A more authoritative judgment to similar effect has been expressed by George W. Merck in an address at Pittsburgh. Mr. Merck was one of those entrusted, during the late conflict, with the guidance of this country's preparations for and against biological warfare. I quote:

> These investigations and the revelation of their inherent quality of producing not only weapons and defenses, but also fundamental advances of knowledge and practical contributions to medicine and agronomy, have necessitated *the writing of a new chapter in Biological Science.*
>
> * * *
>
> Those responsible for our defenses and preparedness in this upset world are alert; they have their programs ready. But they need support—support from scientists, academic and industrial, which should be given generously and in full measure—and it should not wait for an emergency call of patriotism.
>
> There must be support from the people through Congress and its proper committees. That means money for research. If anything is sure about such an investment, it is that it will pay large dividends—dividends for the nation's health and for the country's economy.

Shall biologists have any part to play in the formulation of public policy in biological warfare? We cannot do so as individuals. It must be a matter of group thinking and of group education. Biological warfare involves nearly every branch of plant and animal science: mycology, agronomy, animal husbandry, bacteriology, biochemistry, horticulture, entomology, ecology, mammalogy, veterinary medicine, physiology, both plant and animal. All biology must organize to lead the public in its thinking on biological matters.

Whatever our individual sciences may do to strengthen themselves in public service, it is clear that one over-all organization embracing all the biological sciences is essential *now.*

Research in Fundamental Biology and in Agriculture

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THE TIME IS RIPE FOR RE-EMPHASIS OF the fact that those in the fields of fundamental biology and agriculture derive many benefits from close association, and for calling attention to the opportunity they now have to work together in cooperation and mutual helpfulness to an unprecedented degree in the years immediately ahead. With the enactment by the Federal Government of the Hope-Flannagan measure, permitting appropriations of upwards of $9,500,000 for research in agriculture in 1947, with an increase each year to $61,000,000 in 1951, the way is open for development of a research program of a magnitude hardly yet fully understood or appreciated.

Speaking as one who has been concerned with problems of agriculture, specifically horticulture, I cannot pay enough tribute to the so-called fundamental field of biology for its contribution to the applied field. From the fundamental field comes the new approach, the revolutionary idea, the answer to many a practical problem. Much of the work of the applied field becomes involved in necessary service and in determining that one pound is as effective as two pounds. The basic or fundamental approach provides release from this routine. Added testimony to the contribution of the fundamental approach is the ever-increasing number of men in the applied field who seek training in basic subjects. In fact, in the field of horticulture the trend is to send students into the basic fields for a large part of their training, while maintaining seminars, reading rooms, and discussion groups to provide the horticultural point of view.

The close relation between biology and agriculture is implied in the definitions of the words themselves. Agriculture is "the cultivation of the soil for food products or any other useful or valuable growths of the field or garden," and biology is "the study of living matter." Just what "fundamental" means, as we use the word, is not so clear; I feel that we make altogether too much of it. As with moral codes, so with science: what is fundamental today is no longer so regarded tomorrow. If by fundamental we mean "essential" or "basic," then moisture is fundamental to tree growth, the tree is fundamental to the lumber industry, and lumber is fundamental to the carpenter. Only in the realm of an unsolved problem or an unprovided material does the word "essential" or "fundamental" seem to arise. Any new information is fundamental in the sense that sooner or later it is essential to something else. In fact, new and fundamental information is just as important to agriculture as are the products of agriculture to human welfare. We speak of the race between food supply and population, with famine as a possible outcome. We may as truly speak of the race between fundamental truths and the

advance of agriculture, with famine both of applied truths and of foodstuffs as the possible result.

We also use the word to distinguish pure science from what we call the "applied" field. But in this usage, to say that this or that is fundamental often means merely: "I do not yet see the application." Often only a little imagination is required to transpose a "fundamental problem" into an "applied problem." So much of the so-called fundamental has application that many of us, I fear, literally pirate fundamental biology.

Of course, in all of this there is nothing new, but it needs restating, especially to administrators in the applied field who are responsible for the direction of programs and for the allocation of funds for research in agricultural problems.

So much for the importance of fundamental biology to agriculture. What of the importance of agriculture to fundamental biology? In general, I believe, the applied field is in turn helpful to the fundamental field.

Although there are those who are strong enough and able enough to stand alone and work out problems without regard to others, those individuals are rare. Whether they prosper because of their isolation or in spite of it is a case for argument. There is good reason to believe, however, that, either consciously or unconsciously, most of us work on problems because we see in them some relation to our fellow man, either in the form of attaining recognition of intellectual achievement and acquiring special skills, added power, and prestige or in the form of giving service and help to human beings. The desire to be of service to others is basic in the human race and something from which, as individuals, we derive perhaps our greatest satisfactions in life. The tying of fundamental study to some practical or useful outlet is natural and satisfying.

Not only does association with an applied field make the application of a fundamental truth possible, but it may also materially speed its adoption and thereby increase and hasten the satisfaction to the individual concerned. The rapidity in application of work with growth regulators in preventing preharvest drop of fruit, in killing weeds, and in inhibiting sprouting of potatoes is an outstanding example in which the fundamental, the applied, and industry have succeeded as a triumvirate in pushing ahead where each alone could not proceed. Surely the fundamental has been aided by being tied to the applied field in this particular instance. Would we have had hybrid corn sooner if it had been developed in an applied laboratory? To be sure, it may be said that applied laboratories were working in this field but failed to grasp its significance. However, is this not more a matter of the individual involved than of fundamental or applied science? Many fundamental or basic truth have come from applied laboratories, and there will be more as administration sees the value of a liberal interpretation of both basic and applied problems.

It must be admitted, nevertheless, that there is danger of suppression and of stifling research through improper direction, and I think it is this sort of thing that workers in the fundamental field fear. In this connection it may not be out of the way to quote the remarks of C. E. K. Mees, director of research for the Eastman Kodak Company:

> Research is a gamble. It cannot be conducted according to the rules of efficiency engineering... Research must be lavish of ideas, money and time. The best advice that I can give is don't quit easily, don't trust anybody's judgment but your own; especially don't take any advice from any commercial person or financial expert, and, finally, if you really don't know what to do match for it.... The best person to decide what research work shall be done is the man who is doing the research. The next best is the head of the department. After that you leave the field of best persons and meet increasingly worse groups. The first of these is the research director, who is probably wrong more than half the time. Then comes a committee, which is wrong most of the time. Finally there is the committee of company vice presidents, which is wrong all the time.

With most of that statement the majority of research workers will agree. Yet, to give the other side of the case, may not some of the difficulty lie with the research worker himself in not exercising sufficient imagination to tie his fundamental problem to the applied field? Cytogenetics may tie to breeding of a disease-resistant plant; photoperiod, to bolting of lettuce; tagged atoms, to controlling a virus trouble that threatens an industry; embryo culture, to producing a new rose or a cherry; and dormancy of seeds, to the nursery industry. To tie the fundamental to the applied is not a difficult task, but it is too often neglected. We forget that not many years ago a man labored half his life to become sufficiently independent financially to be able to carry on research. Nowadays the scientist is set aside by society to do this very thing. Is it too much to ask that we spend, say, 10 per cent of our time in harnessing our program to serviceable outlets? My experience is that not more than 10 per cent is required.

The applied field can bring financial support to research. Surely there is evidence that fundamental research has prospered when tied to the applied field. It seems to me that the loudest and most frequent pleas for financial assistance in the fundamental field are from those who have failed to tie to the applied field for support.

Closely related to financial support from the applied field is the encouragement that likewise springs from it. Man does not live by bread alone; neither does the research worker. Anyone who has experienced the enthusiastic support, encouragement, sympathy, and help that an applied field can provide will know what is meant. It is in many ways the most attractive feature of tying closely to the applied field.

Finally, the applied field offers specialists from dif-

ferent fields the opportunity to work together on the solution of a complex problem. We are in an age when the problems that can be solved by isolated individuals or groups are fewer and fewer. The era of cooperative attack is here. The applied field can provide both the specific problems around which specialists can rally to help each other and the means of support for an attack upon these problems.

It may be impertinent to ask whether a biologist really ever exists happily and successfully alone. It is probably not worth while to attempt to answer the question, but it may be worthy of passing comment. Like an active molecule, it is natural for a biologist to cleave to something. This does not destroy the usefulness or the value of a molecule; rather, it enhances its value. To be sure, there are molecules that exist uncombined with others, but it is the combined forms that are most helpful. Just so do biologists prosper when associated with or in symbiotic relation to medicine, plant and animal breeding, plant and animal pathology, agronomy, dairying, poultry husbandry, processing, canning, freezing, and scores of other fields.

Now we are approaching an era of public support for research such as that projected in the new Hope-Flannagan Act—support of gigantic proportions. Here is an opportunity and a challenge to both fundamental biology and agriculture. Agriculture needs the help of fundamental biology; without it, it will starve. Fundamental biology needs the support, the encouragement, the satisfying outlets, and the cooperative opportunities that agriculture can provide; without it, it may grow thin. Let us hope that a liberal attitude on the part of administrators in applied fields may prevail toward fundamental biology and that those in the fundamental field may find it attractive, worth while, and profitable to accept the encouragement, satisfaction, support, and opportunity for cooperative effort that the applied field can provide.

Possible Advantages of Cooperation Between Societies in Publication

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THERE SEEMS TO BE A RAPIDLY GROWing sentiment on the part of biologists toward some form of closer cooperation between the various societies—a sentiment based upon enlightened self-interest as well as upon a desire to contribute as fully as possible to the public welfare.

In the past, the tendency in biology has been toward disintegration. Those in the various fields of specialization have tended to work for the development of their own specialties to the neglect of the needs of biology as a whole. In so doing, they have failed to develop and support a more central and more general biological organization. One reason for this divisive tendency is the fact that biology is so diverse a field. The terminology and problems of one specialty are without meaning to many individuals in other specialties. There is not in biology, as there is in the fields of physics and chemistry, a large enough body of common knowledge and of common techniques to weld all biologists easily into a single, closely knit group. For this reason, biologists find it difficult to stick together; for this same reason, therefore, the need of cooperative effort and of organization is all the greater.

Although we biologists may speak many scientific languages, each being interested in matters unintelligible to many others, there is one thing that we all do in common. We all publish the results of our researches, and we all have to struggle with the problem of getting these results published promptly and economically.

That much can be done to increase the efficiency of our publications may be illustrated by reference to the situation I happen to know best—that of the *American Journal of Botany*. Financial reports of this journal from 1933 to date reveal some interesting facts. The average yearly income of the journal for the years 1936–44 was only slightly more than that for the years 1933–35, and the disbursements were only slightly less. We may say that these items have remained fairly constant. Nevertheless, with essentially the same income and expenses, the *American Journal of Botany* has, since 1936, achieved the following remarkable advances:

(1) It has increased its cash reserves 1,000 per cent.

(2) It has published, on the average, almost twice as much material per year since 1936 as in the years immediately preceding the reorganization (an average of 4,900,000 characters per annum vs. an average of 2,570,000).

(3) It has greatly decreased the time for publication of a paper, which averages at present between four and five months from date of receipt to date of publication, as