Studies of Starvation

As referee editors of several physiological and nutritional journals, we are perturbed by the continuing submission of mediocre papers dealing with starvation. Usually the only experimental method used consists in starving rats to a near-terminal condition and then determining one of the many parameters which can be affected by starvation. Sometimes determination of the duration of survival on a given diet is the only "technique" employed. Previously obtained information, available in the U.S. and foreign literature—often admittedly older literature because of the very simplicity of the techniques used —is generally ignored.

The application of the "findings" to problems of human survival involves questionable extrapolations. What little new information, if any, is obtained in these studies does not seem to us to be commensurate with the suffering inflicted on the animals. There is little doubt that we need to know more about the physiological mechanisms involved in resisting starvation and about the pathological consequences of prolonged undernutrition, whether continuous or intermittent. We would certainly approve for publication papers in which a great many pertinent correlations are studied in order to close the book, at least for a while, on death by starvation. But we find it difficult to approve of these piecemeal dissections which have resulted, and which will continue to result in perhaps dozens of papers, none of them definitive.

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Electronics and the Life Sciences

In their article "Biomedical electronics: potentialities and problems" [*Science* **135**, 198 (1962)], Robert Ledley and Lee Lusted argue the need for conditions which are more favorable to the development of "biomedical electronics." They review the highly important role which electronics has played in the development of devices and systems of major contemporary importance and foresee a similar role for electronics in

the life sciences. It would be most difficult to disagree *in toto* with this prediction.

Nevertheless, the totality of what these writers would seem to offer to medicine and to the biological sciences is only in part the subject matter normally associated with electronics. Rather, the entire field of engineering and those branches of science now largely pursued by those who have engineering training (the so-called engineering sciences) seem to be involved. Let us follow the authors' list, in part. "Measurement and analysis of small electric potentials" is an electrochemical problem to which important contributions have been made by physical chemists and chemical engineers. "Electronic flowmeters" present serious problems in non-Newtonian fluid mechanics as well as in electronics. Governing the design of many "artificial organs" is the approach instituted by chemical engineers to the problems of interfluid transport through membranes and the fluid mechanics of the adjacent liquids—not primarily, as Ledley and Lusted state, "the extensive use of electronics in medicine." The investigation of "infrared detectors" and "ultrasonic receptors" in animals lies in areas of applied physics to which engineers of many types have contributed.

No engineer in any of these areas hesitates to acknowledge the great assistance he derives from the largely electronic instrumentation which he uses. Nonetheless, the application of this instrumentation to problems in the life sciences is a far less worthy objective than the application of the whole of engineering technique, analysis, and science to the goals of biological research.

Electronic instrumentation is primarily a *tool*, useful to those trained in its use and in utilization of the measurements it produces. Most of the important biological problems arising today cannot be solved simply by increasing budgets so that more sophisticated instruments can be brought to bear on these problems. Before the quantitative output can be analyzed—even, given a certain instrumentation capability, before one can decide what to measure—some analysis must be conducted. The biological scientist frequently needs assistance in these analyses, and this assistance can often best be obtained from a problem-oriented individual with training in one of the several branches of engineering.

Alternatively, the life scientist may wish to acquire knowledge that is available in any of the several branches of engineering in which similar problems have been attacked quantitatively. In either case the primary requirement appears to be for a biomedical engineering function (*1*) or even for a broader, "bioengineering" function (*2*) from which will follow naturally the demand for instrumentation. "Biomedical electronics" is an important but subservient function, reflecting the broad cooperation which is developing between life scientists and engineers.

Concerning specific proposals made or analyzed by Ledley and Lusted, a few comments are perhaps in order. I agree that a basic deterrent to biomedical electronics is a lack of financing. But in proposing more support for biomedical electronics per se, the authors are stressing the means with insufficient concern for the end. They attribute the reluctance of industry to participate in the development of electronic devices for medicine to "the prevalent opinion that there is a small market." They cite three other problems: (i) "finding what devices need to be made," (ii) "getting the devices tested," and (iii) "selling the instruments." All of these are facets of one problem: a shallow dialogue between the biological scientist, who knows the subtle morphology of the problem, and the engineer, with his sometimes naive but often useful ca-

pacity to build and analyze tenable physicochemical models.

At the end of their article Ledley and Lusted make a more general plea for increasing the depth and intensity of this dialogue, but even this discussion seems to be oriented toward finding uses for electronics rather than toward finding solutions for pressing problems in biology and medicine. They say, for example: "Because of the extensive mathematical training he has already received, it is usually easier for a physical scientist or an engineer to become a biomedical researcher than for a biomedical researcher to become a physicist or engineer. *Such an electronics trainee . . .*" (italics mine).

One is moved by the tremendous accomplishments of electrical engineers in this field to a high and unqualified admiration of their pioneering efforts. That they, as a group, should choose to fix the boundaries of this new and exciting area of cooperative research so as to make them in any way coincident with the boundaries of their own field is unbelievable.

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Notes

1. The term *biomedical* (without the suffix *electronics*) is a part of the name of Ledley's organization. Lusted is listed as a professor of "biomedical engineering." The recent Nebraska Conference was on "biomedical engineering." Johns Hopkins and the universities of Rochester and Pennsylvania have programs in "biomedical engineering."
2. Many institutions have been entertaining programs involving engineering and the biological sciences for many years. Columbia University has simply made medical applications a part of its long-standing activity in a broad area which we call "bioengineering."

Leonard quite correctly points out that the different engineering disciplines can contribute greatly to the advancement of biomedical research. If he feels our article implies that only electrical engineering or biomedical electronics can contribute to the progress of biomedical research, to the exclusion of other areas of engineering, then he has misinterpreted our intention. The main theme of our article is expressed in the first sentence: "The full application of electronic engineering technology to biomedical science is long overdue." We believe that such application, in many areas, is necessary (though clearly not sufficient in itself) to the general advance of biomedical science.

We should like to point out that in our article we considered mainly the tool—electronic engineering technology

—not electronic engineering science. Leonard's letter is apparently concerned more with the engineering scientific disciplines themselves than with the tools of engineering science. He says that "the biological scientist frequently needs assistance in these analyses, and this assistance can often best be obtained from a problem-oriented individual with training in one of the several branches of engineering." In a previous article, "Digital electronic computers in biomedical science" [*Science* **130**, 1225 (1959)], one of us (R.S.L.) stated, "I strongly believe that 'team' approaches, where the biologist has no . . . [engineering] training and the engineer . . . has no biological training, are foredoomed to failure. For the full significance of the extensively detailed and often subtle . . . use of . . . [engineering science] in biomedical science can be understood only by those well grounded in both fields." Whether or not any of the various engineering sciences—such as chemical, hydraulic, and mechanical, as well as electronic, engineering—is a *necessary* ingredient in biomedical research depends upon the particular problem being approached.

However, we believe that electronics as a tool *is* (or should be) in many cases a necessary ingredient of research. In order to lend weight to this point in our recent article, we described such use of electronic equipment as a necessary ingredient (but obviously not the only one) in many biomedical research activities, and we attempted to discuss the reason why fuller use of this important tool has not yet been made in biomedical research. We do place this electronic tool in a rather exalted position, because it is well known that advances in science closely parallel advances in instrumentation. However, we refute Leonard's accusation that we have attempted "to fix the boundaries of this new and exciting area of cooperative research so as to make them in any way coincident with the boundaries of [our] own field [of electronics]." As a matter of fact, we would like to call attention to a symposium on educational frontiers in biomedical engineering [*IRE Trans. on Bio-Medical Electronics* **BME-8**, No. 4 (1961)] in which the very broad field of biomedical engineering is discussed.

In conclusion, we would like to reiterate the view, stated in our article, that the "use of electronics in biomedical science [as a tool] holds promise of tremendous advances in the study of the origins of the life processes; it may

result in spectacular advances in medical science, which could have a definite effect on individual health and longevity; it might pave the way for the discovery and development of whole new technologies based on intimate knowledge of biological processes."

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A Concerted Attempt To Improve Relations with the Communists

Recent commentary concerning what scientists can do to help resolve the arms race seem to me to overlook one unique contribution that scientists as a group can make. This is to focus attention on treatment of the fundamental disease—the almost total ignorance of the problems and intentions of the "other side" evident on each side—as well as the symptoms and their treatment.

This is not to say that the symptoms can be or should be ignored. But it does seem preposterous to budget over $50 billion on military defense and a pittance, if that, on long-range defense measures aimed at resolving the underlying tensions by improving the reciprocal understanding and appreciation of strengths, as well as weaknesses, of the American and Russian societies. To attempt any such program openly will be attacked as treasonable by many citizens who have closed their minds to the problem and see issues only in clear-cut blacks and whites. Scientific objectivity certainly needs to be applied here, and in generous dosage.

The risks of such a procedure may seem enormous to those among us who are strongly and often vehemently *against* communism (and perhaps also democracy, or some particular religion, and the like) but who more and more fail to emphasize the values that they feel we should be *for*—except in what appear to be vacuous, emotion-laden shibboleths. The corresponding erosion of those freedoms for which our country has long stood is especially disturbing and is aggravated most dangerously, if not initiated, by many of these people. Surely it is time for scientists to take a more forthright and uncompromising position in support of our freedoms, and to emphasize the strengths