that this pattern of dissociation can survive the coming fifty years without serious damage to both science and society, and of the powerful corrective forces now coming into play none is more hopeful than the urge of scientists themselves toward synthesis, both of one special field of study with another and of one with all.

That is why, as a nonscientist who wishes to see science prosper, I am relatively undisturbed at the image of a world in which scientists would be indistinguishable from people, in which scientists would be men and women first and scientists second, and in which—perhaps, in ways that scientists today may find difficult to visualize—everyone else will be scientists, too. The human condition is crowded with ambiguities, and all our acts have unintended consequences. The act itself of posing the scientific dilemma in these terms will suggest to the reader countless other terms in which it might also be posed, perhaps irritating him where it ought to soothe and offering consolation where it ought to kindle wrath. These are emotional objects of dispute, charged with old quarrels and haloed with the motivations we impute to one another. They are not, in that respect, "scientific," but I commend them to the attention of scientists, lest they be left indefinitely in other, and ultimately less sympathetic, hands.

Some Comments on Popular-Science Books

John Pfeiffer
New Hope, Pennsylvania

CONTRARY to optimistic rumors that have been circulating ever since the end of World War II, scientists still have not deserted their ivory tower. But the place is a good deal better ventilated than it once was. Moreover, further renovations are in sight, a fact that may prove heartening to those who have spent years trying to bring American scientists and the rest of the American public closer together. I might add that they are still far apart, and progress along such lines comes none too soon.

One promising sign is the bumper crop of books prepared by scientists for nonscientists. Popularizing is a vice that cannot be indulged in privately. Sooner or later, your efforts will probably be published—and not long ago that would have meant some loss of social status in the scientific community. Of course, your colleagues wouldn't have said anything to your face. But among themselves they would have wondered why you were writing instead of doing research, and concluded that you were slipping.

This attitude has not disappeared entirely. Traces of it can still be detected, particularly in the upper, less efficiently aired, chambers of the ivory tower. Pure mathematicians, snug in their hyperspaces, are most reluctant to take time out for book-writing, or for any other concrete form of popular science. The reluctance coefficient becomes smaller as one passes through the spectrum of the specialties from theoretical physics and chemistry to biology and finally to the social sciences. But generally speaking, writing for the layman is becoming respectable, and it may actually bring the scientist as much prestige as his achievements in research.

This article will confine itself to a series of comments on popular-science books, most of which have been published during the past two years. The majority concentrate on research currently under way or offer up-to-date summaries of scientific thinking on specific subjects. Some books are devoted to various themes in the history of science, and others, the smallest proportion of all, deal with science itself—its methods and aims and values. These three categories may not be all-inclusive; certainly they overlap in many cases. But they may help to indicate those areas of science that are relatively well covered and those that have been neglected.

A Matter of Style

As far as books in the current-research category are concerned, one of the most encouraging developments is an unspectacular but steady increase in the use of the word "I." This statement will have to stand as a general impression until some Ph.D. candidate investigates it statistically. But it is based on considerable reading, and several publishers have commented to me about the significance of the trend. In using the first person the scientist has taken an all-important first step in freeing himself from what is undoubtedly the deadliest, most awkward style ever invented by anyone for any purpose—the nameless style found in technical publications.

If the scientist insists on subjecting his colleagues to this sort of writing, that is his business (although judging by recent criticisms, they don't particularly enjoy it either). But the weight of experience shows that good English is more helpful in communicating with other people. Although uninhibited use of the first person is no guarantee that a book will be well written, it is a valuable index to general readability. The odds are that it will be easier to read than one which, in the name of being "impersonal," falls back on the phrasing typical of the average scientific report.

A good example of what I have in mind is *Stars in the Making,* by Cecilia Payne-Gaposchkin, of the Harvard College Observatory. This book, an introduction to stellar evolution, is written in an informal style that is certain to be appreciated by students, as well as by laymen. Also, it is a completely honest book and does not gloss over areas of ignorance in an effort to give an impression of certainty where none exists. In considering available evidence, Dr. Payne-Gaposchkin writes: "Of these tangled threads it is our problem to weave a coherent web; and I must be frank—the web is full of holes at present, and if I were to attempt to foist it off as a well-woven fabric I should do it at the price not only of compromising with my own conscience, but also of incurring the derision of my astronomical colleagues."

Such humility is not to be found in Fred Hoyle's *The Nature of the Universe.* The British astronomer has been accused of presenting controversial ideas and theories—namely, his own and those of his close associates—as if they had already been accepted by the scientific world. This fault, which is generally attributed to science writers rather than scientists, has justifiably aroused the wrath of astronomers in this country and abroad. Even some of Hoyle's harshest critics, however, concede that he writes beautifully and hope he will publish other, more restrained, books. In fact, *The Nature of the Universe* would be required reading in any course designed to teach people how to explain things simply and vividly.

Two less widely read books also deserve special notice as first-rate examples of science popularizing. The first, *The Physical Basis of Mind,* published more than two years ago, consists of a series of general statements outlining some modern concepts about thinking, consciousness, speech, and other functions of the brain. The statements were prepared by seven specialists including the Nobel prize winners Charles Sherrington and E. D. Adrian. The final chapter, a discussion of the mind-matter problem, presents some of the implications of modern brain research as interpreted by three philosophers.

Doubt and Certainty in Science by J. Z. Young, of University College, London, is also concerned with studies of the human brain. It presents the elements of cybernetics, emphasizing some of the more obvious similarities between the workings of certain centers in the nervous system and the action of high-speed electronic computers. Although written primarily for the layman, it may also prove of value to biologists who have difficulty swallowing—and following—cybernetical theories as described by mathematicians, physicists, and engineers. They may be more receptive to this book since it is written by a highly respected worker in their own branch of science.

It should be noted that the chapters of Professor Young's book were originally broadcasts prepared under the auspices of the British Broadcasting Company. *The Nature of the Universe* and *The Physical Basis of Mind* are also by-products of BBC programs that aroused widespread interest among listeners. Broadcasting can stimulate the development of a colloquial style and the publication of popular-science books, because it encourages investigators to speak simply and informally. Popular writing is rarely difficult for those who can explain themselves without floundering about in technical jargon—and who consider it important to reach the layman.

In this country, however, network officials are not very enthusiastic about talking scientists. They will not experiment with the radio science talk—the *ad lib* talk or conversation—even on "educational" programs, which usually are scheduled for off hours and are not expected to attract sponsors. So far as I know, their sole contribution to popular-science libraries was a work that appeared shortly after the war. At that time Warren Weaver, of the Rockefeller Foundation, arranged to have prominent scientists deliver talks during the intermissions of the New York Philharmonic Society concerts. The broadcasts were later included in an interesting and informative book called *The Scientists Speak.*

Some Trends and Improvements

No discussion of popular science would be complete without a special place for Rachel Carson's *The Sea Around Us.* Having headed best-seller lists for well over a year, it should be considered a phenomenon rather than a mere book. About three decades ago Paul de Kruif developed an effective method of science popularizing. He invented, or at least promoted most successfully, the breathless detective-story style —a style that was epitomized by his *Microbe Hunters* and can be credited with creating a far larger audidience for books about science than would otherwise exist.

But a breathless style requires a breathless subject, and de Kruif's has unfortunately been applied to a host of minor topics (by the originator, as well as by his many imitators). We keep reading exciting lead paragraphs, anecdotes full of suspense, phrases like "the balding, sad-eyed researcher." As often as not, however, the "discovery" being described represents the quintessence of anticlimax. It may be a mere molehill of a discovery, far too insignificant for such a mountainous style. We are informed about a new balm for athlete's foot, or a wrinkle-removing hormone cream, or a portable dehydrating unit for family picnics. No style, however rugged, can stand up indefinitely under such maltreatment.

This may be the strategic time for a different approach, and *The Sea Around Us* may indicate the nature of that approach. It is essentially a literary way of writing about science. The objective is not only to inform, a process which may satisfy the reader but cannot in the long run satisfy the creative writer. Rachel Carson tells us many things about the sea—and she also offers a work of some artistic distinction. She demonstrates once more that the findings of scientific investigators can contribute to our aesthetic ap-

preciation of nature, as well as to our factual knowledge. In other words, she is doing a great deal to emphasize the humanistic and cultural aspects of science—far more, by the way, than the perfunctory and uninspiring sessions of the average "science appreciation" course. If this sort of approach develops into a trend, we can expect a new type of book and, probably, a new type of author.

Another welcome improvement concerns the material used to illustrate books for laymen. Nowadays one of two things can be expected. The publisher and author meet in joint conclave shortly after the manuscript has been completed. They either decide that no illustrations are needed or—and this is the more common course—agree that it might be a good idea to have something besides straight copy. From that point it is usually a matter of rounding up photographs and diagrams previously prepared for other purposes. If any special illustrations are required, an artist can be called in to complete them (at as low a price as possible). When the book is published, the illustrations may be attractive and even somewhat helpful, but are probably not integrated with the text. Basically they are afterthoughts. They may be simpler or more complicated than the text, more formal or less formal. If they fit, it is usually sheer coincidence.

Ideally, the artist would not be summoned after the text had been completed. He would come in at the very beginning, have a chance to read chapters in the rough, and possibly make suggestions for rewriting so that text and illustrations would supplement each other more effectively. Such collaboration between artist and writer has long been the rule in preparing special science stories in *Life* and other picture magazines. It was also practiced extensively during the war to prepare booklets describing the construction and use of new weapons that involved electronic circuits, acoustic mechanisms, and other unfamiliar gadgetry. The booklets had to be written and illustrated as clearly as possible, since they were to be read by laymen of all ranks, from able-bodied seamen to admirals. One of the expert artists who worked on these projects, Sol Ehrlich, is now responsible for the extremely attractive layouts of *Physics Today*.

Most publishers, if cornered, will concede that illustrations could be improved—but not within the limits of present-day budgets. On the other hand, there seem to be ways around the problem that might be studied and applied more often. Two books on space travel, *The Conquest of Space* and *Across the Space Frontier,* include admirable illustrations by Chesley Bonestell and other artists. Interestingly enough, these pictures are well ahead of the texts they go with, as far as the popular touch is concerned (this is a compliment to the illustrations, not an insult to the texts). For almost perfect meshing of text and illustration, interested readers are referred to *The Stars—A New Way to See Them.* The book is unusual in that its author, H. A. Rey, is not only an able popularizer but an excellent illustrator.

Finally, I look forward to the day when publishers will discover a large and, according to my informants, rapidly developing area of science—biology or, rather, biological research. Many good books have been written on various aspects of descriptive or naturalistic biology, books that explore the habits and customs of such creatures as spiders, beavers, octopuses, and bees. Medicine is also well represented. A wide selection of titles is available to people who would like to go into the care and treatment of heart trouble or stomach ulcers, or who would rather read about than undergo psychoanalysis. But most people still believe that physicians were responsible for the development of penicillin, plasma expanders, and other advances for which biologists deserve the major share of the credit.

A series of books that would do justice to basic research in biology might require careful planning, but the main burden need not and should not fall on the publisher. There are qualified investigators who would be glad to serve as consultants and writers, and artists to do the illustrations, although it would not be fair to ask for their assistance without more generous compensation than is customary at present. It is possible that a private foundation might be willing to help support the undertaking. With certain interesting exceptions, the foundations are more sympathetic toward such projects than they were only a few years ago. If the series were successful, it would be as instructive and stimulating to the layman as Ernest Baldwin's *Dynamic Aspects of Biochemistry* is to the biology student.

The History of Science

Most of the books discussed up to this point focus sharply on current experiments and theories. We shine at publicizing the present. Apparently a thing has to be new to be interesting or, if it isn't new, it must at least be used for a new purpose—e.g., chlorophyll. The American public is probably better informed about the progress of research than any other public in the world. But the history of science has received little notice and is widely misunderstood. Too many people think of the past as a series of sudden flashes of discovery, a long line of brilliant individuals shouting "Eureka!"

If I seem too pessimistic, there are good reasons. Among misguided intellectuals, we find men like Arthur Koestler who, in *Insight and Outlook,* builds a strange philosophy, and a naïve one, on the Eureka myth. The notion that discovery bursts upon one has been thoroughly and repeatedly discredited, although it is still a favorite device of hack science and radio script writers. There is ignorance at the other end of the intellectual scale, too.

While I was writing this article and had already run a day or so over my deadline, I turned on the radio and found myself listening to a quiz program. The following problem was under consideration: "Tony Pastor and Louis Pasteur are both known as wonderheads in their own fields. Which was the

French chemist?" The man being quizzed had no trouble at all in providing the master of ceremonies with the correct answer. Although he had never heard of Pasteur, he had half the total information, which was sufficient. Unlike most readers of SCIENCE (I assume), he knew who Tony Pastor was and figured things out by a process of elimination. The incident surprised me, mainly because Hollywood had done a motion picture on the life of Pasteur (although the film has not been revived recently).

This experience may not be typical, and it is certainly not cited as an accurate indication of the scope of the problem. Things are probably not that bad. There are many valuable and penetrating studies in the history of science which can be readily followed by laymen. To cite one of the latest examples, Giorgio Abetti's *The History of Astronomy* has recently been translated. It contains some good anecdotes, a record of technical advances, and interesting biographical sketches of leading personalities from Tycho Brahe to George Ellery Hale. This book is part of the "Life of Science Library," which includes more than twenty other books dealing with great men and great ideas in scientific history. Henry Schuman, the publisher of this important series, is to be congratulated for his active role in making such material available to the reading public.

But can the history of science be brought to even larger audiences—audiences as large as those that follow current aspects of research? There is every reason to believe it can, and books might exert appreciable influence in a well-organized effort. (Radio and television shows and motion pictures, of course, would be more effective in conveying attitudes and feelings on a mass basis.) The task of reaching more people, however, might call for some changes in emphasis. Certain educators believe that the way to teach science as a cultural subject—that is, to students who do not wish to become scientists—is to concentrate on the achievements and ideas of the past. For example, the period of Priestley, Lavoisier, and the phlogiston theory would be analyzed in detail to illustrate basic principles used in scientific investigation.

Such an approach may or may not prove itself satisfactory for students of college age, but it is usually ineffective in popular books or any other form of adult education. As a general rule, the cards are stacked against the scientist or science writer who confines himself to the past and at the same time hopes to be read widely. No matter how vividly and cleverly he writes, he may have trouble combating the feeling that, after all, the events took place long ago and involved people no longer alive. Often an indirect approach may be more suitable for introducing historical subjects.

In planning books that are intended to go into significant developments of the past, it might help to experiment further with the idea of focusing sharply on the present. The idea would be to select a currently active field of research—say, the design of electronic computers, or virus investigations—and describe some of the most interesting current work, using the best techniques of popular-science writing. Then turn back to earlier times and show how modern developments are simply the latest results in a long sequence of observations and theories. This roundabout way of presenting history is not new. In fact, it has been used in practically every good account of atomic research. The latest of these books, *The Atom Story,* by the British biochemist J. G. Feinberg, starts with ancient Greek science and proceeds through phlogiston theory and many other topics before coming to grips with the hydrogen bomb.

Whatever the methods employed, the history of science needs better publicizing. As things stand now, science is almost always presented as the creator of new gadgets and notions, a kind of brash young interloper in the world of culture. That the "interloper" has actually been around for a long time, and boasts an ancient and respectable ancestry, might be emphasized from time to time, if only to reassure those who do not yet understand what science is up to. As George Sarton expresses it, the history of science should be used "to illustrate impartially the working of reason against unreason, the gradual unfolding of truth, in all its forms, whether pleasant or unpleasant, useful or useless, welcome or unwelcome."

THE VALUES OF SCIENCE

The rarest thing of all is a really popular book about science itself, a book the primary purpose of which is to present for all to read the values expressed by Dr. Sarton in the above quotation. Popular science has not yet succeeded in what should certainly be one of its most important missions. There is one particularly spectacular sign of this failure, the wide sale of books that present fantasy as if it were fact—and get away with it. Someday we may have a public sufficiently sophisticated to resist such claptrap, and to resist despite the occasional high-pressure methods of publishers who should know better (and probably do). The millennium cannot be expected, however, until people have learned to distinguish science from science fiction, and that means a serious and vigorous campaign of public education.

An important step in such a campaign would be to expose fakery as soon as it appears and in no uncertain terms. Scientists have long been doing this on an individual basis, in scattered articles and book reviews. The most recent and most effective blast against pseudoscience is *In the Name of Science,* by Martin Gardner, a free-lance science writer who was formerly on the public-relations staff of the University of Chicago. The book identifies and describes a long list of pseudoscientists, past and present. There are flat-worlders and antievolutionists and people who cure diseases with colored lights. Dianetics, that unholy alliance of psychoanalysis and cybernetics, rates a special chapter. So do dowsing rods, food fads, and flying saucers. One of the most important things about

the study is that it indicates how vast the field of pseudoscience actually is. It includes work that is not entirely nonsense and that may even have acquired a measure of respectability.

In the Name of Science deserves the large audience it will probably have, particularly among scientists. For one thing, the antics and arguments of pseudoscientists make first-rate reading. Even more important, this new book is something that should have been prepared, or at least sponsored, by the AAAS or some other scientific organization interested in public education. I am aware of the argument that an official objection to various works of pseudoscience might only draw attention to them and thus boost sales. The only catch to this argument, however, is that—judging by a brief survey of recent best-seller lists—such dubious volumes do quite well on their own. Silence does not seem to have affected sales records.

Also, silence cannot be expected to discourage either the writers or the publishers of pseudoscience. The assumption here is that in the long run such material harms science, that it fosters misunderstanding of the nature and aims of research. If there is anything at all to the assumption, pseudoscience certainly ought to be opposed actively and aggressively. Or is the American Medical Association making a mistake every time it attacks a cancer quack? It happens that, in exposing the efforts of fakers, one must inevitably give some idea of genuine research. The layman will learn a good deal about scientific evidence and standards from *In the Name of Science* and also from *Flying Saucers* by the astrophysicist Donald Menzel.

Much of what has been written about the humanistic values of science appears in books devoted to other subjects. For example *Life of the Past*, an introduction to paleontology by George Gaylord Simpson, includes such comments as the following: "There was no anticipation of man's coming. He responds to no plan and fulfills no supernal purpose. He stands alone in the universe, a unique product of a long, unconscious, impersonal, material process, with unique understanding and potentialities. These he owes to no one but himself, and it is to himself that he is responsible. He is not the creature of uncontrollable and undeterminable forces, but his own master."

I would recommend sections of this and other books to a large and increasing number of laymen, who are not basically interested in paleontology or the history or current achievements of science. They want to know what it is doing to their ideals, their notions about truth and purpose. They want to know what science has to say about the values of the past, and whether it has any values of its own to offer. Not enjoying the benefits of a technical education, they are supremely unimpressed with the fine points of the argument that science is not concerned with matter of right and wrong. They find it difficult to make the distinction between the scientist as scientist and the scientist as human being. Popular books have not yet been written for this audience—that is, they have not been written by scientists. So far, we have heard only from the pseudoscientists.

Scientists *Can* Talk to the Layman

John W. Hill and James E. Payne
Hill and Knowlton, Inc., and American Iron and Steel Institute, New York

COMMUNICATION has become an irksome, two-pronged problem for the scientist. On the one hand, he finds it increasingly difficult to keep abreast of the work in his own and allied fields; on the other, he sees an ever-widening gulf separating him from the public.

Expanding research programs yield data at an accelerating rate, yet the scientist's reading and retention rates are limited by physiological and psychological factors. "If I kept up with all the work being done in the narrow field of antibiotics alone," a chemist observed recently, "I would have no time left for research. As it is, I am buried under a mountain of papers and reports."

Fortunately, scientists realize the seriousness of this bottleneck, and undoubtedly it will be removed before it strangles scientific work. Scientific language, with its mathematical symbology, is universal; consequently, the problem is largely one of engineering. Once a method is set up by which information can be abstracted at various levels of complexity, recorded, cross-indexed in efficient research pathways, and made available in easily accessible form, the scientist will no longer need to flounder through unnecessary data to find what he needs. Increased reading efficiency will enable him to keep informed of developments.

But the problem of communication between the scientist and the public has no such obvious solution. The scientist is changing the world about us. His work is vital to our health, security, and prosperity. Yet to the average layman the work and the language of science are as mysterious as the witch doctor's mumbo jumbo is to the savage. The pace of scientific discovery has left the layman far behind, and the few interpreters of science too frequently speak a language he does not understand.