

The Limits of Science

BRUCE MURRAY

In science, only reproducible, or at least recurrent, observations can be dealt with rigorously. How, then, can scientists assess purported phenomena such as ESP, UFO's or religious miracles?

Up until the last century, most of Western society had a point of view about life that was strongly conditioned by religious precepts. There were religious explanations of both how and why things worked out the way they did. In this century that point of view has been greatly altered by the development of science and technology, so that many people now find themselves at least vaguely familiar with the *how*, but often baffled about the *why*.

The result has been a rise of irrationalism at the very time when we have the most educated population in the history of the world, in terms of science and technology. For example, the average person's knowledge of astronomy in the United States today is higher, I am sure, than it has ever been at any time in any large country. And yet astrology, which is completely inconsistent with the most elementary understanding of astronomy, is widely popular and practiced. This phenomenon suggests that many people don't really care if a belief is apparently irrational, so long as it contributes to explaining the *why*.

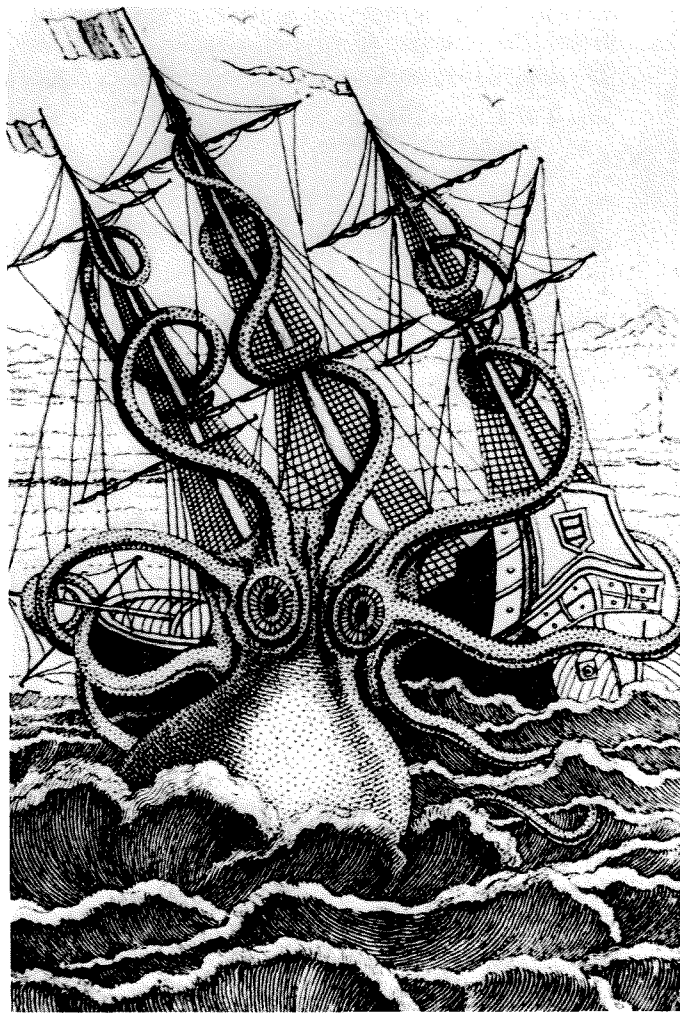
Indeed, we are finding that at the time in man's history when he is supposedly liberated to understand the modern world in modern terms, he seems to grasp at many peculiar, semi-irrational things. I interpret this as both a lack of understanding about the limits of science and a need for a source of values he does not find within science. So there is a need to understand how science can be applied—and what are its limits—in order to establish the proper domain of scientific authority. Most important, understanding the limits of science also implies understanding the unique role of human judgment, feelings,

intuition, and values. Unless the boundary is rather well understood, there can be an attempt to try to apply science to unscientific situations, and sometimes to rely on human intuition in scientific situations. Both circumstances can lead to confusion in the lives of individuals—and tragedy in the histories of nations.

One way to identify the limits of science is to study problematical phenomena—phenomena and events about which there is no clear-cut opinion, even among scientists.

Basically, a scientist can only pass judgment on something if he can observe it and if it can be observed by others. And a phenomenon or an event must be repetitive, or at least recurrent, in order for it to be reobserved. So problematical facts arise in those cases where the phenomena are not recurrent or repetitive, or at least have not been so far. Ultimately, of course, these sorts of things, if they are real, can be brought into the realm of science through long-enough studies, accidental occurrences, and the like. We geologists always like to enumerate and categorize things. So I have made a list that I call a classification of problematical subjects.

The first category has to do with Questionable Living Animals—that is, are such animals alive? All these creatures were at one time doubtful or are doubtful now—giant squids, sea serpents, gorillas, the unicorn, the Abominable Snowman, Big Foot of the Pacific Northwest, the Loch Ness Monster, and the living coelacanth, a very primitive type of fish found only in extremely ancient strata.



This unlikely looking sea monster is a fanciful representation of a creature that really exists—the giant squid, which can attain an overall length of up to 80 feet. Though the squid normally lives deep in the ocean, now and then it is sighted on the surface—and then its size and appearance can be frightening.

The next category is Conjectured Historical Events—events that were conjectured and have since been disproven, or were disbelieved and have since been proven, or are still problematical. They include continental drift, the island of Atlantis, Pleistocene man, the Velikovsky theories of drastic changes in the orbits of the planets explaining historic terrestrial events, pre-Columbian contact with America by European peoples, the antiquity of the earth, man's evolution from ancient primates, dragons, and the Seven Cities of Cibola—a legend prevalent at the time of the Spanish conquistadors that led to the search for mythical cities of gold.

The next category is Purported Natural Phenomena—the extraterrestrial origin of meteorites, germs as the cause of disease, alchemy, the question of canals on Mars, unidentified flying objects, the phenomenon of ball lightning (natural plasma discharge), the question of whether advanced civilizations exist elsewhere in this

galaxy, the issue of life on Mars. The most recent phenomenon in this category is a purported substance called polywater—a new form of water, reported in the scientific literature less than a decade ago, which has led to considerable scientific interest.

The last category I have noted is Purported Human Phenomena, and here I include hypnosis, which was at one time believed not to exist; ESP or extrasensory perception, which is a controversial subject at present, and which actually has many subdivisions; as does the subject of religious miracles, which range from purported events involving individuals to miracles affecting the ocean, the sun, and the sky. Then come ghosts, astrology, and Freudian psychology, which was considered to be a non-scientific subject when it first emerged. Phrenology was at one time considered to be a valid scientific way of relating physiognomy to personality by the bumps on the head. Faith healing, a widespread activity in the early Christian era, has had a renaissance recently, it seems. And there is finally acupuncture, which is back in the news as a result of our Chinese diplomacy.

A list like this only serves to emphasize how diversified these problematical phenomena are, and to show how different aspects of human affairs and human thought overlap the range of these phenomena. Take sea monsters, as an example. Everyone has seen woodcuts showing some monstrous creature attacking a ship. The one shown at the left, which looks like an octopus, used to have the name in medieval literature of kraken, and it was not considered to be real—until three of them washed ashore in Newfoundland in the late 19th century, the largest of which was 80 feet long. They turned out to be giant squid. The giant squid lives deep in the ocean, away from the shore, and normally its body—which contains very few hard parts anyway—is not recovered. In this case the ocean currents happened to bring these things onto the shore, where they could be measured. Stories of these monsters attacking ships have been reevaluated, and now it appears that there *are* squids large enough to be frightening to people in a small sailing vessel, and they *do* on occasion rise to the surface and float there.

So here is a case of something that was considered mythical as late as the second half of the 19th century being certified as real. Because there was no hard physical evidence that could be examined by different scientists—until the squid were actually found—there was no way to trust the description of these things. So they were written off as sea stories.

Nobody has ever found a sea serpent, and none has ever washed ashore to be examined by scientists. But there are still reports of them. For example, the basking shark is a giant animal, and when it washes up on a beach, it looks a little bit like a sea serpent. These have often been

reported, but then competent zoologists have examined the specimens and determined that they really were not anything unusual.

There have also been some very weird fakes, in one case utilizing fossil bones in conjunction with modern ones. Such cases should remind us that whenever one has folklore, it can easily turn into fakelore. I think we have to remember, in evaluating all these reports for which we *cannot find hard physical evidence, that there is a natural tendency*—whatever the origins, and however honest the early sightings may be—to generate the fakes, as a hoax, with a commercial motivation, or whatever. And so one cannot rule this out when dealing with such things as UFO's, for example.

In the case of purported land monsters, there is hard physical evidence of something in the form of tracks. There is one so-called monster or animal purportedly living in the high Himalayas called the yeti, and its tracks have been reported and photographed in the snow at very high altitudes. The tracks measure about 18 inches long and 13 inches wide. Photographs have been taken by people whose credibility is beyond doubt. They did not know what they were seeing, but it clearly was not something wearing shoes because the print has toe marks on it. This has led to quite a long discussion of the yeti track, the general assessment being that there are a variety of evaporation phenomena at high altitudes which tend to enlarge normal animal tracks in snow and give them peculiar shapes. Also, in the case of certain bears, when they are going at a proper gait, the prints of the front and back feet combine to look like a single foot with peculiar human characteristics. And, believe it or not, human pilgrims have been observed walking across these mountains, barefoot in the snow, as high as 19,000 feet.

But in the absence of unambiguous physical evidence, such as a skeleton, the existence of the yeti becomes less likely as alternative explanations continue to emerge and the real thing fails to show up.

The yeti is a kind of oriental Big Foot. We have an occidental Big Foot in our Pacific Northwest and in western Canada, where the Indian name for the legendary beast was Sasquatch. Its footprint (again, it is barefoot) has an hourglass shape. The prints are very large, and they are seen over a wide area. John Napier, an expert in primate biology, feels it would be very difficult to produce these widely occurring footprints as a hoax. So he is inclined to allow that there could be something real and unknown there. Yet he is convinced that there is not adequate food supply in that area for any large primate. I guess that is where one has to leave Big Foot for the present, remembering the horrible possibility of folklore turning into fakelore.

Let me go on to a far more emotionally charged example

—UFO's. This is a subject that seems to be capable of supporting a rather substantial population of paperback books. For a reasonably good writer who can produce some fake pictures, there is a real market for this stuff, which vastly complicates the job of trying to determine whether there is anything to UFO reports. Fakelore so dominates folklore in this situation that it generates a lot of false stories about problematical evidence. Worse than that, it plants the idea of UFO's in peoples' minds so that if they see something they do not understand, they already have the concept of what it might be. One does not find a naive brain, so to speak.

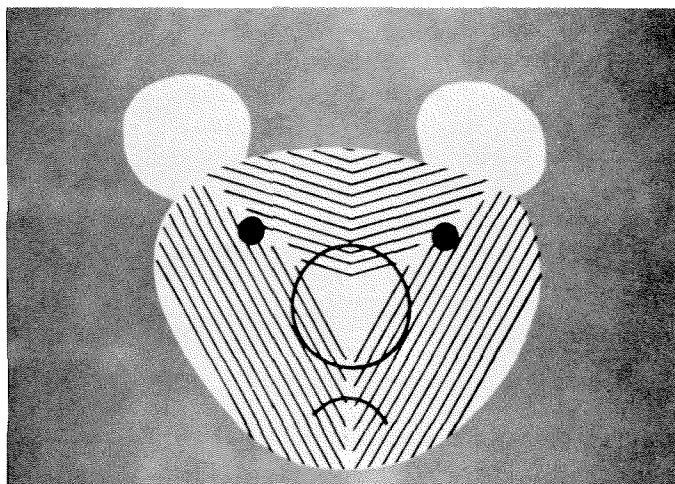
For myself, I am in the middle of the road—mildly negative on UFO's. I do not think there are little green men, but I also do not think you can prove a negative very well. And I do believe there are a lot of honest, sober witnesses who have had the daylights scared out of them by flashing lights or something else happening at night that was real. It was not their imaginations; something was there. But to associate that with spaceships from an alien civilization is a big jump that I think is unsupported.

The existence of UFO's gets to be a debate of almost theological proportions, involving heresy and faith, and that is not very scientific. The reason is that when one is presented with reports of phenomena that do not make sense, some people cannot stand the uncertainty. It is just like the situation in ordinary social affairs, where there is a tendency to want to have an answer right now, right or wrong, and if the only choices are between, "It's nothing," or, "It's the most bizarre thing in the world," you choose one of those two answers. Well, the answer really is that you probably do not have the right answer yet, and so you should not make a choice.

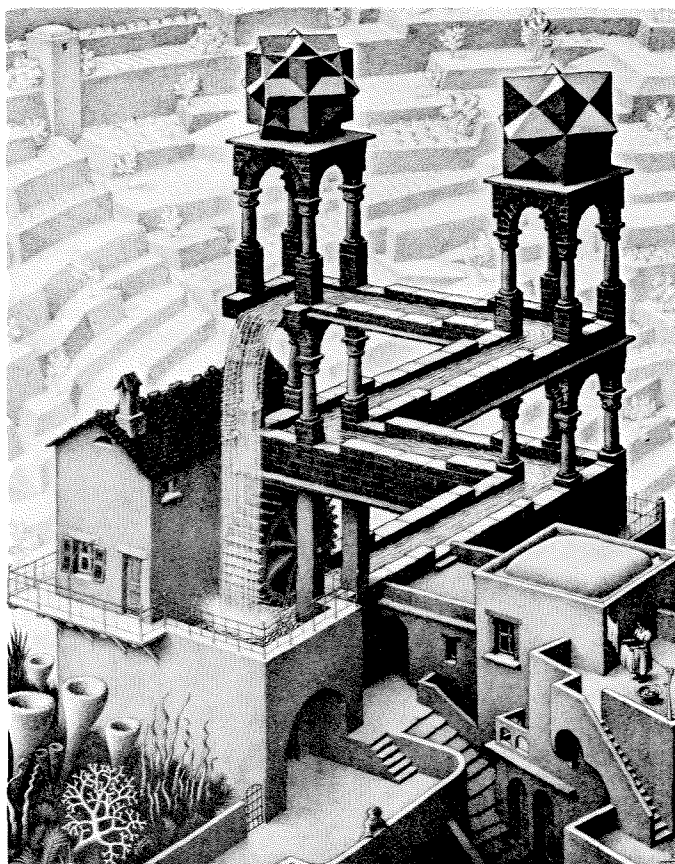
One point I want to emphasize about UFO's and other problematic phenomena is that if there are a lot of emotions involved, on both sides—the debunkers and the advocates—then the situation has gone far beyond the domain of scientific inquiry. The very fact that there is an emotional component indicates the matter involves more than objective evaluation. One can wonder why a scientist feels so compelled to disprove the possibility that something unexplained could be involved. Is he so concerned about his holy church that he cannot stand a little bit of heresy? Similarly, one can question the objectivity of a person who has a conspiratorial theory about how the government is covering up evidence of UFO's. What's the angle? Why is he so emotionally absorbed in this thing that he has to develop such an idea?

However, the real issue with UFO's, or with some of the other purported phenomena, can be stated in this way: Is seeing believing? Can you really trust what you see? Or can you believe an honest, sober person who says he saw something like a spaceship set down in the desert?

From **Take Another Look** by Edward Carini. Copyright 1970. Published by Prentice-Hall, Inc.



In spite of how you see it, the bear's nose in this drawing is a perfect circle. It does not appear so because the illusion created by the perspective of the drawing keeps the eye from transmitting an accurate image to the brain.



The only way to keep water always flowing downhill, no matter what heights it has to scale, is by optical illusion—as artist M. C. Escher has obviously discovered.

One way to inquire into the reliability of visual reports is to consider optical illusions, where obviously the eye is not transmitting a faithful image to the brain.

The bear's nose in the drawing at the left is an exact circle. It doesn't look like a circle, and no matter how hard you try, even when you know the answer, you cannot make it look circular. This is an illusion of perspective. And it is telling you something: Somehow the eye is not processing information and transmitting it to the brain accurately.

In a different kind of illusion, the question is, which way is up? This approach has been used by the artist, M. C. Escher, whose drawing (below) could be bothersome because the stream seems always to be flowing down. Perhaps Escher has produced a perpetual-motion machine.

Let's try a reversal illusion. In the Escher drawing on the opposite page, do you see white angels? Or black devils? It just depends on which you want to see, but I defy you to see both at the same time. What this says is that the brain can choose which image it can assimilate, but the eye-brain combination normally cannot simultaneously perceive both images. It has to have some information to tell us which one to choose.

These illusions are not confined to the abstract world of art. Consider the Mariner 9 picture of Mars across the page. Do you see blisters—or pits? Well, there are no blisters on the picture. The sun is coming from the right, and so the bright things you see are surfaces sloping downward, facing the right. The dark things are surfaces sloping downward, facing away from the sun to the left. This is very important, because it illustrates that you need some *a priori* information—you need to know where the sun is coming from—in order to make that reversal illusion choose the right sense.

In fact, everything we see not only has to be processed and handled by the eye-brain combination, but it must be compared with remembered images or coded signals of some kind in the brain. Otherwise, the brain is helpless. It just says, I don't know. If it is scared, it can say, I'll just take the thing in my memory that looks most like it, and choose that instead. It is very hard for the brain to say, I just simply don't know. So it tends to pick the best guess it can get from what is already in its memory.

Why doesn't the eye image correctly what is outside in nature, so the brain can then ponder what it sees and make a decision as to the reality of what it is looking at? Well, it turns out that you can do simple arithmetic that is helpful. In order to transmit a television picture by wire a special cable called a coaxial cable is needed. Such a cable is equivalent in capacity to at least 500 telephone lines that only carry voice. A television picture simply

cannot be put down a telephone line. It won't fit, so to speak.

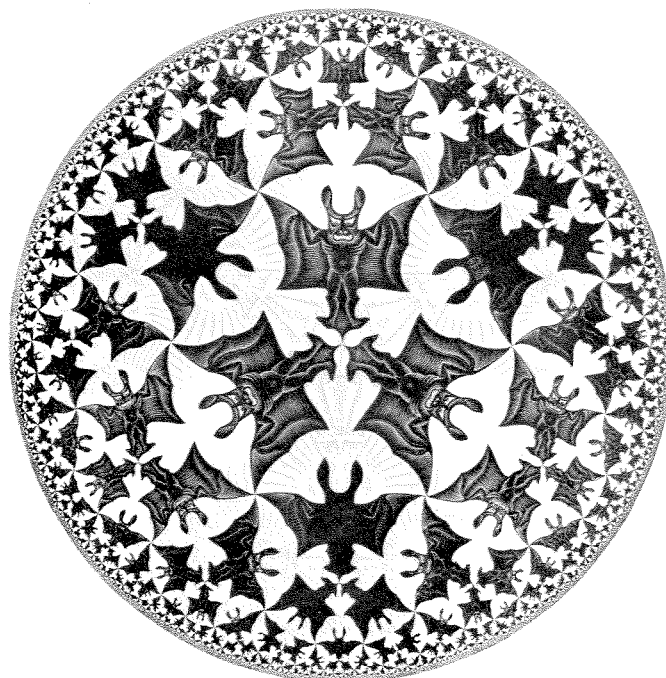
There are wires from the eye to the brain, too. They are called neurons, and they transmit pulses of information, but it takes tens to hundreds of neurons to do the work of one telephone line. So, in order for the brain to "receive" a television picture using neurons only, somehow the information in the picture must be broken up, encoded, and transmitted down as many as several hundred thousand neurons and then reconstituted. That is very hard to do. When you think about it, then, it is not at all surprising that optical illusions and evidences of other kinds of aberrations arise. The eye-brain combination is doing a fantastic job of processing a picture, breaking it down into its elements somehow, transmitting the information, and then reconstructing a "picture" from both eyes in order to get stereo. At the same time it compares the picture with remembered images so the brain can make a decision about what it is looking at.

To quote John Napier, although we do not always know what we see, we tend to see what we know. It is the same as saying we have to choose what we have seen or known about before. And we tend to perceive the conceivable. I would say that it is very difficult for us to perceive the inconceivable.

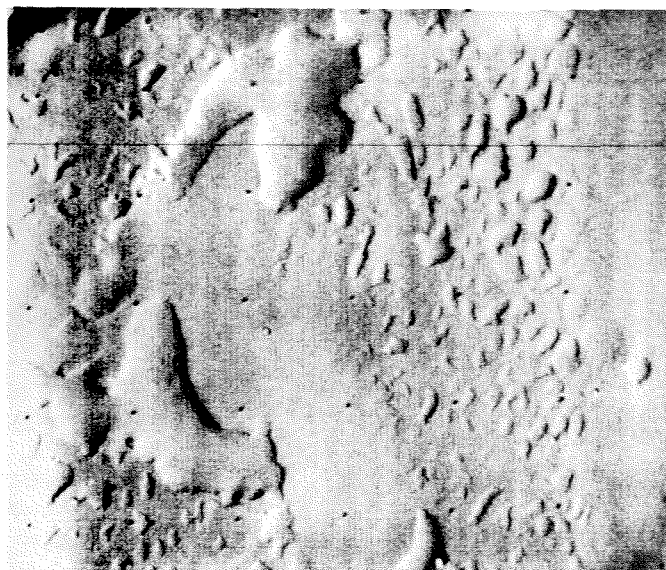
To take an example, a theoretical physicist at Caltech was driving up the Owens Valley on a vacation when he saw off to his left, in the late afternoon, a bright luminous object that was much larger than a star or planet, and—he believed—much brighter. It was near the mountains, and it maintained its shape for a while and then it disappeared. He told me about it later and we checked the astronomical tables. We found that Venus was, at that instant of time, just setting below the crest of the Sierra. This is a place where the world's glider record has been set, because the atmospheric conditions over the Sierra exhibit a lee wave—very peculiar atmospheric effects in which the air is bent in strange ways. Clearly, what had happened was that the image of Venus was being refracted in a very peculiar way, which produced an image of Venus that was unfamiliar even to him.

Had this been somebody who was already preconditioned to believe in UFO's, he would undoubtedly have said that he had seen something that was unlike anything he had ever seen before, or heard described. So it must be a UFO.

In dealing with things like UFO's, or to some extent ESP, where the criteria of reproducible or recurrent observations are not available, one cannot say that such things exist physically—and they do not exist scientifically. Depending only on eyewitness reports is not good enough. Furthermore, if there are emotional elements, not to mention theories of conspiracy and suppression of evidence, then the subject can become hopelessly distorted.



It is possible to see either white angels or black devils in this Escher drawing of a reversal illusion, but the eye-brain combination cannot perceive both simultaneously.



Optical illusions don't all come from the world of art. This picture of the surface of Mars, for example, looks blistered instead of pitted—unless you know that the sunlight is coming from the right, illuminating the bright downward slopes that face it. The dark areas are downward slopes facing away from the sun.

I would like to turn back to my list of problematical phenomena now. Across the page I vote my conscience on whether each of these subjects is significant—yes, no, or maybe so. In each case I have started an arrow at the place on my scale where I think the phenomenon was at some earlier time. The point of the arrow shows where the phenomenon belongs now. I think that what is useful about this exercise is that it illustrates in a sense some of the fringes of science, some of the limits of science. Thus, the giant squid did not exist at one time, but now it does. In earlier times, sea serpents were widely believed to exist; now it seems less likely, but still not all the way to no. One of them could drift up on the sands of Nova Scotia, and that would change our whole opinion. I do not know any way to prove that this could not happen.

There were not supposed to be gorillas at one time; they were thought to be wild men. Now, of course, we know they exist. The unicorn, on the other hand, is a mythical beast; the legend may have developed from reports of the Arabian oryx, an antelope. When seen from the side, it appears to have only one horn—and there are certainly no special powers associated with that horn. The Abominable Snowman, or the yeti, was seriously considered at one time, perhaps, but now is taken much more skeptically. Big Foot, again, was probably once plausible, and though it is less so now, it is still difficult to account for its footprints. The Loch Ness Monster was once plausible, but people have looked and looked and they seem not to find anything that you can come home with. But then it is hard to find something in a deep lake like that, so we will leave a little possibility that something could turn up. The living coelacanth was clearly extinct 200 million years ago—until it turned up alive in a fisherman's net off the east coast of Africa.

Continental drift was rejected by science at the turn of the century, but now it is one of the cardinal beliefs of modern geology. Atlantis was considered to be a myth lingering from the time of Plato, but now it appears that the island of Thira in the Mediterranean might in fact have been the site of ancient Atlantis. The Velikovsky theories never had anything going for them, and they still do not. The pre-Columbian contact with America is now confirmed by hard archaeological evidence that the Vikings established a temporary colony here. There is suggestive evidence that much earlier contacts were made, perhaps even as early as the Phoenician days. The antiquity of the earth, of course, used to be set at 6,000 years; it is now more like 4.5 billion.

Darwin triggered a debate over whether man evolved from primates, and it still develops here and there, but is really well over; there is a convincing paleontological record showing that man has evolved from ancient primates—not from modern apes, but from ancient common ancestors.

Dragons, on the other hand, used to be accepted and then were cast out. But there are still some possibilities. The stories of dragons might in fact reflect cultural memories of the last of the large Pleistocene animals that died away, so you cannot just throw them out as only a fantasy.

The Seven Cities of Cibola was a myth that was faked in part, in the sense that there were Spanish adventurers who wanted to promote an expedition, and so they put out the idea that there were seven cities of gold in what is now New Mexico and Arizona. There was a basis of truth in this, in the sense that the Indian Hopi and Zuni settlements there were in fact little cities, though not at all what the Spanish imagined.

The idea that meteorites were of extraterrestrial origin was condemned by the French Academy of Science in the late 17th century. They are now, of course, recognized as rock fragments from elsewhere in the solar system, based on a lot of confirming evidence. But this is a case in which science itself has had to move over.

The same is true of impact craters on the moon and the earth, which also were not believed initially to be of extraterrestrial origin. Germs as the cause of disease, of course, is an article of faith for modern sanitation and public health as well. It was not always so.

Alchemy at one time was widely believed, but once the atomic theory of matter was generated, it was recognized that alchemy was not possible in the chemical sense but only in the nuclear-physical sense. Lead could never have been turned into gold in medieval times.

Canals on Mars were originally “canali”—linear features on that planet that were accepted as observed by the 19th century Italian astronomer Schiaparelli. The American astronomer Percival Lowell then turned them into “canals,” meaning creations by intelligent beings—which was rather skeptically received. After the Mariner mission to Mars, we know that the “canali” are not there, much less the canals. They never were there, in fact. It was an artifact of pushing too far the limits of visual observations through a telescope.

The dashed line for UFO's on my list means that various things that are reported have various degrees of probability. I think the possibility that there are occasionally atmospheric phenomena involving electrical discharge, for example, or plasma effects, has not been ruled out. It might account for some things that have been seen, but little green men in saucers are very improbable, not just on an *a priori* basis, but on the basis of reports, which are not very convincing, and there is never any hard physical evidence.

Ball lightning, which is a natural plasma discharge, was

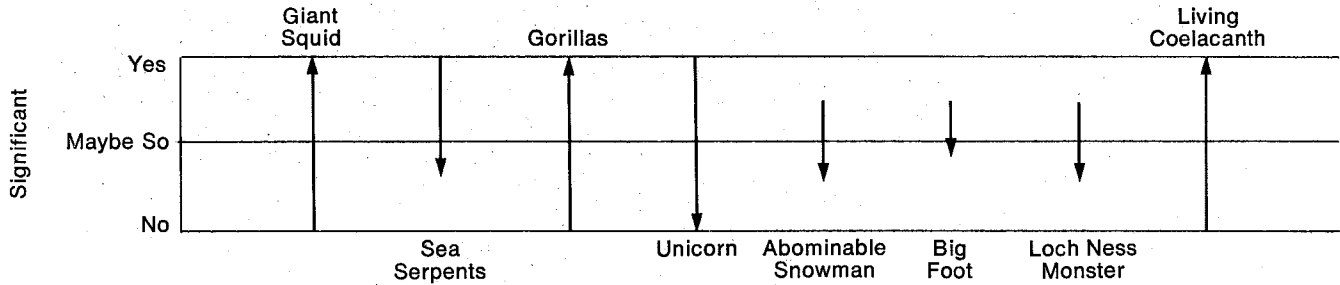
continued on page 16



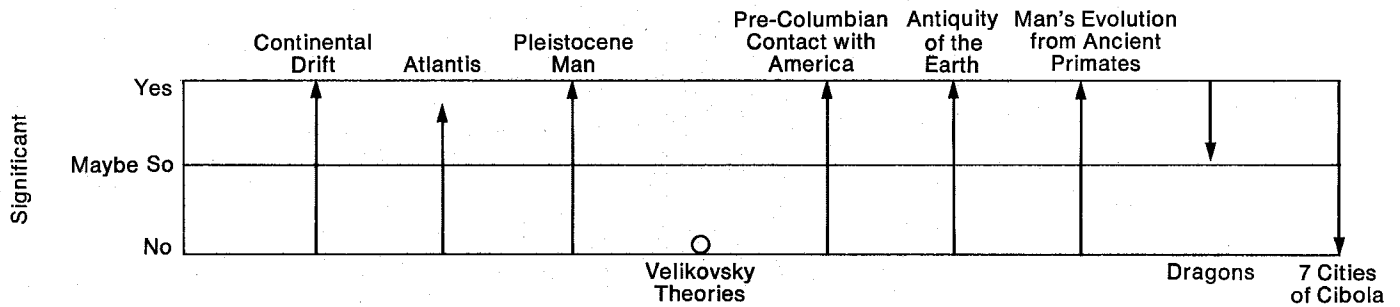
A Classification of Problematical Subjects



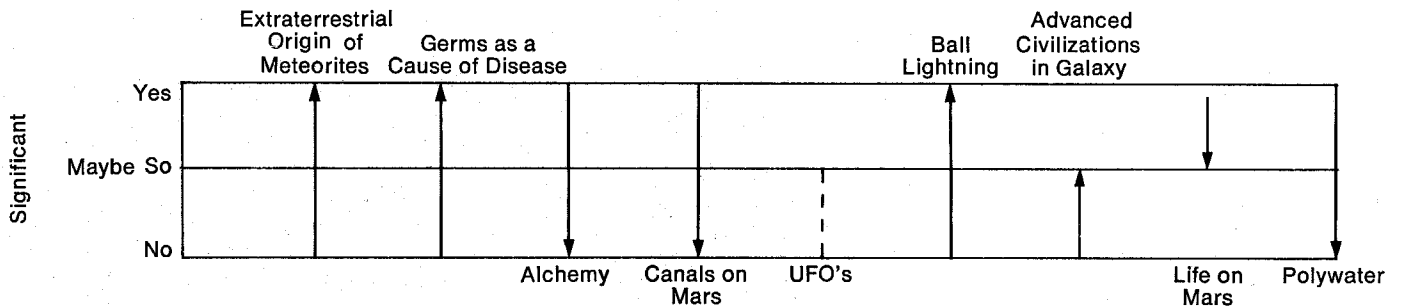
Questionable Living Animals



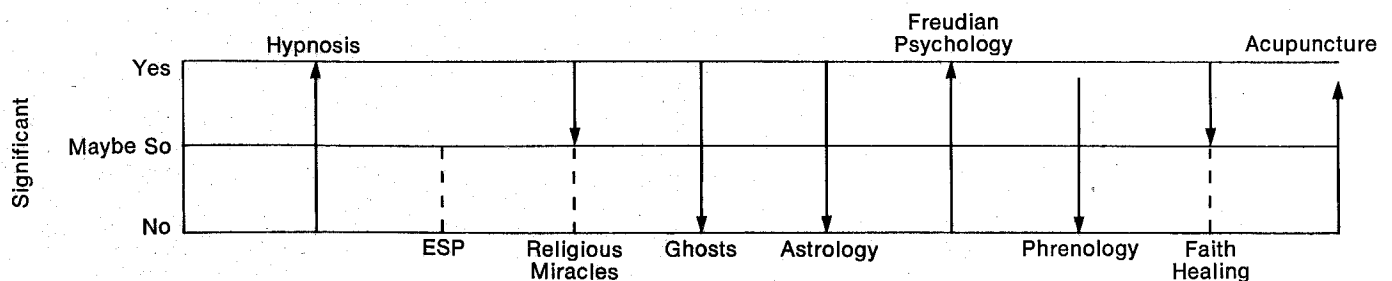
Conjectured Historical Events



Purported Natural Phenomena



Purported Human Phenomena



once not believed to be true and is now accepted.

Fifty years ago, or even less, very few scientists entertained the idea of other civilizations in this galaxy. Now, many do, and people are beginning to wonder how to test this idea observationally.

Although human life on Mars was never widely accepted by scientists, it has been commonly accepted that plant life exists there, and that it is the origin of the seasonal variations. The Mariner program has proven large-scale plant life out of the question. Now Viking is supposed to test for some kind of microbial life or determine whether Mars really is a sterile planet.

Polywater, a supposedly new state of water that was discovered about ten years ago, led to a fast but interesting scientific history in which it was finally shown that the anomalous observation resulted from a subtle contamination of glassware in the laboratory.

To wind up with Purported Human Phenomena, hypnosis was denied as a real thing until medical science was finally able to describe it clinically, and recognize that it is indeed a reproducible state of the human body.

ESP, like UFO's, can mean many things. The idea of psychokinesis—of thought influencing material objects—is pretty hard to swallow, and I do not know of any evidence for this that has stood up in scientific courts. There are other aspects of ESP that have not been excluded as clearly, in an observational sense; in fact, there is some serious scientific research about ESP going on in some institutions.

Religious miracles embrace not only healings, but cases like the one in 1917 when a large crowd in Portugal was reported to have observed the sun stand still in its orbit. This, I believe, did not happen, because the earth would have come apart and destroyed itself if it had stopped its rotation. Certainly, the rest of us would have noticed! But there are other religious miracles, especially those that have to do with healing or with physiological effects on people, that are less easily excluded. I think it would be unwise for science to say flatly that all religious miracles are bunk, because each purported incident needs to be examined on its own merit.

Ghosts were widely believed in Shakespeare's time, but since they have never permitted themselves to be observed for four centuries, I would say there is very little likelihood that they exist.

Astrology not only has no supporting evidence, but we also know where the mythology came from. We know that it was a part of the ancient pagan religions that existed before scientific times. So when we find it recreated in modern guise in the daily newspaper, it is simultaneously tragic and amusing.

Freudian psychology, on the other hand, was greeted very skeptically by the scientific community and only gradually won its place in science as a valid representation of some aspects of the psychological behavior of man.

Phrenology, the reading of bumps on the head, has gone away, and is not even taught in the smallest medical school anymore.

Faith healing, which was also widely believed in early Christian times, and periodically since then, is again one of these situations which should not be dismissed. Parts of it seem absurd, while other parts bear further discussion, and I think acupuncture is a good example. Acupuncture is so implausible to our present understanding of how the body works that one tends to dismiss it out of hand, yet it turns out to have some merit. I think some of the faith healing likewise may warrant investigation later on.

What conclusions can I draw from this little exercise? One very important moral for modern Americans is that we have to live with uncertainty, not just in political, social, and economic affairs, but also in physical affairs. There is always going to be a range of things that are not very clear, and it will be impossible to make them clear because the phenomena that are described are not reproducible in the laboratory, or are not easily reproduced in nature.

Science reduces the miraculous to the ordinary through observation, if the phenomenon is indeed observable. If it cannot be observed, and reobserved, it cannot be a part of science. But sometimes these things take time—decades, even centuries.

My second conclusion is that the irrational approach to modern life—the seeking refuge in beliefs that disregard the facts of science (even condemn them)—is really a step backward toward barbarism. In the fierce competition of the modern world, the cynical materialist, who is not handicapped by irrational beliefs, is always going to win over those who would defy or ignore scientific reality. If we as a people want not only to excel in a materialistic world, but to protect and enlarge the esthetic and subjective side of our legacy to history, we must be very objective about objective things. Otherwise, every time we embrace an emotional or irrational attitude about things that really have physical results and meanings, we will slip a little bit. If we slip enough, we will just disappear from history. And then other groups more limited to strict materialism and less attuned to esthetic, spiritual, and subjective matters will become the dominant forces in this century. It will be their legacy, not ours, that will survive in the minds of the peoples of the next century. □