Difficult things take a long time; the impossible takes a little longer.

—CHAIM WEIZMANN

they can't be explained by the current theory. At first, as in the case of meteorites, the scientific community tries to dismiss or explain away these phenomena. But if no satisfactory account of them is forthcoming, the scientific community is forced to abandon the old paradigm and adopt a new one. In such a case, the scientific community is said to have undergone a *paradigm shift.*

There have been many paradigm shifts in the past. Galileo's discovery of the moons of Jupiter and the phases of Venus led to a shift from a geocentric (Earth-centered) view of the solar system to a heliocentric (sun-centered) one. Darwin's discovery of the strange creatures of the Galápagos Islands led to the shift from creationism to evolution. The failure to detect the "luminiferous ether" (the medium in which light waves were supposed to travel) led to a shift from Newtonian physics to Einsteinian physics. Similarly, say the true believers, paranormal phenomena may lead to another paradigm shift. The resulting worldview may be as different from ours as ours is from the aborigines'. We may have to give up many of our most cherished beliefs about the nature of reality and knowledge. But it's happened before, and, they claim, there's no reason to think it won't happen again. As Shakespeare so eloquently put it, "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy."

So whom are we to believe? Should we follow the scientist who dismisses paranormal phenomena on the grounds that they contradict fundamental physical principles or the true believer who sees paranormal phenomena as a harbinger of a new age? To evaluate the relative merits of these positions, we'll have to take a closer look at the notions of possibility, plausibility, and reality.

LOGICAL POSSIBILITY VERSUS PHYSICAL IMPOSSIBILITY

One can't believe impossible things.

—ALICE, IN *THROUGH THE LOOKING GLASS*

Although it's fashionable to claim that anything is possible, such a claim is mistaken, for there are some things that can't possibly be false, and others that can't possibly be true. The former—such as "2 + 2 = 4," "All bachelors are unmarried," and "Red is a color"—are called *necessary truths,* because there are no situations in which they would be false. The latter—such as "2 + 2 = 5," "All bachelors are married," and "Red is not a color" are called *necessary falsehoods* because there are no situations in which they would be true.[4] The Greek philosopher Aristotle (Plato's pupil) was the first to systematize our knowledge of necessary truths. The most fundamental of them—the ones upon which all other truths rest—are often called the *laws of thought.* They are:

The law of noncontradiction: Nothing can both have a property and lack it at the same time.

The law of identity: Everything is identical to itself.

The law of excluded middle: For any particular property, everything either has it or lacks it.

These principles are called the laws of thought because without them thought—as well as communication—would be impossible. In order to think or communicate, our thoughts and sentences must have a specific content; they must be about one thing rather than another. If the law of noncontradiction didn't hold, there would be no way to distinguish one thought or sentence from another. Whatever was true of one would be true of the other. Every claim would be equally true (and false). Thus, those who deny the law of noncontradiction can't claim that their position is superior to that of those who accept that law.

One of the most effective techniques of refuting a position is known as *reductio ad absurdum:* reduction to absurdity. If you can show that a position has absurd consequences, you've provided a powerful reason for rejecting it. The consequences of denying the law of noncontradiction are about as absurd as they get. Any position that makes thought and communication theoretically impossible is, to say the least, suspect. Aristotle, in Book IV of the *Metaphysics,* put the point this way:

> If all are alike both wrong and right, one who is in this condition will not be able either to speak or to say anything intelligible; for he says at the same time both "yes" and "no." And if he makes no judgment but "thinks" and "does not think," indifferently, what difference will there be between him and a vegetable?[5]

What difference indeed. Without the law of noncontradiction, we can't believe things to be one way rather than another. But if we can't believe things to be one way rather than another, we can't think at all.

Why, sometimes before breakfast I've believed as many as six impossible things.
—THE WHITE QUEEN, IN *THROUGH THE LOOKING GLASS*

Logic is the study of correct thinking. As a result, the laws of thought are often referred to as the laws of logic. Anything that violates these laws is said to be *logically impossible,* and whatever is logically impossible can't exist. We know, for example, that there are no round squares, no married bachelors, and no largest number because such things violate the law of noncontradiction—they attribute both a property and its negation to a thing and are thus *self-contradictory.* The laws of thought, then, not only determine the bounds of the rational; they also determine the bounds of the real. Whatever is real must obey the law of noncontradiction. That is why the great German logician Gottlob Frege called logic "the study of the laws of the laws of science." The laws of science must obey the laws of logic. Thus, von Däniken is mistaken. Some things are logically impossible, and whatever is logically impossible cannot exist.

Aristotle on Demonstrating the Laws of Thought

Since the laws of thought are the basis for all logical proofs, they can't be proven by means of a logical demonstration. But, says Aristotle, they can nevertheless be demonstrated negatively:

> There are some who, as we said, both themselves assert that it is possible for the same thing to be and not to be, and say that people can judge this to be the case. And among others many writers about nature use this language. But we have now posited that it is impossible for anything at the same time to be and not to be, and by this means have shown that this is the most indisputable of all principles. Some indeed demand that even this shall be demonstrated, but this they do through want of education, for not to know of what things one should demand demonstration, and of what one should not, argues want of education. For it is impossible that there should be demonstration of absolutely everything (there would be an infinite regress, so that there would still be no demonstration); but if there are things of which one should not demand demonstration, these persons could not say what principle they maintain to be more self-evident than the present one.
>
> We can, however, demonstrate negatively even that this view is impossible. . . . The starting point for all such proofs is that our opponent shall say something which is *significant* both for himself and for another; for this is necessary, if he really is to say anything. For, if he means nothing, such a man will not be capable of reasoning, either with himself or with another. But if any one says something that is significant, demonstration will be possible; for we shall already have something definite. The person responsible for the proof, however, is not he who demonstrates but he who listens; for while disowning reason he listens to reason. And again he who admits this has admitted that something is true apart from demonstration.[6]

In other words, the law of noncontradiction can't be demonstrated to someone who won't say something definite, for demonstration requires that our words mean one thing rather than another. On the other hand, the law of noncontradiction need not be demonstrated to someone who will say something definite, for in saying something definite he or she has already assumed its truth.

Rothman claims that ESP is impossible. Now if he means that ESP is logically impossible, then, provided he's right, we can dismiss it out of hand, for in that case, it can't exist. But ESP isn't logically impossible. The notions of reading another's mind, viewing distant objects, and even knowing the future are not self-contradictory in the way that married bachelors or round squares are. Neither are such paranormal phenomena as alien abduction, out-of-body experiences, or communicating with the dead. What, if anything, these phenomena violate are not the laws of logic, but the laws of physics or, more generally, the laws of science. If they violate those laws, they're *physically impossible.*

We have to live today by what truth we can get today, and be ready tomorrow to call it falsehood.
—William James

Science attempts to understand the world by identifying the laws that govern it. These laws tell us how various physical properties are related to one another. For example, Newton's second law of motion,

$f = ma$, tells us that the force of a projectile is equal to its mass times its acceleration. Einstein's law, $E = mc^2$, tells us that the energy of an object is equal to its mass times the velocity of light squared. Knowing these laws not only helps us understand why things happen as they do, but also allows us to predict and control what happens. Newton's laws of motion, for example, allow us to predict the positions of the planets and control the trajectory of missiles.

Anything that's inconsistent with the laws of nature is physically impossible. A cow jumping over the moon, for example, is physically impossible because such a feat would violate the laws governing cow physiology and gravity. The muscles of a cow simply cannot produce enough force to accelerate the cow to the speed required to escape the Earth's gravity. But a cow jumping over the moon is not logically impossible. There is no contradiction involved in the notion of a moon-jumping cow. Similarly, there is no contradiction involved in the notion of a bunny that lays multicolored eggs. So physical possibility is a more limited notion than logical possibility; whatever is physically possible is logically possible, but not everything that's logically possible is physically possible.

There is yet another type of possibility that is useful to know about: *technological possibility*. Something is technologically impossible if it is (currently) beyond our capabilities to accomplish. Manned intergalactic space travel, for example, is technologically impossible because we do not currently have the capability of storing enough food and energy to travel to another galaxy. It's not physically impossible, however, because making such a trip does not involve breaking any laws of nature. We simply lack the technology to perform such a feat.

What makes a thing weird or a claim extraordinary is that it seems to be impossible. Time travel, psychokinesis, and ancient astronauts, for example, are weird things—and the claims that they exist, extraordinary—because they seem to run afoul of one or more of the types of possibility discussed above.

Time travel seems to be logically impossible because it implies that an event both did and did not happen. Suppose you travel back in time to a place you've never been before. History records that you were not present at that place and time, but now you are. You cannot both be and not be at a place and time, however. So time travel seems to violate the law of noncontradiction. That is why sophisticated time travel tales, like Michael Crichton's *Timeline,* have their travelers go to parallel universes rather than their own. Science writer Martin Gardner explains. "The basic idea is as simple as it is fantastic. Persons can travel to any point in the future of their universe, with no complications, but the moment they enter the past, the universe splits into two parallel

The Impossibility of Magic

Magicians regularly appear to do things that violate natural laws. They don't actually violate them, of course, but they create the illusion of violating them. Most magicians admit that what they're doing is sleight of hand. There are those, however, who maintain that what they're doing is real; that they're performing supernatural feats. One such is Uri Geller. In the 1970s, as a result of national TV appearances, he convinced millions of Americans that he could bend metal and fix broken watches with his mind. He would take a key or a spoon, for example, and without any apparent use of physical force, bend it. On numerous shows he invited viewers at home to take a stopped watch and place it on their TV set. Through an intense act of will, he claimed he would make them work again. Remarkably, many of them did start working again. Jewelers claimed, however, that the repair had less to do with Geller's psychic ability than with the fact that many watches stop working because their lubricating oil becomes too thick. Putting a watch on a hot TV set thins the oil and thus frees the frozen gears.

A story is told of one young woman who was convinced of Geller's powers. It appears that she got pregnant while watching Uri Geller on television. The woman was using an IUD (intrauterine device) for birth control at the time. She claimed that her IUD failed because Uri Geller's mind energy unwound its coils. Needless to say, she did not receive any compensation from Geller.

Geller's metal-bending feats have been duplicated by many magicians. That doesn't prove that he can't bend metal with his mind, but if that's what he's doing, he's doing it the hard way. Even trained observers can be taken in by magicians' sleight of hand. This is why paranormal investigators such as the Amazing Randi and Martin Gardner suggest that magicians be present when investigating purveyors of the paranormal. Because magicians know even better than scientists how we can be misled by misdirection, they are in a better position to evaluate the veracity of such claims.

worlds, each with its own time track. Along one track rolls the world as if no looping had occurred. Along the other track spins the newly created universe, its history permanently altered."[7] If the universe splits when you travel backward in time, there will be no contradiction because in neither universe will something both be and not be the case.

Psychokinesis, the ability to move external objects with the power of one's mind, seems to be physically impossible because it seems to imply the existence of an unknown force. Science has identified only two forces whose effects can be felt over long distances: electromagnetism and gravity. The brain, however, is not capable of producing enough of either of these forces to directly affect objects outside of the body. So psychokinesis seems to violate the laws of science.

The notion that we have been visited by ancient astronauts or aliens from outer space seems technologically impossible because the amount of energy needed to travel to the stars is astronomical. Marc Mills, project manager for NASA's Breakthrough Propulsion Physics Project, has calculated the fuel requirements for interstellar travel

using various types of propulsion systems, and invariably they seem beyond our reach. For example, suppose we wanted to deliver a Space Shuttle sized payload to our nearest star in 900 years. If we used conventional (chemical) rocket fuel, the amount of fuel needed would be greater than the mass of the entire universe. If we used fission to power our rocket ship (fission is the process that creates atomic bombs), we would need a billion supertanker sized propellant tanks.[8] If we used fusion (fusion is the process that creates hydrogen bombs and powers the sun), we would need a thousand such tanks. If we used anti-matter (the most efficient energy source known), we would still need ten railway car sized propellant tanks.[8] And these are just the requirements for a one-way trip. They would have to be doubled for a return journey, and multiplied many times over if we wanted to make the trip in less time. Interstellar travel, then, looks to be beyond our technological capabilities for many years to come, if not forever.

I have learned to use the word "impossible" with the greatest caution.

—Werner von Braun

Contrary to what von Däniken would have us believe, it is possible to apply the word *impossible* to things. Some things are logically impossible, others are physically impossible, and still others are technologically impossible. And as Krauss's example of interstellar travel shows, even if something is physically possible, it doesn't necessarily follow that it will ever become actual. The principle that should guide our thinking in these matters, then, is this:

Just because something is logically or physically possible doesn't mean that it is, or ever will be, actual.

If logical or physical possibility were grounds for eventual actuality, we could look forward to a world containing moon-jumping cows or egg-laying bunnies. To determine whether something is actual, we have to examine the evidence in its favor.

There are those, however, who measure the credibility of a claim not in terms of the evidence for it, but in terms of the lack of evidence against it. They argue that since there is no evidence refuting their position, it must be true. Although such arguments have great psychological appeal, they are logically fallacious. Their conclusions don't follow from their premises because a lack of evidence is no evidence at all. Arguments of this type are said to commit the fallacy of *appeal to ignorance.* Here are some examples:

No one has shown that Jones was lying. Therefore he must be telling the truth.
No one has shown that there are no ghosts. Therefore they must exist.
No one has shown that ESP is impossible. Therefore it must be possible.

All a lack of evidence shows is our own ignorance; it doesn't provide a reason for believing anything.

If a lack of evidence against a claim actually constituted evidence for it, all sorts of weird claims would be well founded. For example, the existence of mermaids, unicorns, and centaurs—not to mention Bigfoot, the Loch Ness monster, and the abominable snowman—would be beyond question. Unfortunately, substantiating a claim is not that easy. The principle here is this:

> **Just because a claim hasn't been conclusively refuted doesn't mean that it's true.**

A claim's truth is established by the amount of evidence in its favor, not by the lack of evidence against it.

You could claim that anything's real if the only basis for believing in it is that nobody's proved it doesn't exist.
—J. K. ROWLING

In addition, the strategy of placing the burden of proof on the nonbeliever is unfair in so far as it asks him to do the impossible, namely, prove a universal negative. A universal negative is a claim to the effect that nothing of a certain sort exists. Suppose it's claimed that there are no white ravens. In support of this claim, suppose it's pointed out that no one has ever reported seeing a white raven. From this it doesn't follow that there are no white ravens, for no one may have looked in the right place. Or if somebody saw one, it may not have been reported. To prove a universal negative, you would have to be able to exhaustively investigate all of time and space. Since none of us can do that, it's unreasonable to demand it of anyone. Whenever someone proposes something novel—whether it be a policy, a fact, or a theory—the burden of proof is on her to provide reasons for accepting it.

It's not only true believers who commit the fallacy of appeal to ignorance, however. Skeptics often argue like this: No one has proven that ESP exists; therefore it doesn't. Again, this is fallacious reasoning; it's an attempt to get something for nothing. The operative principle here is the converse of the one cited above:

> **Just because a claim hasn't been conclusively proven doesn't mean that it's false.**

Even if no one has yet found a proof of ESP, we can't conclude that none ever will be found. Someone could find one tomorrow. So even if there is no good evidence for ESP, we can't claim that it doesn't exist. We can claim, however, that there is no compelling reason for thinking that it does exist.

Certainly nothing is unnatural that is not physically impossible.
—RICHARD BRINSLEY SHERIDAN

THE POSSIBILITY OF ESP

What about Rothman's claim that ESP is physically impossible? Is it? If so, is investigating it really worth our while? Let's tackle the second