times higher than that in the main body of seawater. This is caused by the adsorption of virus to air bubbles as they rise through the water. When they burst at the surface the bubble skin strips the virus-rich layer of water from the bubble surface and ejects it into the air as small droplets. This mechanism of virus enrichment in the aerosol is, no doubt, the same as that which has been found for bacteria (*11*).

This work has implications for the field of public health, especially because viruses have been found in sewage (*6*), and because the dumping of sewage into the coastal regions of the sea is commonplace.

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Humanity in Science: A Perspective and a Plea

June Goodfield

Summary. The phrase "humanity in science" encompasses several problems of various dimensions, which have been present for a long period. Their particular force can be most clearly appreciated by seeing the historical circumstances in which they arose and by examining the changing nature of the social contract between the scientific profession and society. The new ethical imperatives presently operating within society call for new responses. In addition, new ways must be found of mirroring scientific activity so as to more faithfully reflect its real nature to and incorporate it into our culture.

It is an honor and a pleasure to be asked to give the Phi Beta Kappa lecture to the American Association for the Advancement of Science, and after nearly a century and a half of a remarkable tradition in both America and England, it is a good opportunity to take stock. Here in Denver, representatives of the scientific profession, the media, and the enlightened citizenry of the town meet in an atmosphere if not of complacency, at least one that shows a tendency toward mutual admiration. We are the heirs of a very worthy tradition, which in England goes back some 146 years to 1831, when the British Association for the Advancement of Science held its first meeting in York, and thus started these annual celebrations of worthy endeavor and high purpose.

Now if we look around, both at this present gathering and retrospectively at history, we are tempted to deduce that all is indeed well with the relationship of science and society, and that 146 years earlier all, indeed, was well; that from the beginning the public and the scientific profession together have enjoyed a persistently happy partnership. Both deductions are quite wrong. All is not well with the present relationship between science and society, and in the early years too, when the scientific profession was born in Europe, all was not well. The golden days for the mutual involvement of science and society came much later. At the beginning there were, in fact, great tensions as the profession emerged, and equally there are some now. And I want to argue that at least one problem which lies at the root of some of our present troubles was a specter at these feasts from the very start and has haunted the profession ever since. If I may change my metaphor; it has been like the Cheshire cat, taking on firm outlines at one period, fading at another, and then returning to sneer at us once more. This problem is the theme of my article and it is the problem of humanity in science.

Now this phrase can have several meanings. Marie Curie once said, "Science deals with things not people." The problem arises if, and when, scientists and technologists are tempted to deal with people as things. One of the problems in and around science arises through the inevitable stance of detached objectivity whereby a scientist must approach the natural world. It can be no problem—but as recent work in the biomedical sciences or genetic engineering demonstrates, it can be a serious problem. And at a time when the social contract between this profession and society is in the process of being renegotiated, as it is now, humanity in science considered in these terms becomes deeply significant.

The second interpretation of this phrase means a consideration of the human beings who do science; those remarkable people who come to us in an assemblage infinitely varied. It is difficult to reach out and touch the humanity, or the humaneness, in the people who do

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science, because science is essentially a communal activity whose results must be expressed in the passive voice, to be understood by anyone throughout geographical space and historical time. The expressions of science come in forms from which all the human content has necessarily been drained. So the questions, Who are the people who do science as individual human beings? What is the relationship between them and the scientific ideas they create? How and in what form are individuality and creativity brought to bear and expressed in science?—these are pressing questions which have not received the attention they deserve. I want to ask one other question as well: Why, with very few exceptions, have these themes or these people never stimulated great works of literature or art?

Lastly, the problem of humanity in science can mean the relationship between scientific and humanistic modes of thought and their impact on one another. This touches on the central core of creativity which lies at the heart of both humanistic and scientific work. I shall raise all these questions and answer some of them. I shall also suggest that our attempts to mirror the human life in and around science have been somewhat defective, to put it mildly. Our failure to do this has both deprived our artists of the possibility of portraying this great area of human activity, and contributed to the myths about the scientist and scientific activities which are highly dangerous, especially in the present time. I shall also argue that the schisms and the problems we now see on the contemporary scene arose in an historical setting and had significant historical ramifications. The failure to come to grips with the problem of humanity in science in the 19th century has had important consequences for the relationship between science and society in the 20th century. This problem originated deep in the social matrix of this profession, and its solution lies equally deep in our social matrix.

The British Association for the Advancement of Science

By now the origin of the British Association for the Advancement of Science is well known. Its founding was stimulated by a book by Babbage, *Reflections on the Decline of Science in England* (*1*), written in 1830, at a time when the word scientist was not even coined. After traveling extensively on the Continent, Babbage came to the conclusion that measured by almost any criteria you could mention—status, honorary distinction, or government post—science did not enjoy a status comparable to that of any other profession in England. Not only was it in a very inferior position, it was not a profession at all. As a result, the British Association for the Advancement of Science was formed. Their motives were "To give a stronger impulse and a more systematic direction to scientific enquiry and to obtain a greater degree of national interest in the objects and prosecution of science" (*2*). Their aims were not entirely altruistic, of course. The members of the Association did, indeed, want to remedy the situation that Babbage had portrayed, but they also felt that by showing society the practical justification for the existence of science, by demonstrating science's capacity to respond to social problems, they would strengthen the ties between the practitioners of science and the public. In other words, they had Rousseau's original social contract in mind, defined as a situation of mutual support, where each party relinquishes a measure of freedom for the wider social good.

They described themselves as the "cultivators of science." This was true, for that is exactly what they were. But they were also realistic and practical and, with their new pragmatic attitude, appealed not to the disinterested search for truth but to the benefits that could come by a close association between the profession and society. What happened? While all their initial efforts were not quite disastrous, it is absolutely true to say, as with Wellington after Waterloo, that "it was a damned close run thing" (*3*). For 10 years that profession and the British Association were subject to a degree of indifference or derision and parody, and at times were treated with such humiliation by the newspapers that I sometimes wonder that the profession got off the ground at all. The fact that after 20 years they were inclined to hole up and become more and more introverted surprises me not a little bit when one remembers what was written. For example, *The John Bull Examiner*, reporting on the Association's meeting of 1835, described it as "a whole lot of glaring humbug." The distinguished divine J. Keble, who founded Keble College at Oxford University, described the British Association as "a heap of quack philosophers." Even after 10 years, the London *Times* was being mightily rude in the glorious way that the London *Times* can be from time to time. A convention of Nonconformist ministers set themselves up as a clerical organization modeled on the British Association, and the paper reporting this described the latest British Association meeting in Devonport, 1841, as a "sort of philosophical race-week" and commented that the "new synod of tabernacle Savans" might "even surpass the freaks and fooleries of their model" (*4*).

Now why English society took this attitude is something that I have dealt with at length elsewhere (*5*). But it has to be admitted that, to a certain extent, the members of the British Association were sitting ducks for parody, for as membership increased so did the publicity both before and after the meetings. As the publicity got more flowery and full of puff, the hospitality became more lavish and the dinner menus became more lengthy. These were published along with the scientific papers. After the Newcastle meeting in 1838, *The London Literary Gazette* printed a report from *The Newcastle Journal* which listed the amount of game donated to the feast by the aristocratic lords of Newcastle, "to prove that gastronomy beats astronomy." The *Times*, reporting on the same meeting, spoke of the grand promenade in the ballroom of Newcastle's finest hotel, where some 4000 people were entertained, at which the amusements and refreshments were of the most recherché description. One longs for more details.

Yet, sadly, the British Association did have a record of offending British Victorian susceptibilities. They held one meeting at Castle Howard, the home of Lady Mary Howard, who was a kind of Victorian Carrie Nation. She was so offended by the junketings of the scientists and the hangers-on that she caused the family's wine cellar to be drowned in the lake, and supervised the massacre herself by knocking off the top of every bottle before it went under. Now, as Chaudhry shows in his interesting article on Charles Dickens (*6*), in spite of the Association's very genuine attempts to improve public understanding of science, what in fact came out was an indiscriminate mixture of science, technology, pomposity, and vanity. "Far from popularising science," he wrote, "the British Association had only succeeded in vulgarising it." It appears that its very reasonable aims had been given up in favor of activities which were far from scientific (*7*).

Charles Dickens

My purpose here is to concentrate on one gadfly, Charles Dickens. He became editor of *Bentley's Miscellany*, and in the autumn of 1837 had intended to publish

Oliver Twist in the magazine. But he was diverted from this, for on 9 September the British Association held its annual meeting in Liverpool. In October of that year, Dickens wrote in the magazine "The full report of the first meeting of The Mudfrog Association for the Advancement of Everything" (*8*). He had already taken one laugh at the expense of the British Association in *Pickwick Papers*, and he now proceeded to take several more, basing his parodies on the annual reports. To build up an exaggerated mock excitement of the tension and drama of science, Dickens employs the simple satire of the bustle of the newspapers, which are putting out communiqués at hourly intervals, then half-hourly intervals, and then quarter-hourly intervals. The climax comes when Augustus, somebody's pet pug-dog, is stolen on the eve of the meeting and is dissected by two professors in their disinterested search for truth. The scientists who perpetrate this dastardly crime are thereby correspondingly assaulted by the owner of the aforesaid Augustus, an unmarried lady of otherwise impeccable virtue.

Dickens selected his items for parody from the agendas of all the sections, and few of them escaped his scalpel. For instance, he describes one section whose members were to take a cauliflower and redesign it as a parachute, to be guaranteed to come down from a height of no less than 1½ miles. In this he merges two episodes that had recently occurred: somebody had described a giant water lily at Kew, and also a parachutist had fallen to his death the week before. Having constructed a parachute on what he described as impeccable scientific principles—that is, in the shape of an inverted umbrella—the aviator had gone up to one of London's highest points and had come down to an untimely death. The *Times* reported this as "an unfortunate aeronautical catastrophe."

Among other things, Dickens also describes Mr. Tickle's spectacles, which are designed to enable the wearer to discern, in very bright colors, objects at a very great distance, but which render him wholly blind to those immediately before him. He parodies recent government reports; he talks about whether we could, in fact, utilize the industrial fleas in the zoos. He thinks we ought to license the fleas to do work for us, for they could labor under the direction and control of the state, and their widows and orphans could be put in insect almshouses. From the study of these insects at work we would derive valuable hints for "the improvement of our metropolitan universities, our national galleries and other public edifices." The core of Dicken's parody is not difficult to fathom. The first thing he hated was humbug; the second thing he hated was the denial of humanity, and all his parody has a striking social intent. Humbug is easily disposed of—all you have to do is prick it with a pin. But denial of humanity is not, and it is this humanity which was encapsulated in Marie Curie's aphorism which I mentioned before.

I said that the problem really begins when we are tempted to regard people as things; this especially was the root of Dickens' hearty dislike of statistics. For he saw a situation when science would cease to regard its objects of study as human beings and regard them solely as numbers in a statistical equation, and he would have none of it.

In passing, we may note that Dickens himself was greatly influenced by early Carlisle, who attacked the whole of the utilitarian movement and numerical quantification. Like Carlisle, too, he had a great distrust of institutions designed apparently only for talk. He did not like politics; he did not like Parliament, and he certainly did not like people who, like Mrs. Jellibee, organized charity for the Africans with a general whip-round in order to provide underwear for the people of Senegal. He was very suspicious of such attempts, for he believed that organized charity was merely an institutional device for channeling our sympathies, making them impersonal and unavailable in human terms. It is sad that Dickens, with his comic irony and his vivid sympathy, has no real solution to all this except that of a good heart. In *Oliver Twist*, along comes that nice man and gets Oliver out of the problem. But by the time we get to the later novels, *Our Mutual Friend* and *Great Expectations*, Dickens is sadly pessimistic. He implies that human relationships are so riddled with material ambition, selfishness, and snobbery that the possibilities of humanizing our society recede more and more.

Allegiance of the Scientist

Now as I have indicated, the detached, objective stance which has served, and will continue to serve, science so admirably as a methodology finds no cause for concern when we are investigating the passage of gases through the pores of a leaf. But it really begins to be a source of concern when we look at the implications of recent biomedical research or many of the implications of recombinant DNA research, as they relate to human genetic engineering. Whenever science begins to impinge on the autonomy of human beings such problems always arise, and these force us to reexamine, in our new setting, a very old question—namely, that of the allegiance of the scientist. This was first raised in the middle of the 19th century by a number of people, including Lyon Playfair, who was to be president of the British Association in 1885. But the mid-century was a time when science and society were moving to delineate the forms of their social contract. The question is this: Where is the allegiance of a scientist properly due? Is it to an abstract ethic? Is it to a methodology? Is it to themselves as a profession, or is it to society?

In the 19th century it came to be taken for granted—and almost by default—that the profession's allegiance was solely to the first (*5*). But in the last quarter of this century it is surely patently clear that it must become very much wider. So my first plea is for some practical recognition of the new ethical imperatives operating both on science and on society. At this stage let me give only one example. The United States has the most sophisticated and remarkable biomedical research establishment in the world. It also has a remarkable scientific profession, which is highly privileged. I agree with the distinguished immunologist, Barry Bloom; it is both morally right and scientifically possible to concentrate some of our intellectual and technological effort on the pressing medical problems of the Third World—leprosy, malaria, and schistosomiasis for a start.

There is something distasteful at the sight of a highly developed society being forced to divert great resources, both financial and intellectual, to the cure of its own self-inflicted diseases. We can characterize these as the diseases of choice—those which arise from excesses in its life-style, or the pollution of its environment. In 1975 the United States spent $22 billion on alcohol and $12 billion on tobacco, and in the preceding year it spent $400 million on cancer research. Yet the World Health Organization estimates that to do an effective interdisciplinary remedial job on the problem of the Third World diseases, those that arise not by choice but by causes external to the people themselves, would cost only $15 million per annum. I do not wish this point to be misunderstood. This is not a plea for less basic research. I continue to be greatly impressed with the importance of such work and how, for example, work supported for research in cancer can have an impact in other areas of medicine—how, for ex-

ample, basic immunological studies bear immediately on autoimmune disease. This plea is both for a change in life-style and a research program directed to the problems I mention. To support such work would, I believe, be one of the most farsighted acts this new Administration could undertake. There is an untapped source of idealism, energy, and intellectual skills in the young scientists of this nation, and I would like to see the development of a scientific Peace Corps devoted to tackling some of these problems, to gaining much more knowledge and helping to implement the solutions in terms of the cultures, life-styles, and aspirations of these other countries. Nothing would do more political good to this nation and few single acts, I think, would bring more decency into the world.

Now I must emphasize that there is nothing God-given or immutable in the scientific profession's apolitical disinterested search for truth. Even in the 17th century, more than one-third of the papers of the Royal Society were about social problems and the relationship of science to them. In addition, in the early years of the 19th century the initial aims of the British Association were to bring the problems of society and the skills of science together. That the profession was driven into itself was not, I would argue, its fault. Moreover we have seen a similar emphasis in the late 20th century. When Sir John Kendrew was president of the British Association in 1972, he pleaded for a change in attitude and asked for the profession to look at some of the pressing social problems and direct their knowledge toward their solution. More recently, in the press conference that attended the publication of his book on O. T. Avery, Dubos (*9*) reminded us that Avery's discovery arose not from his interest in the gene, but from his interest in pneumococcal pneumonia. Dubos consistently argues that many scientific problems which have their origins in a deep social context may turn out to be more fruitful, in all kinds of ways.

So that was one critique: science is cold and inhuman and also does not concern itself with the needs of society. The second critique, which is my next theme, also has historical origins: somehow science manages to extract the warmth and beauty from the world, and this is also drained from the personalities of the prosecutors of science. Moreover, insofar as they are scientific solutions, our solutions to humanity's problems inevitably become humanely cold, too. Dickens took up this theme, so did Blake and Keats, and in our time so did F. R. Leavis.

Humanizing Society

So, it is argued, the job of improving and humanizing our society can find neither tools nor methods in science, for then the remedy becomes worse than the disease. We must take note of one counterclaim that was offered in the past and is often offered now. In the effort to humanize ourselves, to enhance our ethical and moral sensibilities, people have often appealed to the humanities to do it for us, almost as to an ideology. The redemptive power of the humanities to produce an enlarged consciousness, to make us aware of the reality of our human predicament, to enlarge our sympathies has been an important theme, whether in Wordsworth, in Shelley, or in many 20th-century writers. I am slightly skeptical about this. I am not at all convinced that somehow, from a study of the great thinkers of the past alone, we automatically get access to moral virtue. It is disturbing but nevertheless true that people can be extraordinarily sensitive to music and poetry and not necessarily apply this to their daily lives. Steiner (*10*) has reminded us how people returned from a day's work in the concentration camps and then put Mozart on their gramophones. I remember, too, a delightful occasion at a conference on science and the humanities when the philosopher Max Black reminded us of the exquisite capacity of philosophers to argue questions of ethics and morality in the most rigorous and convincing style, but he went on to say, "If I wanted to know whether an action I proposed to take was right or wrong, I wouldn't ask my professional colleagues, I'd ask my wife." Stoppard (*11*) equally reminds us how Lenin, when he felt himself being moved by the Appassionata Sonata of Beethoven, rigidly turned away, saying, "We've just got to hit people."

Did the Shakespearean plays, with their almost God-like insight into the way that people behave, make people understand more, make people act better, make people feel more humane? It was with considerable surprise that I learned from David Daiches that the same people who went to the Globe Theatre or to any Elizabethan or Jacobean play, and saw these marvelous dramas with their rich poetry and their human understanding, would at the same place in the same afternoon watch a monkey tied to the back of a horse, chased by dogs who slowly bit it to death. This was their favorite occupation between the acts. For there is a large gap between appreciating the wonders of artistic imagination and going out and doing likewise, as there is between knowing ethical norms and going out and doing likewise, which no amount of discussion of "is" and "ought" will alter. This is my main quarrel with F. R. Leavis—the myth of the redemptive power of great works of art; the belief that by teaching a small group of elite to appreciate Lawrence and George Eliot you will change civilization. You won't at all—not by this alone.

Why have I gone into this at such length? I have three reasons. First, I think it unfair and unwise to regard the humanities in this therapeutic light. They are good in themselves and should not be regarded as remedies for our own failings. Second, we must not delude ourselves about how easy it is. We must not pretend that words and university courses are a substitute for human hearts and human action. Third, we must be very careful of hypocrisy. For if we insist that the scientific profession and the medical profession have a care and a human concern which we ourselves as members of society are not prepared to have or to act on, we shall be raging hypocrites.

Absence of Science in Literature

Now let me go to my second task and raise the question; Why is there the myth that humanity and warmth are drained from the world by science, and how is it that scientists have not been the objects of great works of art or literature? There are, of course, famous exceptions—George Eliot's *Middlemarch*, Sinclair Lewis's *Arrowsmith*, and to a certain extent the novels of C. P. Snow, although he has mostly described scientists acting as politicians or administrators, as anything other than workers in a laboratory. If there is a shortfall here, we must see this in terms of the social streams in the early 19th century, around the time when the British Association was beginning. Here, I believe, we find another and perhaps more serious division between science and the arts. In the early years of the French Revolution, the romantics heralded the new age of freedom and reason—a time when poetry and science would lie down like the lion and the lamb, and inspire and celebrate together. Indeed, from the time of Copernicus to that of Newton, scientists could write and assume that what they wrote all intelligent men would read.

But Wordsworth, Coleridge, Shelley, and Tennyson not withstanding, by the middle of the 19th century this assumption began to fade. It was partly the real-

ity of the French Revolution followed by Bonapartism which smashed that vision; partly the effect of the Industrial Revolution and the shape of the new world to come, when scientists were equated with the engineering devils who had blackened the face of England. The new world that was now fashioned seemed totally alien to the world of poetry and art. So the romantic movement then revived again in a different form, to protest against the deadening effect of the rational style.

There was, on the one hand, the vision of the detached onlooker, who stood aside from the world. But this seemed to be at variance with the desire of the poet to enter with his feelings into the world and to respond and resonate with it. As Keats wrote, natural philosophy apparently undermines this vision; it certainly makes the world much less accessible. Then William Blake came, to speak of a science that darkens the imagination and murders the soul. So the rift began. Among the poets and the artists there was the cultivation of that inner realm of feeling which poetry, but not science, would reflect. Moreover, it was a place where, as Charles Davy reminds us, the truths of poetry did not have to meet the challenges of the truths asserted by science. This difference was not an issue about the nature of the world and who made it, for that topic was left to the classical conflict between the theologians and the scientists. It was the question of the place "where three dreams cross"—but it was a place which a scientist never inhabited and probably could not understand.

Now one consequence of this rift came to be reflected in education; a second, in the ignoring of science and its ideas as themes for artists. Such issues as the relationship between a sensitive artist and bourgeois society, which has been a tremendous theme of literature, never found their counterparts in literature about science. This was partly because people could not decide on what side of the issue scientists lay, but equally because, hating the Industrial Revolution and the philistinism of the whole bourgeois mentality, and equating the scientists with the technologists, people somehow pushed them onto the side of the enemy. Thus scientists became, and have remained, suspect in the eyes of artists.

So we have had a long tradition of writing and investigating how artists and writers work (Joyce Cary's marvelous book *The Horse's Mouth* comes immediately to mind), but where is its scientific equivalent? The psychology of artistic creation has been with us for 200 years, and even though Poincaré raised similar questions about scientists, no one has ever gone really deeply into the psychology of scientific discovery. There is so much that remains unexplored—the human themes around science are vivid and fascinating. But writers do not know how scientists work. They see science as power, or as politics, but there are precious few accounts of the way the scientific imagination is expressed. It may be that novelists are afraid of revealing their ignorance, but I think the reason goes much deeper. I think it is because, somehow, we have not made science accessible. Yet, I contend, if you want as your sympathetic hero a man of imagination, of intellectual interests, of deep moral dilemmas, a scientist will fit your picture—especially, perhaps, a recombinant DNA scientist—not only as well as but, in many ways, perhaps even better than an artist.

Yet one can say that, after all, we have had a long tradition of looking at science. We have indeed had the professional scrutineers of the enterprise, the philosophers and the historians of science. But if, as Neff (*12*) argued, the measure of our success here is the measure of the means by which we have chosen to woo humanity to recognize its own likeness and understand itself, how have we, in professional philosophy and history of science, measured up? Have we succeeded in getting science to recognize its own likeness? No. Judged by scientists and others, much philosophy of science has been just irrelevant—at best a series of brilliant axiomatic games, but often pretentious nonsense, like the pretentious nonsense you can easily find in all academic disciplines. But worse, I think, is what it has omitted to do for us. H. Reichenbach said, philosophers of science are "not interested in the context of discovery so much as in the context of justification" (*13*). But this is only a very small part of the science enterprise.

History of Science

What of history of science? It is a profession I have practiced for a great part of my academic life, and I look around and ask, Where in history of science is our Macaulay, our Namier? Come to that, where is Tolstoy? Who has dealt adequately with the relationship of the individual in science to the march of scientific progress? History as we know it is a tapestry, the parts of which are made up of the mosaic of the small, everyday, individual events. And we derive the pieces of the mosaic from a whole variety of sources over and above formal academic articles: from newspapers, journals, diaries, cabinet documents, and so on. The real historian is the one who can piece the mosaic imaginatively to form the tapestry and so present the past to us in its full, vivid color. Now apart from the waspish memoirs of Watson (*14*), we have seen little of this kind attempted in the history of science, and in any case we would be much better advised to turn not to Watson but to Sayre (*15*), who genuinely attempted to match a person and a personality with the progress of thought. There are a few notable exceptions: Holton (on Einstein) (*16*) and Rosenberg (*17*), both of whom are convinced that the scientists' subjective state of mind has a marked influence on the progress of science; Koestler (*18*) whose vivid account of Kepler in *The Sleepwalkers* is another, superb, example; and Frank Manuel on Newton.

To be fair to the members of my profession, whom I by no means disavow, science makes it very difficult for us to comprehend its history. There are two reasons for this. First, the pieces of the mosaic are often just not there. Second, as Sir Peter Medawar reminded us (*19*), a scientific paper not only conceals but in fact actually misrepresents the reasoning and the imagination and the creation that has gone into it, for the stern eyes of John Stuart Mill are staring out at the editor of every journal. As Medawar also emphasized, the past of science does not have a dignified independent existence of its own, for a scientist's present work is of necessity shaped by what others have done and thought before him. So science is a wave front of a continuous secular process which carries its own history with it. But even admitting the difficulties that are placed in our way as we try to relate the individual work to the march of scientific history, I still believe that we could, and should, be very much more imaginative and comprehensive in mirroring this activity.

Now why am I so confident? It is because during the last 2½ years, I have been following Sir Peter Medawar's recommendations, and Gerald Holton's too, and have been listening in at the keyhole of daily science. I have, in fact, been living with one group of scientists, day after day, as they do science, not as they afterwards say they do science. I have been seeing the smudges, the thumbprints and bloodstains, of a personal struggle with one's ideas. Now after 20 years in orthodox history of science, I am appalled that I could have so ignored

the very human core of its history. Where are the people that, as an historian of ideas, I wrote about? Did I paint them so that I could recognize them and their unique personalities, and how they bore on their science? No, I did not. So my last plea is that it is time to apply to the history of science the lessons of Vico and Herder which have been so beautifully expounded by Sir Isaiah Berlin (*20*). We must become more sophisticated and come to grips with this problem, and reformulate our discipline.

History is not a totally unknown country. It is a study of the human past as a form of collective self-understanding of human beings and their world. It always has been that and it should be always like that. It is a story of human activities, what men did, what they thought, what they suffered, what they strove for, what they aimed at, what they accepted, what they rejected or conceived, or imagined. It tells us about their motives, their purposes, their ambitions, their ways of acting and their ways of creating. These, Vico insisted, are the activities we know, and we know because we are all involved in them as actors, not as spectators. Historians and philosophers of science have been too much spectators and have not been sufficiently involved with science. The kind of knowledge we seek is not just the knowledge of facts or the knowledge of logical truths or the logic of method. The kind of knowledge we seek is more like the knowledge of a friend, his character, his ways of thought or action, an intuitive sense of the nuances of his creative personality. We must use imaginative power of a high degree to enter into the other's mind and world, and this means appreciating them as people as well as scientists.

Without entering into history in this sense, the past remains dead, a collection of objects. Similarly, without entering into science in this sense, scientific history will remain a dead collection of objects or ideas which apparently has been created by stuffed figures in a museum. The only way of achieving any self-understanding is systematically to retrace our steps, historically, psychologically, and above all anthropologically into science. We can begin now to study science as it is done and try to understand those private moments of creativity—to enter with the scientist into "the place where the three dreams cross." We have to enter with empathy into other people's minds and into their modes of being. Then and only then can we go back and redo the history of science.

I have argued that at this time the scientific life and the scientific imagination are not really accessible, for all that more is probably being written about science than at any time in its history. If it were accessible, we could demythologize it. When we have done this, we could incorporate it into public understanding. When it is incorporated into public understanding, then, and only then, will science be truly integrated into our culture.

Science and Society

Finally I want to say something not very original, but I do not think that matters. Science and society can no longer afford to entertain myths and misunderstandings about each other, as the recent public debates about recombinant DNA reveal. Public understanding of science is as vital as it was in the early days. But there is the other side to this coin, and that is the scientist's understanding of the public. Science and society must be closer to one another. When the one is truly incorporated into the other, we will appreciate the humanity that has in fact always been present in science, and in essential respects will always be found there. But if I argue that scientists should now consider new ways of expressing this humanity in response to the new ethical imperatives in our society, I also argue that society should think of new ways both of helping them to do this and of understanding them.

The profession's allegiance can no longer be to a methodological ethic alone. But this does not mean giving up the truth, and we will still look to scientists for significant contributions to objective truth as well as to the practical expressions of science. I am not arguing for a return to stages of irrationality or wishful thinking, but for the application of knowledge of facts in new compassionate ways. I think we are reasonably entitled to ask the scientific profession to assess the problems of contemporary society, and where scientific solutions are called for, to give them first priority. It would be magnificent if, instead of being on the defensive vis-à-vis society as we have seen in recent years, scientists actively extended their notion of accountability in this way. With their example before us, we might then go on and tackle the problem of accountability in other groups—in industry and in the media, for example—and thus help create a climate where all such professional groups recognize their debt and responsibility to society at large. Now is very much the right time—a delightful time in our lives—when it is splendid, is it not, to be able to use old-fashioned words such as "morality" and "honor" without a fear of being sneered at.

I also wonder what Charles Dickens would say if he came back now. He lived his life in a deep pessimism. But looking back I think he would have possibly more grounds for optimism.

References and Notes

1. C. Babbage, *Reflections on the Decline of Science in England* (London, 1830).
2. Report of the British Association for the Advancement of Science (London, 1831–1832), p. 41.
3. Even 7 years later, Babbage was still gloomy about the prospects of science in general and the Association in particular. Reporting his speech to the annual general meeting in 1838, the *Times* quoted him thus (27 August): "Science [Babbage said] stood in the most degraded rank. The lowest honours are given to intellectual powers. We should endeavour to unite classes in country with one interest and that unity should be that of the intellect. Unhappily many of the aristocracy looked with contempt on science. He had heard the assertion made by men in authority that they knew little of science and cared for it less, and others, still higher in authority called it vain and humbug."
4. The *Times*, 21 August 1841.
5. J. Goodfield, *Playing God: Genetic Engineering and the Manipulation of Life* (Random House, New York, and Hutchinson, London, 1977).
6. G. A. Chaudhry, "The Mudfrog Papers," *Dickensian*, 1974, p. 104.
7. There were also some serious internal troubles and the *Times* undertook a little investigative journalism. For example, on 20 August 1840, "We wrote earlier of a spirit of persecution and favouritism [in the British Association] and there are certain doomed victims whose very merits expose them to the relentless spite of its Council and coteries. This we have confirmed and it is worse than we anticipated. We shall expose the transgressions of the Council who encourage favouritism and persecution. Their conduct *should* be regulated by honesty and honour."
8. C. Dickens, *Bentley's Miscellany*, October 1837.
9. R. Dubos, *The Institute, The Professor and DNA* (Rockefeller Univ. Press, New York, 1976).
10. G. Steiner, in *In Bluebeard's Castle* (Faber & Faber, London, 1971).
11. T. Stoppard, *Travesties* (Faber & Faber, London, 1974).
12. E. Neff, *The Poetry of History* (Columbia Univ. Press, New York, 1947).
13. Quoted in P. Schlipp, Ed., *Albert Einstein: Philosopher and Scientist* (Cambridge Univ. Press, London, 1969), p. 292. The full quotation is as follows: "The philosopher of science is not much interested in the thought processes which lead to discoveries. He looks for a logical analysis of the completed theory including the relationships establishing its validity. That is, he is not interested in the context of discovery so much as in the context of justification."
14. J. Watson, *The Double Helix* (Atheneum, New York, 1968).
15. A. Sayre, *Rosalind Franklin and DNA* (Norton, New York, 1975).
16. G. Holton, in *The Interaction Between Science and Philosophy*, Y. Elkana, Ed. (Van Leer Foundation, Jerusalem, 1974).
17. C. Rosenberg, *No Other Gods* (Johns Hopkins Press, Baltimore, 1977).
18. A. Koestler, *The Sleepwalkers* (Hutchinson, London, 1960).
19. P. B. Medawar, in *The New York Review of Books*, 28 March 1968, p. 3.
20. I. Berlin, *Vico and Herder* (Oxford Univ. Press, Oxford, 1970); see also his Tykociner Memorial Lecture, *The Divorce Between the Sciences and the Humanities* (Univ. of Illinois Press, Urbana, 1974).