19 August 1955, Volume 122, Number 3164 SCIENCE

# Food for the Future

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When the problem of food for the future is under discussion, a standard question concerns the extent to which science can assure that future generations will be able to enjoy an adequate standard of living from the point of view of nutrition. However, this would seem to be only part of the problem, since sufficient food for society is the concern not of the scientist alone but of all mankind. There should thus be two parts to the question: namely, what are the responsibilities of society in assuring an adequate food supply, and how can science be applied most effectively to this end?

Many competent individuals, principally demographers, biologists, and conservationists, are deeply preoccupied by the problem of maintaining a balance between food supplies and a rapidly increasing world population. It is not surprising that their conclusions range from the dismal one, that the world cannot support foreseeable increases in population, to the opposite extreme that a world population of 10 billion or even more could readily be supported from known resources. The pessimists and optimists both contribute importantly to our understanding of the world's problems, and both should be listened to with respect. However, we may be placing too much emphasis on the issues of tomorrow, while overlooking the importance of those facing us now. It seems somewhat unrealistic that we should be more concerned about generations as yet unborn than with those living today in substandard conditions. This is a little like worrying about educational opportunities for posterity while keeping one's own children home from school. If we can meet our immediate challenge successfully we will be better prepared to cope with the still larger populations to come.

Unfortunately there is a widespread attitude that problems of food production are "agency" responsibilities and are not the concern of all the instrumentalities of our society. Both present and future food requirements involve coordination between those agencies struggling to accomplish concrete results and those responsible for the political, economic, educational, and religious leadership of the world's citizenry. Each discipline and each aspect of human concern inescapably impinges on the others; and unless all these are intelligently linked, divergencies in opinion, objectives, and activities will inevitably result and will seriously impede progress.

We cannot continue to take for granted that increased food production is the exclusive worry of the scientist and that it is his obligation to find ways to satisfy growing needs and to enable mankind blithely to pursue thoughtless and careless practices in the utilization of natural resources. On the contrary, scientists can carry out their part in the total scheme only when they are working as one segment of society in harmony with the others. When each group and each individual accepts responsibilities relative to food for the future then we can make progress, and many of our present fears will disappear. In part, what demographers and scientists mean when they speak pessimistically about future food supplies is that conditions will grow worse if we blindly go on as we are in the face of an alarming population increase. This fear is justified, but need we go on as we are?

It is useless to expect that all the world will soon reach the standard of living enjoyed today by the more favored areas of the world, and we can only hope to have improvements within the limitations of the areas concerned. Some countries can continue to look forward to tremendous agricultural developments and increasing standards of living. Certain others must face the fact that they do not have large reserves of natural resources and will have to hold or improve their positions in the world community largely through the production of goods and services. Isolated material gifts to the less fortunate countries offer no permanent solution to their food problems, but types of aid that will enable them to join the other nations on a proportionately equal basis have great promise.

One of the surest ways to get at those difficulties involved in feeding present and future generations is through education. An uneducated public cannot readily understand problems that are not of visible, immediate, and local impact. Such people may be led in devious directions because of their inability to reach independent judgments and to appreciate the real consequences of their acts. Thus, food production is severely handicapped in areas where the farmers have not enjoyed the benefits of education. It is not to be expected that we can have anything approaching full agricultural production until those who till the soil are capable of making intelligent use of the improvements that modern agriculture brings. The basic approach to "food for the future" is not through the distribution of more plows but rather through the wider dissemination of knowledge. One may argue that if we follow the long route of general education, delays are inevitable and progress will be slow. Such delays, however, are insignificant in terms of "world time." The fact that educational benefits have thus far reached only small segments of society makes it all the more imperative that they be extended as rapidly as possible. Interim advances in crop production can be expected, but these will be small compared with the total benefits that can accrue when sound, mass education becomes the rule.

Real progress in mass education will lay the groundwork for other significant developments. For example, one of the greatest existing social problems is to be found in the limitations of rural life and particularly in the role of women in farm communities. The influence of rural women is vital to community progress, but as long as many millions of women

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are relegated to the role of farm laborers (as is tragically true in many parts of the globe) much of what they have to contribute to family life and to the training of children is lost to society. Instead, society receives only the meager product of unskilled labor. If the future is to be better, this situation will have to be changed so that coming generations will benefit from social values learned in the home, from mothers with at least basic education. At present there is an understandable monotonous similarity, from generation to generation, throughout underdeveloped areas where tradition, rather than initiative, rules.

The economics of food production and distribution is still largely in the theoretical stage, and the great benefits to be gained from the general application of sound economic theories lie ahead. In many parts of the world landholding and tenure systems are economically unsound, and these are most difficult to change. Under the system of latifundia, vast acreages lie uncultivated; whereas, by contrast, there are other regions in which the cultivation of tiny plots has become so intensive as to approach "flower pot" farming. These extremes may be the natural results of local patterns derived from varying degrees of population pressures, and we can never hope to approach maximum potential production until education and economics combine in support of scientific agriculture. Stable currencies and price policies, adequate agricultural credit, and proper marketing, all are of vital importance to a successful pattern of crop production, distribution, and utilization. When this is generally understood and accepted by society, there can be hope that all the people will be adequately fed and that the fruits of their labors will provide them with greater comforts and opportunities.

Another influence that profoundly affects food production is applied political science. Since political leaders publicly accept responsibilities for guiding the temporal thinking of the peoples of the world, their moral burdens are heavy. If we are to have food for all, political leaders will necessarily become increasingly aware of the importance of a balance between enlightened nationalism and internationalism. Otherwise, inequalities in one area may become explosive and create disturbances that may eventually become world-wide. Here again, the education and judgment of society are the most significant factors, especially since in many parts of the world democratic procedures prevail, and we select our own leaders for better or for worse. Able political leadership is usually available and will continue to be, but we must exercise our franchise with skill and perception if we are to provide ourselves with leadership of the quality necessary to meet the basic human problems.

The role of religious leadership in the solution of the problem of food for the future cannot be overestimated. Lack of understanding among religious leaders and reluctance to broaden the interpretation of their theologies in the light of increasing knowledge could be a serious obstacle to attaining a balance between populations and food production. It would seem, therefore, that the leaders of all faiths have the opportunity and obligation without sacrificing spiritual values to guide their adherents toward the understanding that, regardless of creed, human rights are equal and that they must be jealously protected. And human rights are not merely the right to a minimum of food, clothing, and shelter but rather to all of these on a reasonable scale plus opportunity in the form of education and the chance to participate in social progress.

Before the public demands greatly expanded production from agriculture it should take a hard look at its own responsibilities with regard to conservation of natural resources. In underdeveloped areas, essentially all of the limited agricultural products are utilized because of the demand for food by an underfed population; but losses to production through failure to take maximum advantage of available potentials are a serious permanent source of waste. Examples are the use of low-yielding varieties, poor cultural practices, inadequate control of pests, diseases and weeds, and failure to use fertilizers where they are needed for increased yields. Agricultural scientists could correct essentially all of these conditions in underdeveloped areas, but to be effective their activities would have to be preceded or paralleled by improvements in public health, education, and other social developments.

In areas where agricultural practice is most advanced, there is also the greatest waste of food. This may in part be an effect of economic situations that produce unused surpluses, but it is also the result of domestic habits that lead to waste. Perhaps our own country presents the most glaring example of this pattern, and it has been estimated that each year we throw away enough food to support 10 to 15 percent of our present population. Since the vast bulk of household food wastes is dumped or burned rather than recovered for agricultural or industrial purposes, their loss is total. The same situation prevails with reference to human wastes, which should be used advantageously in completing the food cycle. It seems incongruous to put heavy pressure on scientists, farmers, and resources to increase food production without requiring of society a commensurate sense of responsibility for the conservation of these products so that they will make maximum contributions to human nutrition. Similarly, we cannot complain of mounting costs and failing supplies of food and at the same time use them wastefully and continue to destroy forests, erode tremendous acreages of arable land, pollute rivers and lakes, and throw away large quantities of fossil fuels.

Many persons believe that we can meet the future with assurance, insofar as the technical aspects are concerned. Abundances of agricultural products can be obtained that would far exceed present expectations, if scientists are given a wide opportunity by society to apply their knowledge and ingenuity. There are two requisites: first, public support of pure science that will permit continuous and increased fundamental investigation of the laws of nature so that man's intellectual horizons may be constantly broadened; second, an opportunity for scientists to transmute basic knowledge into applied science, and this must be provided rapidly and be made widely available without restriction. Through the intelligent application of technical advances, an educated public can undertake to feed itself without the wanton destruction of the limited natural resources that are needed also to serve the generations to come.

If we assume that society in general will eventually meet its responsibilities relative to food for the future (and this is a major assumption), then we should carefully examine the responsibilities of science. First, the scientist must gain the confidence of nonscientists so that these two sectors of society will not be separated by barriers of fear or misunderstanding. Real progress is being made in this direction, and certainly the medical, agricultural, and other biological sciences are generally viewed as powerful social assets rather than as liabilities. A long and thoughtful view similarly convinces one that the chemical and physical sciences are equally beneficial, although the public may at times be appalled at the temporary use to which certain advances are put. It is an essential element of the scientific faith that, on a long-range basis, such developments always redound to the benefit of mankind.

We must certainly look to the physical sciences for our future supplies of energy, and nuclear energy may one day prove to be a general source of power. Progress is most rapid when vast amounts of energy are consumed, and the present hope is that power from nuclear fission will eventually replace that from other sources and make fossil fuels unimportant. Up to the present, however, mankind has derived essentially all his useful energy either directly or indirectly from the sun. Fortunately green plants were busy storing solar energy on the earth for many eons before man came along, and our great heritage of fossil fuels, in conjunction with the radiant energy that the earth receives every day, is materially responsible for human progress. Thoughtful persons are alarmed at the rate at which we are exhausting our fossil-fuel reserves, and the most optimistic estimates give the world less than 200 years during which it may draw necessary power from coal and petroleum. If we are to continue to develop agriculture and industry, we must have sustained sources of energy on an increasing scale, and unless these are forthcoming, other questions become academic.

Significant progress has been made in learning to control nuclear reactions for the release of usable energy. There are many technologic and economic factors that must be overcome before any transition from conventional sources of energy to nuclear sources is accomplished on a large scale. There may be very much more or much less fissionable material than is currently estimated or there may be other conversion methods that may be brought into use. It has been suggested that we may eventually learn how to duplicate the sun's feat of converting hydrogen to helium with a resultant tremendous energy release in the form of gamma radiation. Any such speculation seems fantastic at the present time, even though the necessary raw materials are available in unlimited quantities. However, most major scientific developments seemed fantastic and remote before they became realities.

For many years man has dreamed of harnessing free sources of energy, including the sun, wind, tides, volcanoes, and thermal gradients of the sea. Many ingenious solar engines, heat pumps, heat exchangers, wind converters, and tide turbines have been designed and used with varying degrees of success. All these mechanisms merit further investigation, but only the sun holds promise of providing mankind with quantities of energy of the magnitude we must have in order to continue our progress. We may have been lulled to a false sense of security by our knowledge of the present reserves of oil, coal, and fissionable materials and have failed to place proper emphasis on research leading to the quantitative conversion of solar energy to forms usable in industry and agriculture. All the known reserves of coal, petroleum, and wood barely equal the total solar energy that reaches the earth every 48 hours, and conversion of relatively minute quantities to usable forms would solve our future energy problems indefinitely. The sooner we learn to use this resource, initially as a supplement, the better will be our position when at last it becomes our only major free source. It seems doubtful that the most effective way of trapping and storing solar energy is through vegetation, since photosynthesis itself is an inefficient process. Surely we can devise more efficient methods, and ultimately it should be possible to convert immense quantities of solar energy to forms that can be used immediately or stored for future power demands.

Regardless of technologic advances in other fields, we are going to be practicing agriculture for a long time, and we should learn to practice it more efficiently, if we expect to meet growing food requirements. Even though conventional agriculture as we now know it can solve present and proximate food demands, it can be further improved to the end that the possibility of a diminishing food supply can be pushed back in time. This will be accomplished as the result of continuous fundamental investigation of natural phenomena, with respect to both the physiology and biochemistry of living cells and the interrelationships between living forms and their environment. We have made extraordinary progress in agriculture by taking advantage of knowledge gained through basic research, but past applications will seem crude in comparison with refinements that may be expected in the future.

Conventional agriculture as it exists today is a far cry from the pattern of 50 or even 25 years ago. Among the most spectacular developments have been the mechanical aids. It is possible in a single operation to prepare a seedbed from unplowed land; plant, fertilize, and cultivate growing crops with the same piece of equipment, and dig root crops, pick corn, cotton, and hops; or harvest beans, cereals, and peas with mechanical devices. Harvested crops may then be washed, cleaned, frozen, or dried, and packed by other machines. These and other engineering advances have made it possible to produce uniform crops, to harvest them at exactly the right moment, and to handle huge quantities of products with minimum labor. Each year new and improved appliances are developed which enable the individual farmer to produce larger quantities of food more efficiently and at significantly lower cost. And a sound pattern of agricultural production always stimulates and supports industrial developments that absorb surplus farm labor.

The application of chemistry to agriculture has revolutionized farming. Chemical control of diseases and pests has reduced the annual crop losses significantly, and it is now possible to eliminate many weed species in cultivated crops without damaging the economic species. We can defoliate plants with one group of chemicals, hold fruit longer with others, and induce the production of seedless varieties of fruits with still others. There is also promising evidence that minute quantities of chemicals may function as protective agents within plant cells to destroy viruses and to resist attacks by fungi and insects. It is also possible that systemic chemicals may stimulate plants to produce larger quantities of stored food or valuable medicinal or industrial compounds. Similarly, it should be possible to improve both the quantity and quality of milk, meat, and eggs through the use of chemicals.

The science of genetics has proved tremendously useful in plant and animal improvement, and varieties of corn, vegetables, fruit, small grains, poultry, swine, and cattle are far superior as a result. The modern geneticist is a sort of biologic tailor who fits varieties to a specific environment, using such techniques as induced polyploidy, multiple topcrossing and backcrossing, to obtain and fix desirable characteristics and produce blended progenies. In recent years the phenomenon of hybrid vigor has been advantageously employed to increase yields, and the most spectacular example of heterosis is to be found in hybrid corn production. As the science of genetics becomes better understood, new benefits may be expected, such as increased quantities of usable products per plant, higher amino acid content, the development of dwarf varieties with increased production efficiency, as well as plants and animals endowed with greater tolerance to drouth, temperature fluctuations, and parasites.

The soils problems involved in crop production are better understood than ever before. This is true not only with regard to the role of soil biology, which has long been an almost complete mystery. New fertilizer techniques promise still greater average yields, and it is expected that progress in understanding the interaction of soil microflora and fauna will be proportionately greater during the next several decades. Another promising approach is the direct application of nutrients to foliage as an effective and economical way of feeding crop plants. Nutrient elements may be injected into the moist soils or incorporated into irrigation water with economic benefits, and chelating agents and soil conditioners are being widely tested in the hope that they may contribute toward increased average yields. And finally, soil substitutes in combination with nutrient solutions have demonstrated that under certain conditions hydroponics offer important opportunities for supplementing food production. Whether or not multistoried hydroponics gardens will, as has been suggested, be commonplace in the future will depend largely upon economic factors.

Certain of the techniques of modern

atomic physics offer fascinating possibilities for penetrating more deeply into the mysteries of cellular metabolism. The thus far limited use of the radioactive isotopes in tracer studies will in the future permit the further pinpointing of specific cellular activities and help us to understand them as parts of the metabolic process. The use of labeled elements singly and in combination permits the simultaneous study of chemical reactions within the cell. From investigations such as these we shall gain information that may help us to direct the potentialities of the cell toward the conversion of simple substances into more complex compounds of value to man. Furthermore, when crop plants are subjected to irradiations from atomic sources, spectacular changes may occur in metabolic processes. The fact that irradiation may speed up the process of mutation immediately suggests this as a method to induce cellular changes that may be of benefit. Evidence from preliminary trials indicates that dwarfing, increased productivity, and greater resistance to certain diseases may result from irradiation. Present methods are necessarily of the shotgun type, but as this tool becomes more refined it may be possible to use it more precisely and actually apply it for specific results. If, for example, such basic food crops as corn, wheat, and rice could become symbiotic nitrogen fixers, enormous increases in annual world yields would occur, with equally important reductions in costs of production. The phenomenon of symbiotic nitrogen fixation is peculiar to members of the legume family and a few other species; and why this should be true is a tantalizing mystery. There are great possibilities that induced genetic changes in conventional crop plants might increase both the quantity and quality of food production.

The use of microorganisms for the production of substantial quantities of food substances merits careful investigation. This might involve a direct approach through the use of chlorophyllous microorganisms that are relatively efficient producers of proteins and fats and the employment of methods to stimulate the activities of those species that aid in the fixation of nitrogen and other nutrient elements in soil. There is already sufficient evidence to suggest that microorganisms offer promise both as direct and indirect food sources and in the economic conversion of human wastes to usable products. The gap between the costs of the production of fuel or food energy from microorganisms and from conventional sources is still great. But as improved techniques increase production and price levels rise, this gap will tend to narrow. It seems doubtful that algae will soon be a highly competitive source of direct food in most parts of the earth, but they may be sources of proteins and fat concentrates that would be of great value in the enrichment of foods and feeds.

There is much current interest in the sea as a gigantic and relatively untapped food resource. At the moment, the amount of research going into marine biology is infinitesimal in terms of the food potentialities of the sea. But as we become more convinced of the importance of the sea as a usable resource and understand its complexities, many techniques will be evolved that will enable us to harvest vastly more food from the sea than we do today. Land is the medium of the land-dweller, and consequently the sea seems foreign and difficult. However, as our knowledge of the sea increases, ultimately it will be possible to solve many of its secrets and to "farm" the sea more intensively for human benefit.

Similarly, it is generally accepted that climate is capricious and uncontrollable. There is insufficient evidence, however, on which to base such a final conclusion, and there are at least possibilities that man can affect climatic trends in such ways as perhaps to improve both the quantities and distribution of rainfall. Any success in this area resulting from studies of cloud physics in relationship to air movements, temperature gradients, and natural barriers could have an appreciable beneficial effect on agricultural production. Rain water and ground water are at present our only sources of agricultural water and are insufficient for our demands. Effort must be made to conserve fresh waters, reclaim waste water from industry, and begin to convert sea water to semifresh water. At the moment the costs of partial desalting and transportation make this latter practice uneconomic for agricultural purposes. There is little doubt, however, that we shall eventually learn to process sea water efficiently, and when that time comes there will be an unlimited source of agricultural water available wherever such water can be economically distributed.

## Summary

There is ample justification for concern about adequate food supplies for future generations of mankind, but this concern should be broadened to include the immediate problem of an adequate standard of living for the world's present population. The successful solution of the immediate problems would furnish the best background of experience for meeting those that will arise in the future. First steps include the acceptance by society of responsibilities for the extension of the benefits of education throughout the world and provision for the type of scientific, economic, social, political, and religious leadership necessary to assure food for all on a continuing basis.

Striking improvements in the food supply can be readily made through the application of present knowledge, if the foregoing conditions are met. The rapid pace of modern science, both pure and applied, gives promise that future benefits may be much greater than those thus far experienced. Current advances do not signal the end of a technical road but rather that the great scientific developments still lie ahead. If we have the intelligence and wisdom to recognize human responsibilities and to make constructive use of our natural and human resources, we can look forward to a better world in the future and improved standards of living for all.

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*It is better to know a few things and to have the right use of them than to know many things which you cannot use at all.*—SENECA.