The Responsibilities of Physicists for the F

By ***George R. Harrison***

"SCIENTISTS should have a greater awareness of their responsibilities to society." This statement, often heard nowadays, has the ring of truth, but the specific responsibilities are seldom listed except in a vague way. When they are discussed by humanists some of the principal responsibilities turn out to be of a sort scientists cannot accept. Usually there lurks in the background an insinuation that physicists, having released on an unsuspecting world some sinister force such as nuclear energy, should bottle up their djinn again and be more careful in the future. A number of commentators have even gone so far as to state flatly that humanity would be much better off if science had been nipped in the first bud and never allowed to develop its materialistic control over man at all.

Scientists could afford to ignore such misunderstandings of their role in human affairs if these misunderstandings did not exist in such places. A very able, important, and enlightened government official of the United States is said to have remarked, when someone commented on the great strides being made in science in Russia, that he felt that this was to be expected, as the Russians were essentially a godless people and could be expected to excel in science. This confusion of the basic with the base every physicist owes it to himself to combat. That he has great responsibilities to society we will all agree, but throttling the search for truth is surely not one of them.

The 25th anniversary of the founding of the American Institute of Physics, which was dedicated by the physicists of the nation to assisting in carrying out their responsibilities, affords an appropriate occasion to consider once again what these are. If the growth of physics continues at the rate of the past quarter century, physics and its companion sciences will soon be controlling in respect to the growth of society, if indeed they are not already. Physics, so recently leading from weakness, now leads from strength. We would do well, then, to consider the responsibilities of the physicist as they relate to society, to industry, to the government, to his kind, and to himself.

IN what direction are physicists supposed to lead their science? The layman immediately says, "You should move in the direction that will most benefit society." To this the physicist is likely to reply, "This is right. But there is no direction other than forward. The fire of knowledge spreads in rings, and its travel in any new direction will benefit society so long as light is preferable to darkness. There is no such thing as a bad fact, if it is a true fact." The layman needs to know that one cannot pick and choose among the truths uncovered by science, but must take them as they come and use them as one can. To an audience of physicists the idea that truth can be subjected to picking and choosing is bewildering. Yet there are really intelligent people who feel that Fermi and his colleagues would have done well, when they first uncovered the

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"terrible" truths of nuclear energy, to have quickly averted their gaze, thrown a blanket over their apparatus, and quietly sunk the discovery under the waters of Lake Michigan. One of the responsibilities of the physicist surely is to help people understand the impossibility of such behavior.

It is, of course, difficult to explain to a mother who feels that her entire family is likely to be wiped out by an atomic bomb, and would not be if the bomb had not been invented, that man must for the sake of his own spirit seek to uncover whatever truth he can, and that the force about which she is worrying can be one of the most beneficent that has ever come to mankind. Yet if taken slowly the task is not impossible. The transients that inevitably attend any new discovery do gradually smooth themselves out. We can see this happening already in the magnificent achievement of the world's scientists at Geneva, and in the rapid development of the Atoms for Peace program.

It is heartening to see the increased frequency of exchanges in the columns of such journals as *Science* and *Nature* between humanists and scientists as to where the responsibilities of each extend. Physicists, as followers of one of the most broadening and cultural of all disciplines that men have developed, should be able to hold their own in such discussions.

Spiritual progress comes, not from shutting away from our lives the problems of the material world, but by embracing them and solving them. Sensitizing man's responses to his environment, and increasing his reactions to the forces coming in from the world about him, tend to make him more human rather than less. It has always been true during the course of plant and animal evolution that greater awareness leads to fuller living; to assume that with man things will now be otherwise is to have little faith in the continuity of nature.

The world is up against an age-old problem—improvements in man's control of his physical environment force him to examine his emotional responses, sharpen his mental facilities, and distill from his new experience new essences of wisdom which add to his spiritual enlightenment. This has been the whole path of man's spiritual evolution. The release of nuclear energy is merely the most recent in a series of new responsibilities through the acceptance of which man increases in spiritual stature.

The position of some humanists in accusing scientists of interfering with man's spiritual progress reminds me of a story I was told about the family of a friend. This family was fond of picnics, but the mother, after spending much time corralling her brood for an all-day outing, through poor planning was likely to hold up departure at the last minute. On one such occasion everyone was ready and eager to be off when it appeared that Mother had decided to take a bath. Repeated poundings on the bathroom door finally brought some response to the cries of, "Hurry up, Mother. We're waiting for

you." "I'm all ready," came Mother's reply, "Father, start the car; Ethel, find my underwear." At times it appears that Father Science has the motor of human progress purring quite actively, while Mother Humanities, who, after all, takes ultimate responsibility for the human picnic, hunts somewhat distractedly for her basic habiliments. Our friends in the humanities will not, of course, take this story too seriously, for they recognize that Mother and Father face a long and happy married life together, wedded in bonds of ever deeper affection as understanding ripens.

I do not think that we need take too seriously the plaint of the humanists that science makes living more complex. It does indeed do this, but this is the whole direction of evolution. Science also helps men themselves to become more complex, thus increasing their capacity to enjoy living. As any creature learns to contact nature over a wider area and on more levels, its awareness is enhanced and its aliveness is increased.

TYPICAL of the way that the developments of science in the long run produce quite opposite effects from the ones the public fears, are the worries of the layman having to do with new machines. Take, for example, the fearsome word "automation", which conjures up pictures of factories of the future run by robots while displaced laborers roam the streets in search of work. Yet it is in the very fields in which automation is being most rapidly applied that employment is greatest. Between 1940 and 1955, the period of most rapid introduction of automatic machinery that the United States has yet seen, the number of available jobs increased by more than 35%. This increase resulted, not in spite of the machines but because of them; it came from an expansion of the economy that was made possible by the improved control of energy that machines bring.

Except for the snobbishness of a few ivory tower academicians, their responsibilities to industry seem to me to be well appreciated by physicists. Useful applications seem to come about most rapidly when the physicist keeps his eye focused as closely as possible on fundamentals. It is becoming increasingly apparent that the best way to educate an applied physicist, and even an engineer, is to give him as broad and basic a training as he can take, and to postpone his specialization as long as possible. As for industry itself, a recent estimate showed quite convincingly that in the United States at present, investment in research and development can be expected to bring an average return of from 100 to 200 percent per year over a 25-year period.

The research spirit is now so active in American physics that there appears little cause for worry as to its continuance. It is being well watered and fertilized by the universities, with increasing governmental and industrial support. While some fear that this support is pushing physical research in the applied direction and away from the fundamental, I see little evidence of this. The enlightened support that the government continues to give fundamental scientific research through such agencies as the Office of Naval Research, the National Science Foundation, and many others, is having a profound effect in the orderly development of all varieties of physics.

The physicist has a continuing responsibility to his government. Though life among the statesmen has its special rigors to one accustomed to scientific ways of thought, the lot of physicists in Washington can be greatly ameliorated by their own efforts. As a group they performed magnificently in the defense of the nation during World War II, and in so doing brought physics to maturity and to public recognition. The cooperation that ultimately developed during wartime between physicists and the military was a phenomenon that probably could not have been predicted in advance. Thoughtful physicists still feel surprise that things worked out as successfully as they did. It is more difficult to keep this up in peacetime, when no tension arising from immediate emergency keeps the mechanism taut. Yet it is the responsibility of every scientist to use his skills to some extent for the benefit of the government that makes possible continued existence of the secluded laboratories in which he likes to work.

ANOTHER major responsibility of the physicist is to reproduce his kind. This he is not doing at a satisfactory rate. The tree of American physics is flourishing at the top, but growing ever more spindly in its main trunk. In 1890 almost a quarter of all high school students took courses in physics; today the fraction is not much more than a twenty-fifth. During the period in which physics has been growing in importance as a factor in society, the proportion of the population that embraced physics as a career has been diminishing. Between 1947 and 1952 not only was there a percentage drop in high school enrollments in physics, but the actual numbers of those taking this subject decreased. One of the arteries of physics has developed a slow leak, and unless something can be done to plug this, society will be developing anemias and needing transfusions.

The difficulties in getting satisfactory teachers of secondary school physics are being widely discussed. They accompany the gradual depreciation of standards of instruction in the high schools, particularly in disciplinary subjects. Part of the difficulty comes from downgrading the instruction to fit the average student, part from a misunderstanding and misapplication of "progressive" methods in education, and part from poor pay scales for high school teachers. The long-standing dependence of their salaries on the real estate tax rate, coupled with the current general inflation, has resulted in pay scales becoming relatively so low that as many teachers as can, unless unusually dedicated, escape to other fields. Physicists have a responsibility to help to attract more students into scientific fields in the secondary schools, to help ameliorate the position of the secondary school science teacher, and to help make his position more dignified, responsible, and properly paid. Until this is done we cannot conscien-

tiously try to interest in going into the field of secondary school science teaching those fitted for it. In the meantime, the wives of Cabinet ministers in Russia teach in high schools to set an example.

In the colleges there is a strong trend into physics, though there is evidence that many who enter the field would have become chemists in an earlier decade. In my own institution, for instance, 180 out of an entering class limited to 950 this year signified, a full year before they needed to make a choice, a desire to major in physics, and our total number of physics majors, graduate and undergraduate, is now more than 600. But there is still a shortage of physicists, as of other scientists, and this will surely grow much worse before it grows better. Our present annual national output of only 500 doctorates in physics must be stepped up. Employers, tired of bidding for each other's scientists and engineers, are now approaching the colleges for special in-service educational programs leading to advanced degrees.

Only a small fraction of the individuals capable of becoming physicists actually do so. While no one owes it to society to become a physicist rather than a follower of any other light that attracts him, our country is in dangerous need of many more physicists than it now possesses, and we have an extra responsibility to proselytize our science.

Fortunately this is no longer as difficult as it once was. In 1937 the American Institute of Physics, in attempting to discharge some of its responsibilities on behalf of physicists, formed a strong committee to look into ways of making the public more conscious of what physicists are and do. The committee set up a mild sort of selling campaign. Then came the magnificent contribution of physicists to the war effort, with the vast development of electronics and the unfolding of the vistas of controlled nuclear energy. The public by and large is coming to recognize these things for what they are—great steps forward in man's control of his environment, and ultimately of himself, and physics has not been the same since.

Our science, then, was "sold" to the public during World War II, as chemistry was during World War I. We must be careful that it does not become over-sold, as chemistry to some extent has been. People are already taking earth satellites for granted before even the first is tossed into space, as they clamor for new drugs and antibiotics and vaccines before they are perfected.

PHYSICISTS also have a responsibility to see that their particular body of ore in the mine of knowledge is explored in an orderly manner. To keep the growth of a discipline from becoming disorderly, progress, inevitably intermittent, needs to be made on all its frontiers. Not many years ago acoustics was considered to be a static field, worked out and unworthy of further attention by real physicists. Today the demand for experts in its specialties is often even greater than in many branches of nuclear physics. Ceramics, once largely concerned with building better bathtubs, now is basic both to the continued improvement of jet planes and the improved release of nuclear energy, and, like Lazarus, is readying itself for renewed activity. Experts in many fields of classical physics such as optics are becoming scarcer than those in some of the newer fields. The physicist should choose his specialty in accord with his own interests rather than with trends of the moment.

We must also avoid over-concentration in the centers of our professional fields without proper regard to their areas of contact with neighboring disciplines. Thus the fields of biophysics, geophysics, astrophysics, chemical physics, and physical metallurgy are lively and growing, and worthy of the best attention we can give them. As the number of physicists grows, they will inevitably spread into these borderline fields to an ever-increasing degree, but it is important that the spreading be as much as possible from the fundamental toward the applied, rather than in the opposite direction.

As the success of the physicist increases, so do his responsibilities to remain modest. His training in weighing problems without prejudice, and the very great leverage his methods of investigation give in uncovering truth, make him likely to become rather sure of himself. In his own field he is held in rigid discipline, for he must submit his theories and his experimental results to a jury of his peers, through the "literature", before his contributions are considered a part of "science". When he gets outside of his own field the discipline is relaxed, and his apparent authority may expand. Every wife of a good physicist will know what I am talking about. It cannot be better exemplified than by the charming story told by Laura Fermi in her book *Atoms in the Family*, about the Mason and Dixon Line. This story, with which every physicist may by now be expected to be familiar, will surely remind us all of red-faced occasions when a ploy in the dark failed to pay off. Self-assuredness is not, of course, a failing of physicists alone, but being aware of experience in their science since the days of Aristotle that reveals the dangers of the transfer of authority, they have a special responsibility to avoid presumption.

As is true in most disciplines, physicists range over a wide spectrum of capabilities, both within and outside of their profession. There is likely to be a wide variation in correlation between their excellence of performance within their field and that outside it. In many cases the correlation is excellent, as witness the great success of many able physicists in directing wartime laboratories, and the number who have become outstanding college presidents.

Among the responsibilities of the physicist, then, I would emphasize the conscious acquisition of patience, modesty, understanding, appreciation, and farsightedness—a list reminescent of that committed to memory by every Boy Scout. Physicists are human beings with special capabilities and interests, and to the degree that they live up to these they discharge their responsibilities to society.