't true for two reasons. First, because there are most often nontechnical ways to describe the same thing—in fact, this is a hallmark of good popular science communicators. Second, because even if you don't understand various technical details, there are still common elements to the scientific process (e.g., best practice in study design) that you *can* understand and use to establish whether you should be inclined to trust the research in question or not.

Another element of oversimplification is found in the fact that science journalists can be guilty of taking a press release and repurposing it (or simply republishing it) without ever reading the actual study in question, which can result in a very incomplete and misleading picture being communicated to the public. This practice is (unfortunately) common enough that it even has a name: "churnalism." As a result of this journalistic laziness, websites have emerged—but sadly, mostly failed to survive—dedicated to helping you discover instances where instead of writing original copy, journalists simply tell you what a public relations company hoped they would tell you.

As Robbins (2011) has persuasively argued, there are two clear objections to churnalism. First, it undermines editorial integrity in that readers assume they are reading objective journalism, but are instead simply reading an entirely uncritical—in fact, partisan—summary of a study or series of events. Second, churnalism threatens the livelihood and value of paid journalists, whether in science or elsewhere. We value good journalism precisely because we trust that someone has done the research and can offer us

insight into whether to trust research findings or not. The work isn't easy, and can require a level of expertise that laypeople typically lack. This expertise could be lost unless we can encourage writers to enter the field and excel at it—and this would in turn be impossible unless we remunerate such writers fairly.

Of course, it might be too late to think this battle can be won—science editors are a dying breed in newspaper offices, never mind science journalists, so the lesson is perhaps simply, and unfortunately, that science reporting in the popular news media is quite often anything but scientific. Even more worrying, this practice is not limited to journalists being irresponsible—a recent paper in the *BMJ* argued that a full 40% of press releases already contain exaggerated advice, meaning that what the journalists are regurgitating is a source that was already fairly unreliable (Sumner et al., 2014). So, whenever you can, read the original study rather than the press-release version of it.

Conflicts of Interest

There are some situations in which we are well aware that someone might be trying to make a fool of us or exploit our trust for financial or other gain. Think of the prototypical used-car salesman, for instance. The exploitation doesn't need to be particularly strong or overt for this to be the case, and it's not even consistently malicious. A salesperson might not be trying to sell us a *bad* or *defective* product, but nevertheless, she might be trying to sell us one particular product rather than another for the sake of a higher commission. The same reasoning can easily apply in scientific research: When a scientist is quoted or otherwise seen to be endorsing a particular drug or line of inquiry, it might be the case that he is employed by the company marketing that drug, or might have some other incentive to see it succeed, such as stock options or nepotistic connections. These sorts of relations don't *necessarily* corrupt or invalidate research, but they are worthy of concern in that they might do so, and are certainly factors that need to be considered when weighing any endorsement.

As ever, the judgment call regarding when to consider research compromised is not an easy one—and our own biases can get in the way of making a sound judgment. For example, when a scientist is employed by an advocacy group for a cause we support—hypothetically, let's say the World Wildlife Fund, with research involving the protection of some rare species—it should still be the case that we consider whether there is a conflict of interest, and therefore, whether the research in question is potentially compromised (Kiem, 2007). In a shift from even 15 years ago, most scientific journals today require the authors of articles they publish to list potential conflicts of interest and funding sources in order to increase the transparency of this issue.

Anecdotal Evidence

Anecdotal evidence consists largely of entirely uncontrolled observations, such as a person or group of people reporting that something happened to them, and others have no way of establishing the truth of their claim. This is not to say that they are lying, because lying is only one way of being wrong—they might simply be mistaken, perhaps fooled by their brains (see Chapter 5) or their world (see Chapter 6). For example, I (JR) might report that I experience greater levels of energy and alertness when consuming a particular herbal remedy, which I assiduously add to my morning tea. But that "data" is of little use unless we are sure that I'm not *also* sleeping better, or exercising more, or eating more healthily. This is why scientific studies explicitly control for these other variables, in order to give us greater confidence that it is the herbal remedy, rather than other factors, that are giving us the result we're observing.

Small and/or Unrepresentative Sample Sizes

The issue of sample size is related to the problems with anecdotal evidence, in that even if a study is controlled for known variables of the sort described previously, without testing that herbal remedy on a sufficiently large number of subjects, we can't know whether the (small) group we did test it on happen to share a common characteristic we didn't think of, and therefore didn't control for. A large sample size increases randomness, and therefore introduces such a diverse range of secondary factors (diet, sleeping habits, unanticipated factors, and so forth) that we can achieve a higher level of confidence that our observation regarding the remedy's efficacy will be less likely to be the result of chance, and more likely to point to some genuine causal relationship.

A familiar and useful analogy is that of elections. We value a high voter turnout because if 50% of potential voters actually vote and express a 70% confidence in the leadership of Sarah Jones, we have a far stronger indication of the community in general supporting her than if only 10% of voters express a view. The larger voting population is also unlikely to be homogenous, and this is the value of trying to ensure a *representative* sample. Even if a sample is large, the quality of evidence is impaired if the participants are all similar in some crucial way (and we might not know, in advance, what is and isn't crucial). Voters in a general election should not all come from the same economic class, for example, because people with similar class interests may well be more sympathetic to one political platform over another—better schools for their children might be a greater concern than crime if the voters tend to live in relatively crime-free areas.

Cherry-Picking

As we pointed out in Chapter 2, many areas of scientific inquiry involve debate and controversy. Despite this, it's frequently the case that strong results emerge in favor of one conclusion or another, and if you only look at studies that support one side of an argument, it's easy to get the impression that a consensus exists, and that "all the evidence" supports a particular point of view. This is the problem of "cherry-picking," and pseudoscience is rife with it. As Novella (2014) points out, it's even possible to find a glimmer of support for homeopathy (one of the most implausible of the alternative medicines; see Chapter 11) if you look hard enough, or if you interpret a study charitably enough.

But a glimmer of support, no matter how tenuous, doesn't resolve the debate, because it's the *totality* of evidence that should inform our attitudes and conclusions. A cherry-picker interprets the totality of evidence to be something closer to "the studies that happen to support my point of view"—and with that attitude, it should come as no surprise to us to find that they believe the evidence to be on their side.

No Control Group, No Blind Testing

Control groups are a standard feature in clinical trials examining whether a particular treatment helps a particular problem, because they allow us to eliminate many chance findings, or the possible effects of variables we didn't foresee in planning our study. Let's imagine that you want to test a new headache tablet—you already know it's safe (for the sake of argument), but you're not quite sure whether it *works*. To test the efficacy of this pill, it would certainly be helpful to give it to a (large and representative) group of people—but to make your findings even more reliable, it would be better to give a randomly selected group of people a different pill that looks and tastes just like the drug you're wanting to test but is chemically inert (in other words, a *placebo*). If you find that the control group benefits as much (or more!) than the group getting the "real" drug, you know that your drug doesn't do what you think it does.

In performing this test, it's important that people don't know whether they are receiving the real drug or the placebo, because that knowledge might in itself have an effect on how they respond. If you know you're getting the real drug, you might persuade yourself that your symptoms aren't as bad as they were a half hour ago and report that the drug is working. And if you're getting the placebo, you might perhaps think things are worse than they are, and report an excruciating pain. You'll notice that in both cases, you'd be reporting an anecdote, and a particularly unreliable one, because

you've been *primed* to think in a certain way, based on knowing which group you're in.

It's even better if the researchers *themselves* don't know whether you are in the control group or not, because the ways in which they relate to you on the basis of that knowledge, might also have an effect on how you respond to the treatment or the placebo. When you don't know which group you're in, the experiment involves *blind* testing, and if neither you nor those who are directly involved in running the experiment know which group you're in, the experiment is being conducted under *double-blind* conditions (in Chapter 10 we will go over clinical trials and testing the effectiveness of treatments in greater detail).

THE LIMITS OF SCIENCE

It's perhaps easy to see the attraction of some pseudoscientific claims. Our own anecdotes are psychologically meaningful (to us), and the world of real science has difficult stories to tell, often resulting in no conclusive answer (yet). By contrast, pseudoscience allows room for those personal narratives to have meaning, and even explanatory power. If you don't like the sounds of what "scientists" are saying, or see some sort of conspiracy in what they say, you'll usually be able to find an alternative point of view that's more satisfying, even if it violates various principles of sound scientific reasoning.

But there's a conflict between our desire to have conclusive answers and what the scientific method is capable of. Science is less about final—or ultimate—answers, than about a way of evaluating claims and gathering the evidence that informs those claims. Science also cannot draw conclusions about things that fall outside of the empirical realm— things that we cannot measure or manipulate experimentally. This inability is not to be taken as proof one way or the other on any of these claims, but simply makes the point that at any given time there will be various claims that fall outside of the scientific realm. In time, as we discover more about the world around us, some or all of those claims might fall inside the net of things that can be scientifically investigated.

The point is that science is not omniscient, nor is it infallible. Science is conducted by human beings, who are known to be prone to making mistakes or misinterpreting information. But even so, it's simply the best method we have for understanding the universe, particularly given the error-correction mechanisms that are integral to it. To quote Albert Einstein: "One thing I have learned in a long life: that all our science, measured against reality, is primitive and childlike—and yet it is the most precious thing we have."

CONCLUSIONS

To some extent, anyone can be a scientist. This doesn't mean you that have to put on a white coat and perform formal experiments in a laboratory, but rather that anyone can understand the basics of what the scientific method looks like, as well as what the warning signs of pseudoscience look like. As long as we remember that a shortage of knowledge or information is never an excuse to simply make things up, or to dogmatically believe what you would prefer to be true regardless of the evidence that does exist, and instead test your ideas in a controlled way that helps to reduce bias, you are thinking like a scientist. You are employing, critical thinking, which is the focus of our next chapter.

QUESTIONS FOR REFLECTION

1. *Health care plans in some countries, including the United States, cover the costs of consulting with pseudoscientific practitioners such as professional homeopaths or chiropractors. Is this appropriate, given that payments in collective schemes like these affect everyone's contributions?*
2. *Imagine being presented with a belt that is said to create healing vibrations that ease lower back pain. How would you go about testing it to see whether it's a scam?*
3. *Should anecdotes ever be taken seriously in scientific inquiry? When do you think they could add value?*
4. *Quack science is fairly common—many newspapers carry astrology columns, for example, and you can often see people on television who claim to be psychics. Do you think publishers and broadcasters have a moral obligation to avoid publicizing quackery?*
5. *Do you agree with the idea that humans in general seem to dislike uncertainty and ambiguity? Why do you think this is the case?*

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