Chapter 13

CONTENTIOUS QUESTIONS: THE SHADOWY
BORDERLANDS OF SCIENCE

“Then the one called Raltariki is really a demon?” asked Tak.
“Yes—and no,” said Yama. “If by ‘demon’ you mean a malefic, supernatural creature, possessed of great powers, life span, and the ability to temporarily assume virtually any shape—then the answer is no. This is the generally accepted definition, but it is untrue in one respect.”
“Oh? And what may that be?”
“It is not a supernatural creature.”
“But it is all those other things?”
“Yes.”
“Then I fail to see what difference it makes whether it be supernatural or not—so long as it is malefic, possesses great powers and life span and has the ability to change its shape at will.”
“Ah, but it makes a great deal of difference, you see. It is the difference between the unknown and the unknowable, between science and fantasy—it is a matter of essence.”
(from Lord of Light by Roger Zelazny)

SOMETIMES, results are reported that lie far outside the scientific mainstream. These unorthodox results are rejected by most, but not all, scientists. Although cases like this are occasionally labeled as pseudoscience in order to attack their validity, I believe this label is wrong. As we have seen (chapter 12), the defining characteristics of pseudoscience concern the methods of thinking, not the unlikelihood of the content. Pseudoscience seems an inappropriate description of cases where all parties agree on the validity of basic scientific methodology, even if there is heated disagreement over whether it’s being applied properly. Another label that has been applied to the subject matter of this chapter is “pathological science.” Once again, some less emotional term might be a better choice. But rather than quibbling over terminology, let’s look at some cases in detail. Of the many subjects that might be discussed in this chapter, I have chosen two: cold fusion and parapsychology.
§1. Cold Fusion

Nuclear Fusion

The word “fusion” in this context refers to a process in which lighter atomic nuclei combine together (fuse) to form heavier nuclei, releasing energy. Some of the mass of the nuclei is converted into energy during the fusion process. Fusion is the process that drives energy production in the sun and other stars, so fusion is ultimately responsible for almost all of our energy on earth. Fusion is also the energy source in the hydrogen bomb, a terrifying weapon of mass destruction. The name “hydrogen bomb” refers to the fact that hydrogen nuclei fuse together into helium nuclei. (To be more precise, nuclei of the isotope of hydrogen known as deuterium are the nuclei that fuse. A hydrogen nucleus is a single proton, while a deuterium nucleus has both a proton and a neutron.) For many years, scientists and policymakers have been hoping that fusion can someday be used as a new source of energy for our society. The required fuel is abundant (deuterium replaces hydrogen in a certain fraction of the water naturally occurring on earth; such water is called heavy water), and the radioactive waste products are few, making fusion a highly desirable energy source.

Before recounting the cold fusion story, which is fairly recent, let’s look at the efforts to harness fusion energy by standard techniques; these efforts, which have been going on for over forty years, provide the context for our story. Fusion occurs naturally in the sun because the sun is very hot. At the fantastically high temperatures found in the sun, the nuclei and electrons of atoms are separated, forming what is known as a plasma. The nuclei are positive and the electrons are negative, so the plasma is a kind of charged particle gas. The charged particles making up the plasma in the sun have extremely high energies and speeds because of the high temperatures. These high energies and speeds enable the colliding nuclei to get close enough to each other to fuse, overcoming the mutual repulsions caused by their charges (which ordinarily keep them apart, preventing fusion). Along with the extreme temperatures needed, the density of the plasma must also be high enough to yield significant numbers of collisions. If the density can be kept high enough after the fusion reaction has started, this reaction will be self-sustaining because the energy released by the fusion process will keep the temperature high. The sun’s own gravity keeps the density high enough in the sun. In a hydrogen bomb, the density doesn’t need to remain high very long, because the explosion lasts only a short time (the needed high temperature is provided by an atomic bomb explosion as a trigger). The challenge to the plasma physicists has been to create a plasma with a steady high temperature and sufficient
density so that a controlled self-sustaining fusion reaction can be main-
tained on earth. If this can be done, we might be able to use nuclear fusion
to satisfy the world’s need for energy.

The problem with creating these conditions may already be apparent
to you. At temperatures like those in the sun, any container in which we
tried to keep the plasma would be immediately vaporized. The solution
to this problem has been to use the fact that the plasma particles are
charged; because they are charged, they can be trapped using magnetic
fields instead of material containers. In other words, the plasma can be
confined within a magnetic bottle. This method gave rise to a multitude
of difficult technical problems, many of which have now been solved.
We’ve made steady progress toward attaining the combination of temper-
ature, density and duration that will yield a self-sustaining energy-produc-
ing reaction. But many years and many billions of dollars have been in-
vested to reach the present state of progress. Although we have learned a
lot about the physics of plasmas and have achieved many milestones to-
ward practical fusion energy production, we are at best several decades
and many more billions of dollars away from this elusive goal. But the
effort continues because the fuel for this energy is cheap, relatively non-
polluting, and virtually limitless.

Claims of Fusion at Room Temperature

Such was the background for the dramatic announcement (in 1989) that
two electrochemists (M. Fleischmann and B. S. Pons) had achieved nu-
clear fusion at room temperature, using equipment no more complicated
than a standard electrochemical cell (which is little more than two pieces
of metal, called electrodes, sitting in some liquid, called electrolyte, and
connected to a battery). Fusion occurring at room temperature in an elec-
trochemical cell was quickly dubbed “cold fusion.” One of the electrodes
was made of the metal palladium and the electrolyte contained some
heavy water, that is, the hydrogen isotope deuterium was present. Pallad-
ium metal is well known to be capable of absorbing large amounts of
hydrogen (or in this case, deuterium), the way a sponge absorbs water.
The idea of cold fusion is that, under the conditions of the electrochemical
reaction taking place in the cell, the amount of deuterium in the palladium
electrode becomes so great that the nuclei become close enough to un-
dergo fusion. It’s difficult to understand how or why this should happen.
But, according to proponents, experimental evidence indicated that cold
fusion was in fact happening. In particular, large amounts of heat were
measured, which the chemical reactions in the cell couldn’t account for.

The results were announced at a press conference before being pub-
lished in any scientific journal, and the media gave the story a great deal
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of coverage. Cold fusion was presented as a solution to all of our energy problems (which a cheap and simple way to achieve fusion would indeed be). The experiments were also presented as a revolutionary scientific breakthrough, since the new results seemed to contradict a great deal of well-established science. There was also a human-interest side to the story: the triumph of lonely innovators working on a shoestring budget, where teams of experts with vast resources had failed. What the media did not emphasize was how little documented evidence for cold fusion really existed. Following the original announcement, several research groups quickly started working to test the cold fusion claims. The situation was initially very chaotic and confused. Different groups made conflicting claims of positive and negative results, sometimes followed by retractions. This confusion was probably the result of too much haste and carelessness, brought on by the excitement of the extraordinary claims and their societal implications. As time went on and the results of more careful and well-controlled experiments became available, few research groups found any evidence for cold fusion in the end. The few experiments that did find such evidence were inconsistent and not reproducible. Let’s examine this scientific evidence in more detail.

Experimental Evidence

What sort of measurements would indicate that nuclear fusion was taking place? One measurement, which was widely emphasized, is excess heat in the electrochemical cell, indicating that energy is being produced. In addition, the fusion process results in a number of measurable radiations (gamma rays and neutrons) and substances (helium isotopes and tritium). Measurement of these fusion products would indicate that fusion is taking place. The amounts of these fusion products, relative to each other and to the amount of heat produced, can be predicted. This is a crucial point, because the experiments should not only find the fusion products but should find them in the correct amounts. Let’s take a closer look at this issue, because much of the argument over the validity of cold fusion turns on this point. Figure 7 is a schematic illustration of the three ways in which deuterium can undergo fusion. Protons are indicated by plus signs (+) because they have a positive charge, and neutrons by empty circles because they have no charge. Deuterium is represented by a proton and neutron together, the helium nucleus by two protons and two neutrons, the lighter isotope of helium by two protons and one neutron, and tritium (another isotope of hydrogen) by one proton and two neutrons. In all of these reactions, fusion of deuterium occurs in a way that conserves charge. From many years of experiment and from well-understood theory, we know that the first two reactions are about equally probable, while the
Figure 7. Three possibilities for the nuclear fusion of two deuterium nuclei (deuterium, or heavy hydrogen, is an isotope of hydrogen with one additional neutron). (a) Two deuteriums fusing to produce a helium isotope and a neutron. (b) Two deuteriums fusing to produce tritium and a proton (tritium is another hydrogen isotope, with two additional neutrons). (c) Two deuteriums fusing to produce helium and a gamma ray. This reaction occurs very infrequently compared to the other two.

third reaction is about a million times less probable than the other two. We also know how fast these reactions must proceed in order to produce a given amount of energy (the alleged source of heat in cold fusion).

How do the results of cold fusion experiments compare to these reactions? Results were mixed. Some experiments detected no fusion products (neutrons, helium, etc.) at all, while other experiments detected small quantities of one product or another. Critics have questioned whether those small quantities were really fusion products, as opposed to detector artifacts or naturally occurring contaminants (in other words, phony data). Leaving such questions aside, however, the amounts of the fusion products were far too small to account for the heat that was measured. Also, the amounts were not consistent with the probabilities of the various fusion reactions shown in Figure 7. To make a crude analogy, it’s as if someone told you about going on a 2000-mile trip, showed you gasoline receipts consistent with driving 2000 miles, but had an odometer reading
increase of only 5 miles on the car. In the case of cold fusion, the inconsistency is dramatic. Some of the people doing the experiments would have received massive lethal doses of radiation to account for the heat, instead of the barely detectable amounts of radiation they reported.

Experiments are always difficult to do. Sophisticated equipment can easily produce readings that are wrongly interpreted; this is why scientists criticize each other’s work and try to reproduce experiments. In this case, detecting neutrons is difficult for two reasons: There are always some neutrons around anyway (called background), and detectors sometimes say that the number of neutrons has increased when it hasn’t (called drift). Even measuring excess heat isn’t as easy as it sounds. Temperature differences across the cell, if they are not measured properly, can make the amount of produced heat look bigger than it really is. Experiments that account for such possible spurious results are better experiments. We say that such experiments are well-controlled experiments, or that they have better controls. The experiments in cold fusion that had the best controls detected no fusion products and little or no excess heat.

**Evaluation**

Claims for the observation of cold fusion were based on a considerable amount of excess heat and a minute amount of fusion products. Two mysteries therefore needed to be explained. The first mystery is how fusion can occur at all under the conditions of the electrochemical cell (i.e., how do the nuclei get close enough together?). The second mystery is why there are not enough fusion products to account for the heat produced. Several theorists attempted to explain these two mysteries, but the proposed explanations all suffered from the same problem: they were all ad hoc explanations. An ad hoc explanation is an explanation that is not based on anything, an explanation where you just make it up as you go along and use any assumptions needed to achieve the result you want. No coherent theory that really explains the results has ever been proposed to account for cold fusion. A highly developed and interconnected set of theories and experiments, on the other hand, has evolved over fifty years to give us a coherent picture in which cold fusion is not possible.

But, you may object, experiment should be the ultimate authority here; theories must change if experiments contradict them. This is true. But consider the quality of the experimental evidence. None of the experiments claiming evidence for cold fusion have been reproducible. The most carefully done experiments have seen no indications of fusion at all. Even experiments done by proponents of cold fusion have results that conflict with each other in their details. In addition, the experiments are known to be difficult to perform properly, and known to produce phony results.
sometimes looking much like those obtained by the cold fusion proponents. Is this kind of evidence sufficient to spark a major scientific revolution? The answer to this question is, in the end, a judgment (see chapter 14). The judgment of the mainstream scientific community has been clear: cold fusion does not exist. Few scientists are even paying attention to the question anymore, regarding it as a closed issue. A very small number of scientists consider cold fusion to be real, and they are still working in the area. If these scientists could ever make a convincing case, the mainstream judgment would change. Alternatively, the number of cold fusion proponents may dwindle over the years until it reaches zero some day, and the issue will then die.

§2. Parapsychology

Parapsychology is the study of various extraordinary abilities ascribed to the human mind. Examples of such paranormal abilities are these: acquiring information without using the senses (extrasensory perception, or ESP); causing something to move without any physical mechanism (psychokinesis); and knowing in advance that some unpredictable event will happen (precognition). Many people (scientists and nonscientists alike) vehemently deny the very existence of all these things and believe that parapsychology is bogus and pseudoscientific. The proponents of parapsychology, on the other hand, believe there is good evidence for the existence of such paranormal abilities. We’ll take a look at some of this evidence and discuss how it might be interpreted. We’ll also reconsider the question of how to judge whether a field is scientific or not: Should our criteria be based on the methods used or on the subject matter studied?

Historical Context

Folk beliefs about paranormal human abilities are found in almost all cultures and are usually rooted in an irrational worldview. These common folk beliefs are a kind of “prehistory” for parapsychology, but they have little to do with our present discussion. The involvement of scientists in paranormal studies began in England, near the end of the nineteenth century. A quasi-religious movement known as Spiritualism had become prominent (in both the United States and England) at that time. The main activity of Spiritualists was (allegedly) communicating with the spirits of the dead, but this activity was usually accompanied by strange sounds and lights, furniture moving on its own, and other weird things. Much of that display, not surprisingly, turned out to be trickery and fraud. But
a number of scientists became interested in these seemingly paranormal phenomena, and they began to engage in a scientific study of Spiritualism. The Society for Psychical Research was founded to provide an organized forum for such studies (a similar American Society was founded shortly afterward). Several prominent scientists and scholars participated in this work. A good deal of their effort was devoted to unmasking fraud, but a number of cases were judged by the scientists to involve genuine effects. These cases were investigated, but in the end it was too difficult to exert proper scientific controls. Interest in this kind of study gradually faded over a number of years.

Parapsychology in its modern form began in the 1930s at Duke University, under the direction of J. B. Rhine and L. E. Rhine (even the word “parapsychology” comes from this source). A new research method was developed. Instead of looking at the spectacular claims of prominent Spiritualists, the Rhines looked for evidence of weak paranormal abilities in average people. In a typical experiment, a subject might look at a random series of images on cards, while a second subject (who can’t see the cards) tries to identify which card is being viewed. If this second person can identify the correct card image more often than expected based on random chance guessing, the result is interpreted as evidence for paranormal abilities. A major innovation of this method was the central role given to statistical arguments. Considerable work has been done using such methods, initially at the Duke laboratory and later at several other institutions. Early work was criticized for having insufficient controls (e.g., people might identify cards by seeing smudges on the backs or torn corners). In response to this criticism, experimental designs were improved. Statistical methods were also criticized and, as a result, improved. A professional association was founded, and several journals were established to publish the results of these studies. These same research methods (i.e., looking for small paranormal effects using statistical techniques) are still prominent in present-day parapsychology. Several innovations have been added during the last several decades, such as the increasing use of automated data collection (which is intended to avoid bias and fraud).

So far, I have only been relating the history of the practitioners of parapsychology research. Part of the history of parapsychology, however, is the criticism its practitioners receive from people outside the field. During every phase of the historical sketch I’ve outlined, critics have said: “These alleged paranormal abilities simply don’t exist. Parapsychology doesn’t have any subject matter that is real. The results that have been published can all be accounted for by either fraud or careless experimental design.” Such charges have been made against the work of each generation of parapsychologists throughout the history of the field.
Reasons for the Controversy

I think the major reason that parapsychology is so severely criticized can be stated very simply: The existence of the paranormal abilities that parapsychologists study is contradicted by the many well-established results of the natural sciences. In other words, the mainstream sciences (physics, chemistry, and biology) look for and find lawful regularities and identifiable causal mechanisms in the workings of the world. In the understanding that these sciences have achieved, there is no way for human minds to affect the world (or other minds) directly, without the use of muscles; or for human minds to gain information from the world (or other minds) directly, without the use of the senses. In the words of one critic, science is a “seamless web,” and we can’t simply graft the paranormal onto it without disrupting the entire structure. Since this seamless web of interrelated ideas and results is so well confirmed (by countless experiments and observations made by many thousands of scientists over hundreds of years), then we may dismiss the results of parapsychology without further consideration.

Why is this reasoning not compelling to the advocates of parapsychology? There are at least three replies that advocates make to such reasoning. First: Science grows and develops by learning new things and incorporating these new things into a broader understanding; this might eventually happen with paranormal phenomena, even if we can’t see how it could happen at the moment. After all, revolutionary changes have occurred before in the history of science. Second: The empirical evidence that paranormal phenomena exist is overwhelming. In the face of empirical observations supporting the phenomena, we can’t simply deny the existence of the paranormal because it doesn’t fit our current understanding. Third: The results of parapsychology may not actually contradict our current scientific understanding, because certain aspects of quantum physics appear to be consistent with it, for example, nonmaterial information transfer. Needless to say, critics of parapsychology are not convinced by any of these replies. A relationship between quantum physics and psi (“psi” is a general term coined to describe paranormal phenomena and the causes thereof) is highly speculative at best. Any role for quantum physics in explaining psi would be even more controversial than the existence of psi (the very thing it’s supposed to justify). Regarding a revolution in scientific thinking to accommodate psi, critics point out that such revolutions only happen when there is a pressing need. In other words, revolutions occur when so many anomalies have accumulated that we can no longer use current scientific ideas productively. If the empirical evidence
for psi were indeed overwhelming, then we would be forced to undergo a revolutionary change in our thinking. But the evidence for psi is only meager and weak.

Evidence

You can see that the key question now has become this: How strong, really, is the empirical evidence for the existence of psi? The advocates and critics of parapsychology answer this question in exactly opposite ways. We can’t even attempt a complete and detailed review of the parapsychology literature. The number of published studies is very large, and each study would require a critical evaluation. For many studies, a secondary literature of criticism and rebuttal already exists, and we’d also have to look at that. Instead, I’ll just describe a few of the studies that parapsychologists consider exemplary. My main interest isn’t in settling the issue (even if that were possible); my main interest is in showing how to think about scientific evidence.

The early work with guessing-card images provides several illustrative examples. In Rhine’s laboratory during the 1930s, a series of tests were run with J.G. Pratt and H. Pearce. There is little question of subtle sensory clues in this case because the two people were in different buildings (using synchronized watches to time the guesses with the card choices). The cards had five different images (a standard technique in such work), so guessing at random would presumably result in correct guesses for about 20% of the attempts. A lot of data was collected (1850 attempts), and Pearce guessed right on about 30% of these attempts. A later card-guessing series from Rhine’s laboratory involved a subject named W. Delmore. Using ordinary playing cards (i.e., 52 images instead of 5), the experimenter placed each card in an opaque envelope and showed the envelope to Delmore, who tried to guess which card was in it. Once again the number of attempts was large (2392). In this case, we would expect correct guesses at random in about 2% of the attempts. Delmore guessed correctly about 6% of the time. The probability of the results observed in these two experiments is vanishingly small. However, it’s almost impossible to rule out trickery completely in experiments of this type. Because of the problems with card guessing (e.g., the danger of sleight-of-hand being used), more recent work has often employed an electronic random-event generator. This device is often based on the radioactive disintegration of atoms as its source of random events. In practice, the device might have four possible states that it can choose among randomly, and then indicate its state to the subject by turning on lights. The subject tries to predict which state the device will choose (precognition) or to influence
this choice (psychokinesis). The subject registers the prediction by pressing a button; the device records the prediction of the subject automatically, and keeps a running total. Random-event generators are able to acquire large amounts of data quickly and easily, and make cheating difficult. In general, the effects that have been observed using these devices have been small; but because the number of trials has been so large, the results have been statistically significant. For example, one subject predicted correctly 27% of the time (instead of the 25% expected by random guessing). This isn’t much, but based on the 15,000 attempts that were made, we would expect such a result only once every 100,000 experiments. Critics of work with random-event generators have questioned whether the device really does produce genuinely random choices, since proof of this randomness is not always included in the published work. Also, the subjects sometimes do worse than random guessing instead of better, which is confusing. Some results with random-event generators, however, have now been replicated by independent investigators.

Our final example illustrates a different kind of research method. Subjects are first asked to relax, and note the imagery that enters their minds. Meanwhile, an experimenter in another room is concentrating on some particular image (which might be anything, e.g., an art print). The test is whether the subject’s mental imagery is related to the image the experimenter concentrates on, and whether the subject can identify this image when presented with a number of choices. A typical procedure in these experiments is to promote a relaxed state in the subject with diffuse light and white noise. After about 50 such experiments had been performed, results were pooled for the 39 of them in which the same research methodology was used: Four pictures were presented to the subject, and only a correct choice was counted. (In some other studies, choosing a wrong but similar picture was given partial credit.) The subjects would then be expected to choose correctly 25% of the time by chance. The results of these 39 studies, reporting data from 1,193 subjects, were combined. The subjects chose correctly more than 30 percent of the time, which once again is extremely improbable. Some of the criticisms of this work include problems with randomizing the pictures, and problems with subjects receiving sensory information (e.g., if the same picture that the experimenter handled is used as one of the subject’s choices). Also, only about half of the individual studies obtained positive results, making replicability an issue.

**Evaluation**

There are two questions to consider, and I think the two questions should be considered separately. Is parapsychology a science? Are the paranormal effects studied by parapsychology real effects? I first need to justify
my opinion that these are really separate questions, because even this opinion is itself controversial. My reason for this belief is that science is a way of investigating and understanding a phenomenon, not a specific body of knowledge concerning that phenomenon. This subtle point is easy to overlook because in a mature science (like optics or botany) our level of understanding has become so high that the methods and subject matter of the science merge together; the fact that light has different wavelengths and the act of making a rainbow with a prism become inseparable in our minds. The early stages of a science are quite different. In the early history of chemistry, for example, we once thought that a burning material was losing a substance called “phlogiston.” We now know that burning materials are combining with oxygen, and that phlogiston does not exist. Many chemists (e.g., the highly respected Joseph Priestley) did experiments to study the properties of phlogiston. No one has suggested that these experiments were not science because phlogiston does not exist. So, it is possible for a science to study effects (at least for a while) that are not real. Parapsychology might still be a science, regardless of whether paranormal effects exist or not. Of course, I haven’t answered our question yet, I’ve only tried to convince you that I can ask the question. Is parapsychology a science?

Although several eminent authorities would disagree with my assessment, I believe the answer is yes. My reason for this answer is that the parapsychologists, in the published works which I’ve read, accept the ground rules of science: Assertions need to be tested by experiment; flaws in experimental design must be corrected; the generally accepted rules of logical inference should be followed; experimental results should be replicable by independent investigators; and, the ultimate goal of the endeavor is a coherent understanding of the observations. Individual parapsychologists have sometimes made unwarranted statements that violate one or more of these ground rules, and those statements can legitimately be used to argue against my position. But isolated examples are not convincing. The proper question is whether the field as a whole (as an institution) condones such unwarranted statements. There is another argument against parapsychology as a science, and this argument merits serious consideration. The understanding achieved within any science must be consistent with all other sciences. This is the “seamless web” argument that I discussed earlier. We can’t have a valid science with an inbred worldview, isolated from the scientific community as a whole. To give parapsychologists more time in which to integrate their results into a broader framework may not be entirely unreasonable, however. Critics will answer that parapsychology has had many years to pursue this goal and has come up empty-handed. But perhaps this is an argument that


the field is an unsuccessful science, not an argument that the field is not a science.

We now come to the second question: Are the effects real? We face here a situation similar to that found for cold fusion. A small number of committed workers in the area are convinced that the evidence demonstrates real effects, while a large number of mainstream scientists think this conclusion is nonsense. We’ve looked briefly at some of the evidence marshalled by the parapsychologists. How should we evaluate this evidence? The key issue here is the burden of proof required. The more radically an idea diverges from well-established knowledge, the more strikingly we demand ironclad proof that the idea is right. Since the existence of psi would be a revolutionary change of unprecedented proportions, the evidence for psi must be subjected to unprecedented critical scrutiny. This evidence hasn’t yet stood up to the stringent tests required, despite the fact that more modern experiments have eliminated many of the initial objections to their work (such as the easy availability of ways to cheat). The unusually high demand for proof (which is justified by the extravagance of the claims) accounts for the continued skepticism of the scientific community, even when parapsychologists believe that their evidence should suffice.

§3. Comparisons

An important similarity between cold fusion and parapsychology is the problem with replicability, which both fields have. If two scientists can’t do the same experiment and achieve the same result, we are bound to have confusion and controversy. After a body of well-documented and well-replicated work starts to emerge, controversies tend to die out. In the case of cold fusion, advocates claimed that the problem with reproducing their results was that the experimental techniques of the critics were not right. But this claim couldn’t withstand scrutiny for very long, because cold fusion advocates were obligated to specify the right procedures in detail. In the case of parapsychology, the replication problems are in a different category; these problems may be due to the individual differences among the human subjects. If an alleged psi ability is found in experiments with a particular subject, how can another experimenter test this claim without having the same subject? Although this problem might be unavoidable for individual experiments, aggregate results of collections of experiments should be reproducible.

A major difference between cold fusion and parapsychology has been in their historical developments. Cold fusion burst dramatically upon the
scene, caused a frenzy of activity, and then almost died out. Parapsychology, in contrast, has had a small but relatively stable number of investigators for over a hundred years. The reason for the initial burst of cold fusion activity is undoubtedly the shock of the initial announcement combined with the social and economic implications of plentiful energy. The reasons this activity ended are related to the string of failures the field endured. The reasons for continued activity in parapsychology are unclear. Proponents argue that the successes of the field continue to attract new investigators each generation, while critics maintain that the widespread and irrational urge to believe in psi accounts for the continued activity of the field.

A rather superficial similarity is that both fields have been labeled pathological science. This label is a term coined by the famous chemist Irving Langmuir to describe the activities of scientists who study nonexistent phenomena by deluding themselves into observing things that aren’t there. A classic case cited by Langmuir is the study of N-rays. Around the beginning of the century, many scientists studied N-rays intensively for several years. N-rays don’t exist, except (apparently) in the imaginations of those scientists. Cold fusion and parapsychology do share one characteristic that Langmuir attributed to pathological science, namely, they both study effects that are small and difficult to observe. But neither field meets all of Langmuir’s criteria, and it’s not clear that using this term accomplishes anything. Another similarity between these two fields is that proponents of both fields call for revolutionary changes in our scientific thinking. We have already discussed the basis, in each field, for demanding drastic changes in our understanding. Likewise, we have discussed the case against drastic changes, both in general terms and also for each field in particular. But there is also an interesting difference between these two fields, namely, in the kind of changes demanded. Cold fusion demands specific changes in specific, highly studied physical systems. Parapsychology, on the other hand, calls for changes that are far-reaching but only vaguely defined.

For Further Reading


