CHAPTER 12

The Dispassionate Scientist

THE MYTHS

In Chapter 4 on the kinetic theory of heat, we referred to a common myth about scientists: that they are objective, dispassionate observers of nature, who care only for truth and are willing to discard without a qualm any theory they hold just as soon as experimental disproof is provided. We pointed out in that chapter how little Rumford fit this myth, and how effective he was precisely because he didn't.

The myth about the personality of the scientist is related to a myth about scientific method itself—that it is a set of prescribed rules or procedures for the discovery of truth, which can be applied mechanically, independently of the personality of the person who uses it.

THE REALITY

Scientists, being people, tend to be governed in what they do by a mixture of motives, some altruistic and some selfish. They are more conservative than they like to imagine, sticking to the ideas they have grown up with and not lightly replacing them with new ones. The ideas or theories they have developed themselves are emotionally important to them: they are likely to overlook the weaknesses and to work harder proving them right than they would proving them wrong.

To have intense emotional commitments to one's own work is both natural and necessary—why work hard on something if one has no stake in the outcome? Of course, the drawback is that a strong commitment to one side of a dispute tends to make one overlook negative

evidence and overstress the importance of positive evidence. But what tends to protect science as a whole from such errors (although it doesn't eliminate them) is that science rests, in the long run, on the consensus of scientists, not on the authority of any one individual, no matter how outstanding.

Scientists, like creative artists, do not always act only from a disinterested love of truth or beauty. Both are motivated also by pride, greed, the hunger for fame and the honors and rewards that go with it. This is a fact that has received some public recognition since the publication of the book *The Double Helix,* by James Watson, describing his role in the discovery of the structure of nucleic acid, for which he and F. H. Crick received the Nobel Prize.(1) But it is really an old story. There is a lot of competition in science: there are times when in a particular field there will be a sense of discovery in the air, a shared feeling about the best way to solve some important problem, and many individuals will be working simultaneously in the same direction. The result is that very often a major breakthrough will be made simultaneously or almost simultaneously by several different people, although each may come to it by slightly different paths. Such simultaneous discoveries have led to very bitter arguments among scientists as to who was first, and as to whether the original discovery may not have been "stolen" from its first discoverer.

For Example: Isaac Newton

The sociologist Robert Merton has described such conflicts in an article in *The American Scholar:*(2)

> Long after he had made incomparable contributions to mathematics and physical science, Newton was still busily engaged in ensuring the luster and fame owing him. He was not merely concerned with establishing his priority but was periodically obsessed by it. He developed a corps of young mathematicians and astronomers, such as Roger Cotes, David Gregory, William Whiston, John Keill and, above all, Edmond Halley, "for the energetic building of his fame" (as the historian Frank Manuel has put it in his recent *Portrait of Isaac Newton*). Newton's voluminous manuscripts contain at least twelve versions of a defense of his priority, as against Leibniz, in the invention of the calculus. Toward the end, Newton, then president of the Royal Society, appointed a committee to adjudicate the rival claims of Leibniz and himself, packed the committee with his adherents, directed its every activity, anonymously wrote the preface for the second published report on the controversy—the draft is in his handwriting—and included in that preface a disarming reference to the legal adage that "no one is a proper witness for himself and [that] he would be an iniquitous Judge, and would crush underfoot the laws of all the people, who would admit anyone as a witness in his own cause." We can gauge the pressures for

establishing his unique priority that must have operated for Newton to adopt such means for defense of his claims. As I shall presently suggest, this was not so much because Newton was weak as because the newly institutionalized value set upon originality in science was so great that he found himself driven to these lengths.

By comparison, Watson's passing account [in *The Double Helix*] of a priority-skirmish within the Cavendish [Laboratory of Cambridge University] itself can only be described as tame and evenhanded, almost magnanimous. That conflict largely testified to the ambiguous origins of ideas generated in the course of interaction between colleagues, touched, perhaps, with a bit of cryptamnesia. . . . (pp. 205–206)

Freud Also

But perhaps the most apt case of the myth [that scientists are indifferent to the credit for a discovery] taking precedence over an accessible reality is provided by Ernest Jones, writing in his comprehensive biography that "Although Freud was never interested in questions of priority, which he found merely boring, he was fond of exploring the source of what appeared to be original ideas, particularly his own . . ." This is an extraordinarily illuminating statement by a scholar who had devoted his own life to penetrating the depths of the human soul. For, of course, no one could have known better than Jones—"known" in the narrowly cognitive sense—how very often Freud turned to matters of priority: in his own work, in the work of his colleagues (both friends and enemies) and in the history of psychology altogether. In point of fact, Freud expressed an interest in this matter on more than one hundred and fifty recorded occasions (I make no estimate of the unrecorded ones). With characteristic self-awareness, he reports that he even dreamed about priority and the due allocation of credit for accomplishments in science. . . . (p. 214)

Merton cites examples of how Freud's obsession with issues of priority entered into his relationships both with his associates and with his rivals, and concludes his discussion of Freud as follows:

Judging from this small sampling of cases in point, it may not be audacious to interpret as a sign of resistance to reality Jones's remarkable statement that "Freud was never interested in questions of priority, which he found merely boring . . ." That Freud was ambivalent toward matters of priority, true; that he was pained by conflicts over priority, indisputable; that he was concerned to establish the priority of others as well as himself, beyond doubt and significant; but to describe him as "never interested in the question" and as "bored" by it requires the prodigious feat of denying, as though they had never occurred, scores of occasions on which Freud exhibited profound involvement in the matter, many of these being occasions that Jones himself has detailed with the loving care of a genuine scholar. . . . (pp. 215–216)

WHY SCIENTISTS CARE SO MUCH

Merton goes on to point out the very human reasons why scientists should be concerned to receive the credit for their discoveries:

From still another perspective we can see the fallacy of the new mythology that construes the thirst for priority as altogether self-serving. Often the drive for recognized originality is only the other side of the coin of the elation that comes from having arrived at a new and true scientific idea or result. The deeper the commitment to the discovery, the greater, presumably, the reaction to the threat of having its originality denied. Concern with priority is often the counterpart to elation in discovery—the eureka syndrome. We have only to remember what is perhaps the most ecstatic expression of joy in discovery found in the annals of science: here, in abbreviation, is Kepler on his discovery of the third planetary law:

> When I prophesied 22 years ago as soon as I found the heavenly orbits were of the same number as the five (regular) solids, what I fully believed long before I had seen Ptolemy's Harmonics, what I promised my friends in the name of this book, which I christened before I was 16 years old, what I urged as an end to be sought, that for which I joined Tycho Brahe, for which I settled in Prague, for which I spent most of my life at astronomical calculations—at last I have brought to light and seen to be true beyond my fondest hopes. It is not 18 months since I saw the first ray of light, three months since the unclouded sun-glorious sight burst upon me! . . . The book is written, the die is cast. Let it be read now or by posterity, I care not which. It may well wait a century for a reader, as God has waited 6000 years for an observer.*

We can only surmise how deep would have been Kepler's anguish had another claimed that he had long before come upon the third law, just as we know how the young Bolyai, despairing to learn that Gauss had anticipated him in part of his non-Euclidean geometry and with the further blow, years later, of coming upon Lobachevsky's parallel work, suffered a great fall from the peak of exhilaration to the slough of despond and never again published any work in mathematics. The joy in discovery expressed by the young Jim Watson does not outstrip that of [the French chemist] Gay-Lussac, seizing upon the person nearest him for a victory waltz so that he could "express his ecstasy on the occasion of a new discovery by the poetry of motion." . . .

In short, when a scientist has made a discovery that matters, he is as happy as a scientist can be. But the height of exultation may only deepen the plunge into despair should the discovery be taken from him. If the loss is occasioned by finding that it was, in truth, not a first but a later independent discovery, that he had lost the race, the blow may be severe enough, although mitigated by the sad consolation that at least the discovery had been confirmed by another. But this is nothing, of course, when compared with the traumatizing experience of having it suggested that not only was the discovery later than another of like kind but that it was really borrowed. The drive for priority is in part an effort to reassure oneself of a

*We have used this quotation earlier (p. 195) in a different context.

capacity for original thought. Thus, rather than being mutually exclusive, as the new mythology of science would have it, joy in discovery and the quest for recognition by scientific peers are stamped out of the same psychological coin. In their conjoint ways, they both express a basic commitment to the value of advancing knowledge. (pp. 222–224)

THE DEPERSONALIZATION OF DISCOVERY

In Chapter 11, on where hypotheses come from, one can get some appreciation of the role of individual, personal, and chance factors in scientific discovery. However, once the discoverer has to write an article to announce his results, a process of depersonalization begins. In modern times, a dry, unemotional tone which uses a prescribed, rather colorless jargon has become fashionable. Papers written in the lively, engaging style of Rumford or the measured prose of Snow are no longer common. But in spite of the writing style new discoveries still bear the stamp of the discoverer and express something of his own view of the meaning of his work. We have mentioned that the absorption of any discovery into the body of science is the act of a scientific consensus. As the other members of the scientific community begin to accept a new idea and apply it in new ways to new problems its discoverer may not have anticipated, the idea begins to change its form. It is now seen in new lights, and begins to alter in response to the various insights of those who use it. Eventually it reaches a degree of acceptance that leads it to become textbook material. By this time it has lost most features that reflect the idiosyncrasies of the person who found it in the first place and the way the discovery was made. As science develops, the idea changes still further, sometimes being incorporated into new theories, as Snow's hypothesis on cholera became one application of the more general germ theory of disease, and sometimes being expressed in different language or formulation. Although physicists still use the laws of mechanics discovered by Newton, they do not learn them from Newton's book, nor do they use Newton's mathematics. New kinds of mathematics have been developed since Newton's time that are easier to use and that make it possible to solve problems Newton could not.

Science has been compared to a coral reef, where the living organisms at the surface produce the growth of the reef on top of tens or hundreds of feet of skeletons of organisms that have long since died. The life of the reef is only at its surface; the life of science is only at its frontier.[3]

There is truth in this rather unhappy image. In the light of it, science compares unfavorably with the arts, where the object in which the creative artist embodies his insight retains its value and interest. However, there is a role for the personality of the individual in spite of this eventual depersonalization of the discovery. There is such a thing as a scientific style that distinguishes one scientist from another. It is expressed in the field a scientist chooses, in the problems he chooses within his field, and in the way he attacks these problems. One feels this in reading Black's and Rumford's accounts of their researches. While the dry, unemotional style used in scientific publication today conceals it, scientists still use as wide a variety of approaches as did their predecessors of a century or two ago.

Science, as we have indicated, works by a consensus, and does not require that each individual practitioner have all of the contradictory qualities that characterize the scientific venture itself. There is room for the daring, speculative, inventive spirit who creates new theories or tries bold, imaginative experiments as well as for the cautious, critical spirit who examines theories searchingly or patiently designs and performs tedious but necessary experiments. There are those who like the power and conciseness of mathematics and those who prefer the nuances and color of words; those who prefer the laboratory and those who prefer the library. One person wants to deal with human beings and human problems and is willing to pay the price of vagueness and uncertainty; another person prefers atoms and molecules, about which precise questions can be asked and definitively answered. There is still another division, between those whose satisfaction in their work requires that it be useful and those who are satisfied with the knowledge itself.

But, for all, one goal is the joy and excitement of discovery, described above by Merton and expressed in the quotations we have given from Kepler, Kekulé, and Poincaré.

REFERENCE NOTES

1. James Watson, *The Double Helix*, Atheneum, New York, 1968.
2. Robert K. Merton, Behavior patterns of scientists, *American Scholar* 38:197 (1969). Reprinted with the permission of Professor Merton.
3. Attributed to the physicist and Nobel laureate W.L. Bragg.

SUGGESTED READING

Lives in Science: A Scientific American Book, Simon and Schuster, New York, 1963.

James R. Newman, *Science and Sensibility*, Simon and Schuster, New York, 1961. An abridged paperback edition was published by Anchor Books in 1963.

CHAPTER 13

The Cultural Roots of Science

THE SUBJECTIVE ELEMENT

Throughout this book on scientific method we have repeatedly stressed how little "method" there really is in science. There is no set of prescribed rules which, when followed, will lead unerringly to the truth. Instead, progress is made by reliance on the judgment of individuals choosing among a complex set of possible strategies that are often in conflict with each other, and depends more on intuition than on explicit procedures.

We have often pointed out the subjective element in science. This appears first in the realization that even "scientific facts" contain a more or less culturally conditioned component. It appears also in the creative processes of individual discovery and in the role of the consensus of scientists who decide, on the basis of commonly shared but subjective criteria, what problems are important, what experiments are decisive, what theories are correct. And we have indicated that this consensus is not a democratic consensus of everybody but rather a narrow consensus of interested specialists who have taken the time and effort to master the methods and problems of some particular discipline. We have described the risks of such a procedure—the frequency in the history of science with which the informed consensus shared misconceptions that hindered understanding, and the struggle therefore required of the few creative thinkers to change those misconceptions.

It follows, then, in view of the overriding importance of this subjective element, that the science of any particular time is rooted in the intellectual climate of that time, and can escape its limitations only with difficulty. One can go further: the concepts of what we call science are

inextricably bound up with the particular cultures that have given birth to it and that it in turn has helped to shape.

We cannot offer the reader any magic procedure for rising above the limitations of the intellectual climate to which he is exposed, or, more broadly, above the limitations of his own culture, and enable him to think in other than "culture-bound" terms about scientific questions. But in the final chapter of this section we dó want to discuss the role of a specific culture in determining the nature of the science that can be done in that culture.

THE TACIT COMPONENT

We may use as an example a fact about this book to which the reader has almost certainly given no thought but which he or she must concede as true the moment it is pointed out. *This book is written in English.* We have assumed that the reader shares with us a common language, with its vocabulary, grammar, and nuances of expression. We did not begin this book with a course in the English language to make sure the reader understood the sentences in the way we meant them. We took the common language for granted.

In the same way we assumed that the reader has the common experiences and common sense of members of an industrialized, scientifically oriented society, the concepts, beliefs, logic, and familiarity with things and facts shared by most people living in such a society. We took for granted what we and the reader agree on, and spent time explaining only those aspects of science that we supposed were unfamiliar. We did this because we had no alternative in writing a book of this kind, any more than we had an alternative to writing it in *some* language or other.

We do not believe that it would be possible, even if we wanted to, to explore and discuss every assumption, every concept, used by ourselves and by the reader in developing our picture of scientific method. But in this chapter we have a smaller ambition: we hope we can help the reader realize that there are shared components of our culture that we accept without conscious awareness and that these tacit and unanalyzed components are as essential in providing the conditions for scientific activity as are the methods, procedures, and practices with which this book has been largely concerned.

The discussion so far has been abstract. To make it more concrete, we will provide an example of how a culture determines what kind of science is possible. Historians of science have studied in detail the relation between the scientific thought of a period and its cultural and intellectual climate. We have discussed one example from the history of physics in Chapter 4 on heat, where we dealt with the reasons why Rumford's experiments, which in retrospect seem conclusive to us, were not accepted as such by most scientists of his time, and why half a century had to elapse, during which discoveries had to be made in seemingly unrelated fields of physics, before the ideas of the kinetic theory prevailed. Other examples could have been chosen from similar historical studies, but we feel that the points we wish to make can be made more sharply by considering a culture as different from our own as possible. The example we have chosen is one of a "primitive" culture—that of the Azande in Eastern sub-Saharan Africa, as studied by the British anthropologist Edward Evans-Pritchard in the late 1920s.

THE BELIEF IN WITCHCRAFT

The Azande believe that some people of their own tribe are witches by biological inheritance and that this can be experimentally demonstrated by the discovery of a distinct substance in their bodies after death. Witches have the power, out of spite or envy, to injure others and even cause their deaths. As we will see, the belief in witchcraft fulfills many of the criteria of a scientific system: it provides understanding, it is generally applicable to a wide range of phenomena, and it is based on experimental evidence.

The pervasive role played by witchcraft (see Figure 23) is described by Evans-Pritchard as follows[1]:

> Witchcraft is ubiquitous. It plays its part in every activity of Zande life; in agricultural, fishing, and hunting pursuits; in domestic life of homesteads as well as in communal life of district and court; it is an important theme of mental life in which it forms the background of a vast panorama of oracles and magic; its influence is plainly stamped on law and morals, etiquette and religion; it is prominent in technology and language; there is no niche or corner of Zande culture into which it does not twist itself. If blight seizes the ground-nut crop it is witchcraft; if the bush is vainly scoured for game it is witchcraft; if women laboriously bale water out of a pool and are rewarded by but a few small fish it is witchcraft; if termites do not rise when their swarming is due and a cold useless night is spent in waiting for their flight it is witchcraft; if a wife is sulky and unresponsive to her husband it is witchcraft; if a prince is cold and distant with his subject it is witchcraft; if a magical rite fails to achieve its purpose it is witchcraft; if, in fact, any failure or misfortune falls upon any one at any time and in relation to any of the manifold activities of his life it may be due to witchcraft. Those acquainted either at first hand or through reading with the life of an African people will realize that there is no end to possible misfortunes, in routine tasks and leisure hours alike, arising not only from miscalculation, incompetence, and laziness, but also from causes over which the African, with his meagre scientific knowledge, has no control. (pp. 63–64)

Arguing with the Azande

Evans-Pritchard at times attempted to convince the Azande that witchcraft was not causing these misfortunes, using the sort of argu-

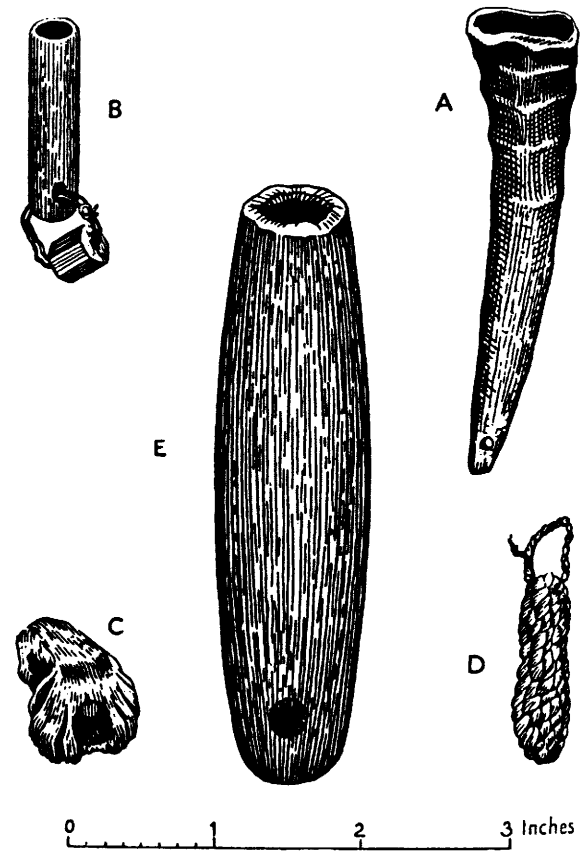

FIGURE 23. Zande magic whistles. (A) Gazelle's horn for preventing rain. (B) Whistle of the *Mani* association with the blue bead badge of the association attached to it. (C) Whistle to protect a man against *adandara* cats. The mouth has been scraped away to provide dust for eating. (D) *Gbau*, a charm of invisibility. (E) A whistle to give protection against witchcraft. From Evans-Pritchard's *Witchcraft, Oracles and Magic Among the Azande.* (Reproduced with permission of Oxford University Press.)

ments that would naturally occur to a person from a Western scientific culture[1]:

> I found it strange at first to live among Azande and listen to naïve explanations of misfortunes which, to our minds, have apparent causes, but after a while I learnt the idiom of their thought and applied notions of witchcraft as spontaneously as themselves in situations where the concept was relevant. A boy knocked his foot against a small stump of wood in the centre of a bush path, a frequent happening in Africa, and suffered pain and inconvenience in consequence. Owing to its position on his toe it was impossible to keep the cut free from dirt and it began to fester. He declared that witchcraft had made him knock his foot against the stump. I always argued with Azande and criticized their statements, and I did so on this occasion. I told the boy that he had knocked his foot against the stump of wood because he had been careless, and that witchcraft had not placed it in the path, for it had grown there naturally. He agreed that witchcraft had nothing to do with the stump of wood being in his path but added that he had kept his eyes open for stumps, as indeed every Zande does most carefully, and that if he had not been bewitched he would have seen the stump. As a conclusive argument for his view he remarked that all cuts do not take days to heal but, on the contrary, close quickly, for that is the nature of cuts. Why, then, had his sore festered and remained open if there were no witchcraft behind it? This, as I discovered before long, was to be regarded as the Zande explanation of sickness. . . . (pp. 65–66)
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> One of my chief informants, Kisanga, was a skilled woodcarver, one of the finest carvers in the whole kingdom of Gbudwe. Occasionally the bowls and stools which he carved split during the work, as one may well imagine in such a climate. Though the hardest woods be selected they sometimes split in process of carving or on completion of the utensil even if the craftsman is careful and well acquainted with the technical rules of his craft. When this happened to the bowls and stools of this particular craftsman he attributed the misfortune to witchcraft and used to harangue me about the spite and jealousy of his neighbours. When I used to reply that I thought he was mistaken and that people were well disposed towards him he used to hold the split bowl or stool towards me as concrete evidence of his assertions. If people were not bewitching his work, how would I account for that? (pp. 66–67)

Carelessness and Witchcraft

The Azande do not explain all misfortunes as the result of witchcraft. They recognize fully that misfortunes can be caused by one's own carelessness, inexperience, or improper behavior. A girl who breaks her water pot and a boy who forgets to close the door of the henhouse at night will be admonished by their parents, but the harmful consequences of their negligence are not attributed to witchcraft; if a clay pot cracks during firing, and it is found on examination that a pebble was left by accident in the clay, this will be blamed on the carelessness of the potter. It is only those misfortunes that occur to people who have taken normal and reasonable care in their work or their lives that need such an explanation[1]:

> In speaking to Azande about witchcraft and in observing their reactions to situations of misfortune it was obvious that they did not attempt to account for the existence of phenomena, or even the action of phenomena, by mystical causation alone. What they explained by witchcraft were the particular conditions in a chain of causation which related an individual to natural happenings in such a way that he sustained injury. The boy who knocked his foot against a stump of wood did not account for the stump by reference to witchcraft, nor did he suggest that whenever anybody knocks his foot against a stump it is necessarily due to witchcraft, nor yet again did he account for the cut by saying that it was caused by witchcraft, for he knew quite well that it was caused by the stump of wood. What he attributed to witchcraft was that on this particular occasion, when exercising his usual care, he struck his foot against a stump of wood, whereas on a hundred other occasions he did not do so, and that on this particular occasion the cut, which he expected to result from the knock, festered whereas he had had dozens of cuts which had not festered. Surely these peculiar conditions demand an explanation. . . . (pp. 67–68)
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> In Zandeland sometimes an old granary collapses. There is nothing remarkable in this. Every Zande knows that termites eat the supports in course of time and that even the hardest woods decay after years of service. Now a granary is the summerhouse of a Zande homestead and people sit beneath it in the heat of the day and chat or play the African hole-game or work at some craft. Consequently it may happen that there are people sitting beneath the granary when it collapses and they are injured, for it is a heavy structure made of beams and clay and may be stored with eleusine as well. Now why should these particular people have been sitting under this particular granary at the particular moment when it collapsed? That it should collapse is easily intelligible, but why should it have collapsed at the particular moment when these particular people were sitting beneath it? Through years it might have collapsed, so why should it fall just when certain people sought its kindly shelter? We say that the granary collapsed because its supports were eaten away by termites. That is the cause that explains the collapse of the granary. We also say that people were sitting under it at the time because it was in the heat of the day and they thought that it would be a comfortable place to talk and work. This is the cause of people being under the granary at the time it collapsed. To our minds the only relationship between these two independently caused facts is their coincidence in time and space. We have no explanation of why the two chains of causation intersected at a certain time and in a certain place, for there is no interdependence between them.
>
> Zande philosophy can supply the missing link. The Zande knows that the supports were undermined by termites and that people were sitting beneath the granary in order to escape the heat and glare of the sun. But

> he knows besides why these two events occurred at a precisely similar moment in time and space. It was due to the action of witchcraft. If there had been no witchcraft people would have been sitting under the granary and it would not have fallen on them, or it would have collapsed but the people would not have been sheltering under it at the time. Witchcraft explains the coincidence of these two happenings. (pp. 69–70)

Why? And How?

It would not be correct to say that modern science provides a better explanation than witchcraft for the things the Azande wish to explain. Rather, the questions the Azande seek answers for are *different* from the ones science tries to answer. Why did this particular cut in the foot get infected, while dozens of other such cuts did not? Why did the granary collapse just when people were sitting under it?

If we look for scientific answers to such questions, we do not always succeed. For example, modern medicine gives us at present an explanation of why cuts *in general* can become infected: microorganisms must grow in the wound to produce the infection. But many cuts do not become infected, either because microorganisms were not introduced into the cut, or because cleaning and disinfecting the wound eliminated them, or because the natural resistance mechanisms of the body were able to prevent their growth. A precise explanation of why *this* cut became infected and *that* cut did not is not always possible. We do not usually observe all the facts necessary to reach a conclusion, and are driven to "explanations" based on chance.

We have quoted in an earlier chapter P. B. Medawar's statement, "Science is the art of the soluble." This implies a willingness to leave unanswered, perhaps for the time being and perhaps forever, many kinds of questions, to accept that there are problems we would like to know how to solve but can't, and to acknowledge our impotence.

But the question of why some particular misfortune occurred can also be asked in a different sense, a moral one concerned with purpose in the universe, with the will of God, rather than a scientific one. Why did this young and talented person get killed in an auto accident? Why did this child we knew and loved die painfully of cancer? Why *him?* Why *her?* No questions are more meaningful than these, but science doesn't answer them.

One may say that science deals with questions of *how.* Questions of *why* relate to conscious purpose and are beyond its reach. Indeed, this distinction exists for the Azande as well. The question of how the misfortune produced by witchcraft actually occurs they explain much as we do. The collapse of the granary occurs because termites have eaten the supports. A man who is injured by a charging elephant because of the influence of witchcraft is injured by an elephant, not by a witch masquerading as an elephant.

But in the Azande world much more of what happens can be explained; much less is left to chance or fate or the will of an inscrutable God.

The Poison Oracle

The Azande have a procedure for ascertaining if someone is threatened or being made to suffer by witchcraft, and who the witch is. It is by the use of what Evans-Pritchard calls the "poison oracle."

The procedure for appeal to the poison oracle requires the preparation of *benge,* a presumably poisonous extract of a particular plant (which does not grow in the country the Azande live in, but must be prepared elsewhere and brought in).

An operator forces *benge* down the throat of a young fowl (see Figure 24) while addressing questions to the *benge* inside the fowl. Sometimes the fowl dies during the procedure and sometimes it lives. The life or death of the fowl provides the answer to the question.

The primary question to be answered may be, for example, "Is Namarusu's health threatened by Nabani and her relatives?" That is, is Nabani using witchcraft or some other form of magic to harm Namarusu?

The operator speaks as follows, having administered the poison:

"Poison oracle, if Namarusu's health is threatened by Nabani, kill the fowl. If Namarusu's health is not threatened by Nabani, spare the fowl." If the fowl dies, the answer to the primary question is "yes"; if it does not die, the answer is "no."

One may wonder, as Evans-Pritchard did, if the Azande realize they are administering a poison that might kill the fowl regardless of the question asked[1]:

> Therefore, to ask Azande, as I have often asked them, what would happen if they were to administer oracle poison to a fowl without delivering an address or, if they were to administer an extra portion of poison to a fowl which has recovered from the usual doses, or, if they were to place some of the poison in a man's food, is to ask silly questions. The Zande does not know what would happen, he is not interested in what would happen, and no one has ever been fool enough to waste good oracle poison in making such pointless experiments, experiments which only a European could imagine. Proper *benge* is endowed with potency by man's abstinence and his knowledge of tradition and will only function in the conditions of a seance.
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> When I asked a Zande what would happen if you went on administering dose after dose of poison to a fowl during a consultation in which the

FIGURE 24. Operating the poison oracle. The operator contemplates the chicken during the address to the oracle (above). The chicken, held in the operator's hand, is at its last gasp (below). From Evans-Pritchard's *Witchcraft, Oracles and Magic Among The Azande.*

oracle ought to spare the fowl to give the right answer to the question placed before it, he replied that he did not know exactly what would happen, but that he supposed sooner or later it would burst. He would not countenance the suggestion that the extra poison would otherwise kill the fowl unless the question were suddenly reversed so that the oracle ought to kill the fowl to give a correct answer when, of course, it would at once die. When I asked a Zande whether you might not put a handful of the poison into a man's beer and rid yourself of an enemy expeditiously he replied that if you did not utter an address to the poison it would not kill him. I am sure that no Zande would ever be convinced that you could kill a fowl or person with *benge* unless it had been gathered, administered, and addressed in the traditional manner. Were a European to make a test which proved Zande opinion wrong they would stand amazed at the credulity of the European who attempted such an experiment. If the fowl died they would simply say that it was not good *benge*. The very fact of the fowl dying proves to them its badness. . . . (pp. 314–15)

If you ask a Zande what would happen if a man were to administer three or four doses to a tiny chicken instead of the usual one or two doses he does not perceive that there is any subtlety in your inquiry. He will reply to you that if a man were to do such a thing he would not be operating the oracle properly. He does not see the relevance of your question, for you are asking him what would happen if a man were to do what no one ever does and he has no interest in hypothetical actions. During the early part of my residence among them they used to say to me, "You do not understand these matters. However many doses you administer to a chicken it does not alter the verdict of the oracle." You say to the oracle, "So-and-so is ill. If he will live, poison oracle kill the fowl. If he will die, poison oracle spare the fowl." "If he is going to live, however many doses of the poison you administer to the fowl it will still survive." They responded to my questions without signs of distress. Clearly they were not defending a position which they felt to be insecure. (p. 324)

One should recognize that the Azande, in refusing to consider the "experiments" suggested by Evans-Pritchard, are not being unreasonable or unscientific by the standards of their own culture. They are responding much as an astronomer might if he were asked if he would still see the stars through his telescope if the outside of it were painted blue. He would regard the question as pointless, based on a complete misconception of how a telescope works, and he would not be in the least tempted to paint it blue to convince the questioner or reassure himself.

The Confirmatory Test

In using the *benge*, or poison oracle, a confirmatory test is required: to be sure of the answer, two tests on two different fowls must be made. In the second test the same basic question is being asked, but in order for the answer to be confirmed, the wording of the question must be such that if in the first test the fowl died then in the second test it must live, and vice versa. Specifically, in the second test (if the fowl died in the first one) the operator must address the *benge* in a form equivalent to the following: "If the poison oracle told the truth on the previous test, spare the fowl. If it lied, kill the fowl."

If the results of the second test confirm the results of the first (the fowl in the second test lives), the result is trusted. If, however, the second test does not confirm the first (the fowl dies), the result is invalid. Assuming for simplicity that about half the time the poison kills a fowl and half the time it does not, we can apply probability theory to predict that about half the time the two tests will lead to a consistent answer and about half the time they will lead to an invalid answer. How do the Azande deal with the invalid results? What happens if the answer given even by a valid result turns out to be wrong?

Dealing with Contradictory Results[1]

What explanation do Azande offer when the oracle contradicts itself? Since Azande do not understand the natural properties of the poison they cannot explain the contradiction scientifically; since they do not attribute personality to the oracle they cannot account for its contradictions by volition; and since they do not cheat they cannot manipulate the oracle to avoid contradictions. The oracle seems so ordered to provide a maximum number of evident contradictions for, as we have seen, in important issues a single test is inacceptable and the oracle must slay one fowl and spare another if it is to deliver a valid verdict. As we may well imagine, the oracle frequently kills both fowls or spares both fowls, and this would prove to us the futility of the whole proceeding. But it proves the opposite to Azande. They are not surprised at contradictions; they expect them. Paradox though it be, the errors as well as the valid judgements of the oracle prove to them its infallibility. The fact that the oracle is wrong when it is interfered with by some mystical power shows how accurate are its judgements when these powers are excluded.

A Zande is seated opposite his oracle and asks it questions. In answer to a particular question it first says "Yes" and then says "No." He is not bewildered. His culture provides him with a number of ready-made explanations of the oracle's self-contradictions and he chooses the one that seems to fit the circumstances best. He is often aided in his selection by the peculiar behaviour of the fowls when under the influence of the poison. The secondary elaborations of belief that explain the failure of the oracle attribute its failure to (1) the wrong variety of poison having been gathered, (2) breach of a taboo, (3) witchcraft, (4) anger of the owners of the forest where the creeper grows, (5) age of the poison, (6) anger of the ghosts, (7) sorcery, (8) use.... (pp. 329–330)

Witchcraft... is often cited as a cause for wrong verdicts. It also may render the oracle impotent, though impotency is usually attributed to breach of taboo. Generally speaking, the presence of witchcraft is shown by the oracle killing two fowls in answer to the same question, or in sparing two fowls in answer to the same question when it has killed a fowl at the same seance. In such cases the poison is evidently potent and its failure to give correct judgements may be due to a passing influence of witchcraft. For the time being the seance may be stopped and resumed on another day when it is hoped that witchcraft will no longer be operative. Out of spite a witch may seek to corrupt the oracle, or he may act to protect himself when the oracle is being consulted about his responsibility for some misdeed.... (p. 332)

But when faith directs behaviour it must not be in glaring contradiction to experience of the objective world, or must offer explanations that demonstrate to the satisfaction of the intellect that the contradiction is only apparent or is due to peculiar conditions. The reader will naturally wonder what Azande say when subsequent events prove the prophecies of the poison oracle to be wrong. The oracle says one thing will happen and another and quite different thing happens. Here again Azande are not surprised at such an outcome, but it does not prove to them that the oracle is futile. It rather proves how well founded are their beliefs in witchcraft and sorcery and taboos. On this particular occasion the oracle was bad because it was corrupted by some evil influence. Subsequent events prove the presence of witchcraft on the earlier occasion. The contradiction between what the oracle said would happen and what actually has happened is just as glaring to Zande eyes as it is to ours, but they never for a moment question the virtue of the oracle in general but seek only to account for the inaccuracy of this particular poison, for every packet of *benge* is an independent oracle and if it is corrupt its corruption does not affect other packets of the poison. (p. 338)

SCIENCE VERSUS WITCHCRAFT

As we pointed out, the Azande belief in witchcraft has many of the features of a scientific system. First, it has great explanatory power and is of great generality in application: it explains more of the events and misfortunes of daily life than any Western scientific system does. Also, it is supported by experimental evidence: the stubbed toe that becomes infected, the wooden bowl that splits, the granary that collapses. Further experimental evidence is provided by the poison oracle.

One may ask, but what about the truth or falsity of the belief in witchcraft itself? Can that not be subject to an experimental test that would convince the Azande of its falsity?

Here we must remember a point made many times in this book: testing a theory is not a routine procedure. What kind of experimental evidence will be considered relevant is always a subjective judgment of the scientific community involved. When the Azande disregard or brush aside the types of experiments we would propose to refute their belief in witchcraft, they are not acting so differently from ourselves. We too stick with a theory that we have found useful, in spite of awkward contradictory facts, unless we have a better one to replace it with. We may also fail to recognize contradictions and absurdities in our strongly held beliefs, although they may be apparent to others who do not share them.

All the arguments and evidence we could muster to refute the Azande beliefs may be appropriate and convincing to fellow members of our own culture, but not to members of theirs, as Evans-Pritchard points out frequently.

There is no appeal to "common sense," either. The Azande have survived as a people for a long period of time in a hostile and difficult environment, and have developed a complex society based on both hunting and agriculture which includes different occupations: princes, witch-doctors, and woodcarvers, among others. Whatever we mean by common sense, we cannot say that they don't have it just because ours is different.

In making these points we are raising difficult philosophical questions that are beyond our competence to answer: Is what we have called the scientific method, as developed mainly in Western societies, a better, surer road to truth and understanding than any other? Or is truth relative, and what is true in one culture false in another, with no objective way to decide? We are not trying to answer these questions. Our purpose is a much less ambitious one: to make the reader aware that such questions exist.

However solid and universal scientific knowledge may seem, it should be recognized that it is a culturally determined kind of knowledge, expressed in the language—in both the literal and conceptual senses of the word *language*—of a particular culture, and it depends in complex ways on the unspoken assumptions of that culture.

CULTURES AND SUBCULTURES

We hope that this description of Azande beliefs has helped the reader recognize the relation between science and the presuppositions of the culture of which science is a part. It should also reveal something about the relationships within a society among the various subcultures that are distinguished by their adherence to particular sets of beliefs. This includes the different disciplines which constitute science as well as the competing schools of thought within each discipline. It also includes other subgroups within Western society: for example, those having distinct sets of religious, political, or esthetic beliefs. Members of such subgroups share not only formally expressed beliefs of which they are consciously aware, and which they recognize set them off from others, but also sets of tacit and unconscious concepts which provide the foundations that the formal beliefs are based on. This unacknowledged foundation of beliefs is something we sense dimly when we argue with members of subgroups other than our own, and it is the existence of such tacit components that often makes such arguments difficult, frustrating, and pointless.

SCIENTIFIC SUBCULTURES

The tacit part of knowledge creates problems for communication between adherents of different belief systems, and, more narrowly and more relevantly to this book, it creates problems within science. Controversies between different scientific schools of thought are not only about what is conscious and acknowledged but also about what isn't.

In the case histories we discussed examples of such controversies: between the kinetic and caloric theories of heat, between psychodynamic and biological theories of the origin of schizoprenia. In both, the members of opposing schools of thought formed their own subcultures, each with its own distinctive philosophy, style, type of training, way of asking questions, and so forth. The differences were about much more difficult things than just facts. In truth, at times the differences between scientific subcultures can seem as great as those between Western society and the Azande. Using the term proposed by T. S. Kuhn, they operate according to different "paradigms."[(2)]

The problems that arise in the course of a scientific revolution, when scientists belonging to a particular subculture are faced with the necessity of rising above its limitations and seeing things from an entirely different viewpoint, were described in a pessimistic and cynical way by Max Planck, one of the discoverers of the quantum theory of the atom[(3)]:

> An important scientific innovation rarely makes its way by gradually winning over and converting its opponents: it rarely happens that Saul becomes Paul. What does happen is that its opponents gradually die out and that the growing generation is familiarized with the idea from the beginning. . . . (p. 97)

BREAKING THROUGH

One should avoid the temptation to feel superior to the conservative and culture-bound members of a scientific discipline faced with revolutionary new ideas. Most dazzling and startling new ideas are not revolutionary advances at all—they are false starts and deserve rejection. There is a lot to be said for judgment, discrimination, a measure of caution, even if once in a thousand or ten thousand times they cause one to disregard a new and valuable insight.

Fortunately, we do break through the limitations of our culture from time to time. Scientific revolutions have occurred and will occur again, with dramatic consequences for our previous conceptions of ourselves and of our universe, as happened with Darwin's statement that we are descended from animals, with Einstein's discovery that matter and energy are different manifestations of a single entity, with Freud's revelations of the sources of our deepest feelings.

Of course, most scientific discoveries are not really breathtaking new insights which change our most fundamental conceptions of what is true and what is not. They are often humble affairs, having no dramatic consequences outside the narrow discipline in which they take place. Yet all of them do involve to some extent a process of making explicit what had previously been tacitly accepted, and challenging it. Something that had been buried in the collective unconscious of the members of some culture or subculture is forced to the surface and looked at for the first time. Much of scientific discovery, particularly that which changes us, the discoverers, is a discovery of a part of our tacit heritage, a recognition that something that has been so taken for granted that we have never dreamed of doubting it is, first, doubtable, and, finally, wrong.

Fortunately, there are simple enough examples from our own history, which to some extent we have to relive in our own individual intellectual development, to convey the idea of what a scientific revolution is like. To think of the world as round rather than flat is one such. To make such a leap in thought, it was necessary to overcome one basic concept we all have developed from our earliest experiences: the concept of *up* and *down*. It is easy for us, having been indoctrinated with the idea, both in school and out of it, that *up*, and *down* are determined by the earth's gravitational field, to be aware that up and down in China or Australia are different from up and down in New York or London. But a young child, seeing things fall down, falling himself as he begins to walk, feeling with every step the sense of the downward force of his own weight, takes as given the idea that *down* is the unique direction in which things fall and *up* is its opposite. The basic experiences that define these directions do not hint to us that they are relative, and that under other circumstances—on a rocket traveling to the moon, for example—*up* and *down* are not even there. One can see what a leap of the imagination, what a denial of the obvious and unquestioned, was involved in thinking of a round earth.

A second such revolution, again repeated in our individual intellectual growth, was to see the earth as moving, rather than the sun and the stars. Again, we had to discard what was obvious from our earliest experiences. Almost all our experiences of motion are experiences of rough motion. Although we no longer ride much on horseback or in ox carts but rather use cars and planes, we associate motion with jerks, bumps, the pulls of acceleration and deceleration. How could the earth be moving if we do not feel it? To imagine a moving earth was not simply a matter of stating glibly that motion is relative. It was necessary to imagine an idealized kind of motion that lay outside ordinary experience—a smooth motion at a constant speed, without those bumps and jerks that give real motion away. Once this was done, it became possible to speculate that our impression that we are standing still, and that the sun and stars are moving about us, might be only an impression, and that reality might be something else.

Living through such revolutions—being forced to drop our old viewpoint, which we may have relied on for most of a lifetime, and which had seemed to offer us such a solid, true picture of reality, and adopt a completely new one—can be an unnerving experience. The history of science is filled with examples of scientists, even great ones, who were unable to face it. But it can also be an exhilarating and liberating experience, and the highest reward of the scientific life.

REFERENCE NOTES

1. Edward Evans-Pritchard; *Witchcraft, Oracles and Magic Among the Azande*, Clarendon Press, Oxford, 1937. Reprinted by permission of the publisher.
2. Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd ed., University of Chicago Press, Chicago, 1970.
3. Max Planck, *The Philosophy of Physics*, W Johnston, trans. W. W. Norton, New York, 1936.

SUGGESTED READING

In this chapter we quote extensively from Edward Evans-Pritchard's book, *Witchcraft, Oracles and Magic Among the Azande* (Oxford: Clarendon Press, 1937) with the permission of the publishers. An abridged paperback version, also published by Oxford University Press, has just appeared. More detailed discussions of the issues dealt with in this chapter have appeared in *Modes of Thought: Essays on Thinking in Western and*