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The World Food Problem

Allen D. Tillman

THE WORLD FOOD PROBLEM

Professor Allen D. Tillman
Oklahoma State University

(Professor Tillman is a Commander in the Naval Reserve who performed his 1967 active duty training at the Naval War College. His article supplements Lieutenant Commander Somers' article, "The Place of Population Control in U.S. Foreign Policy," which appeared in the January 1968 issue. The reader should find the subjects of these articles challenging and provocative. Ed.)

The problem of obtaining sufficient food has plagued man since his beginning. Despite many advances in science and technology during the 20th century, the problem is still acute today; its nature and seriousness was summarized in a recent document of the Food and Agriculture Organization of the United Nations (FAO):

> . . . some 60% of the people in the undeveloped areas comprising some two-thirds of the world's population suffer from under-nutrition or malnutrition or both. Since there undoubtedly are some people in the

developed countries who are ill fed, it is concluded that up to a half of the people in the world are hungry or malnourished.

Throughout the early history of man, population was kept under control by disease and famine. The advancement of medical knowledge and its application has reduced the effect of the former to an extent that we have a "population explosion" and a condition in which over 10,000 people starve to death each day. It appears that we are now in a deadly race between an increasing number of people and food production. The purpose of this review is: (1) to consider major factors affecting the demand for food, (2) to consider present-day agricultural production, and (3) to consider assistance programs which the developed areas can extend to the developing ones.

Factors Affecting Food Needs. Two major factors are causing the expanding food needs: the population explosion and increasing incomes of people all over the world.

It is estimated that there are three billion people in the world today and that this will increase to four billion in 1980 and six billion by 2000 if effective curbs are not initiated.

During the early years the population of man increased slowly (figure 1).[1] For example, in the year 1000 B.C., the world's population was about 100 million. A thousand years was required for it to double and at the time Christ lived there were about 200 million people. It required 1,600 years for it to double again, and by the middle of the 17th century there were about 460 million people on the earth. The acceleration of population since 1650 has been phenomenal: the population doubled again by 1810, only 190 years later, and again by 1930, requiring only 90 years. By 1930 we had two billion people on earth, and the shape of the growth curve since 1930 (figure 1) staggers the imagination.

During the coming 20 years food needs will more than double in the countries which are already hungry, if present rate of population growth continues. Family planning will help, but the effect of such planning, if initiated now, would become more apparent after 1985 than during the next 20 years. The impact of population control will be realized over a period of many years and is very important in solving the overall problem; however, there is an immediate and increasing need for food unless population control programs become drastic. Thus it appears that even with the most optimate estimates regarding a successful population control program it would reduce food needs by only 20 percent, thus we will have to feed an additional one billion people by 1980. The world has simply never before added so many people in a span of 15 years. It is significant that 800 million of these will be added to areas where the population is already hungry.

The food problem is made even more acute by rising income levels throughout the world. All countries have goals for raising the income level of its people and this is noble; however, rising incomes generate additional demands for foods. In some of the more advanced countries, a rise in income has caused more demand for increased production of food than has the increased population. Japan is a good example. Her income is increasing at an annual rate of 7 percent and the population by only 1 percent, but she is presently consuming much more of the world's food resources than in past years. Grain is a major world food resource and its consumption is related to per capita income as is illustrated in figure 2.[2] When low income brackets

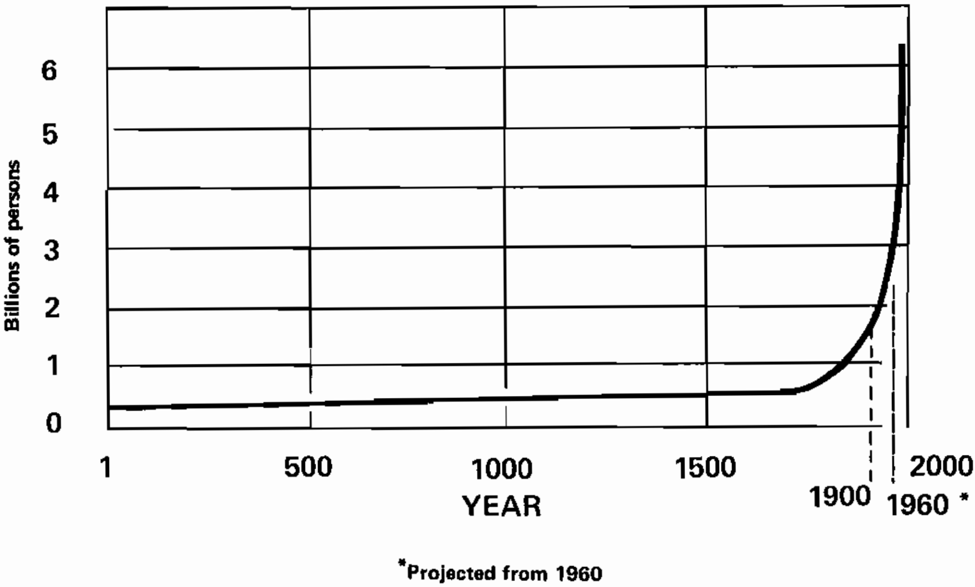

Figure 1 — World Population Growth

are considered it is apparent that the direct consumption of grain as human food rises as per capita income rises up to a point, and at higher incomes grain consumption declines until it levels out at approximately 150 pounds per year. A good example would be the consumption in the United States of breakfast cereals, bread, pastries, etc.; there would be no further increase in these if incomes were increased greatly. However, the more significant relationship in figure 2 concerns that one between income and total grain usage. When personal income is high, man uses more grain for the production of meat, milk, and eggs. As animals convert the energy and protein of grain to the meat, milk, and eggs with an efficiency varying from 10 to 33 percent, there is a loss of energy and protein when grains are used for these purposes rather than being consumed by man. The upper part of the curve indicates that each $2 increase in annual per capita income requires one pound of additional grain with most of this being used to produce animal products.

The explosive effects of increased population and increasing incomes upon food demands represent something new and terrifying to the world, and both have occurred since the World War II. In addition, they are gaining worldwide momentum. The effect of these two factors on world grain surpluses is shown in figure 3.[3] From 1953 to 1961 the world was producing more grain than it was consuming. The size of the annual increase in carryover stocks varied during this period from a small amount to about 20 million tons. Since 1961 we have been using more grain than is produced, the average being about 14 million tons per year. As the lines between consumption and production have to be brought together, the obvious question concerns *How?* The alternatives are simple: either food production will be increased or consumption will be decreased. A reduction in consumption where population is increasing and fully 50 percent of the people are not properly nourished is not the popular answer. We must increase food production. If the increased food is to arise from conventional agriculture, as is expected for some time to come, there appears to be only two methods available: (1) expanding the amount of cultivatable lands or (2) increasing yields per unit of land.

Agricultural Production. It is estimated that the cultivated lands in the world are about three billion acres. There are many estimates regarding the possibilities of expanding these lands, and the quantities of these estimates

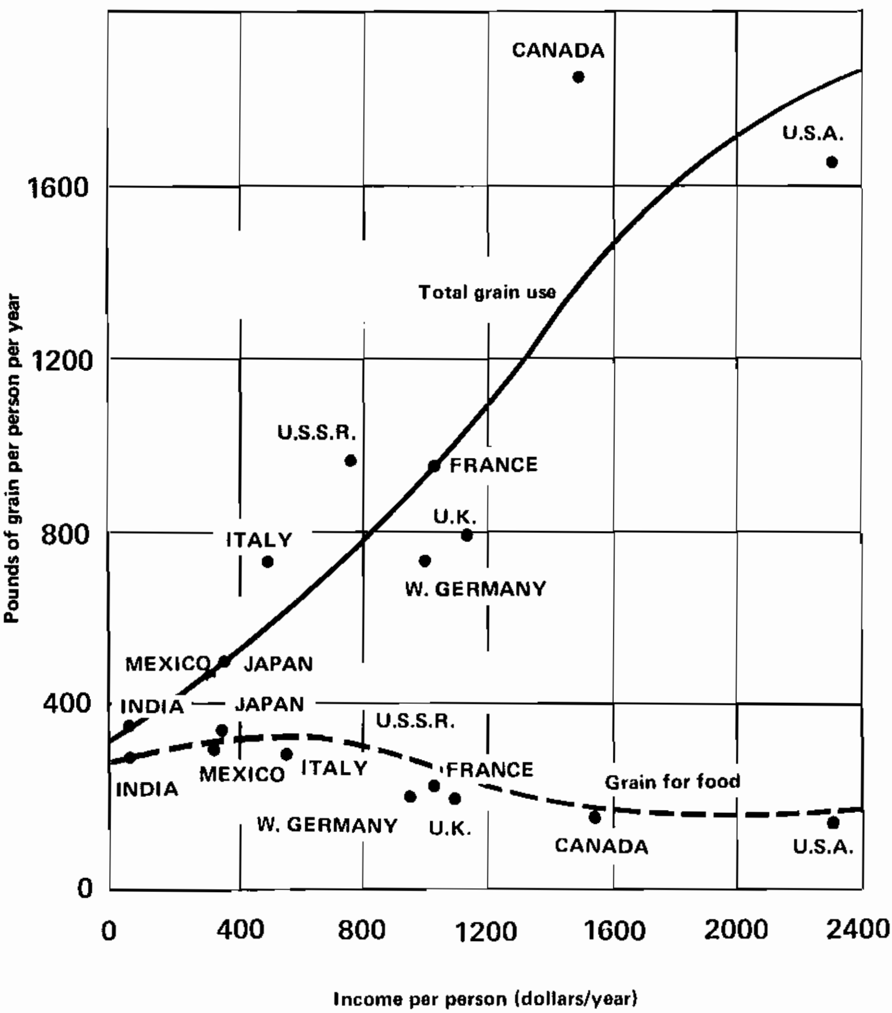

Figure 2 — Income and Per Capita Grain Consumption Total and for Food

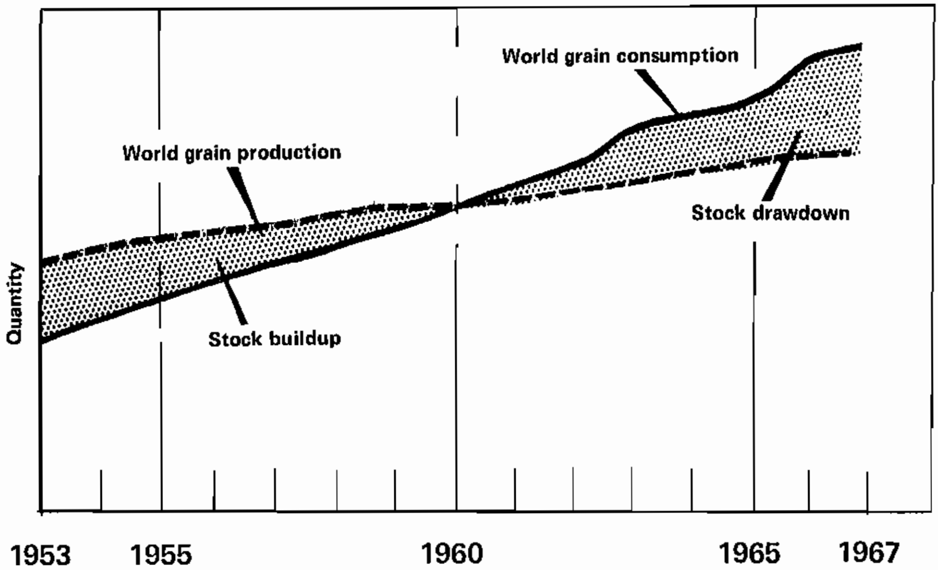

Figure 3 — World Grain Production and Consumption

vary from a few hundred million to several billion acres. The question is complex because of variable inputs required to make different lands productive. Obviously, if required input is greater than expected return, the land in question will not be cultivated. It is now common to find that in many countries land which was cultivated a few years ago has now been abondoned to pastures and recreational purposes because it is no longer profitable to cultivate it. Examples include some of the former cotton-producing areas of Southeastern United States and areas of New England and the Appalachian Mountains. Similar changes have occurred in other countries. In Japan the cultivated land area reached a peak in 1920 and has declined ever since. Most countries find it hard to expand the cultivated land areas. For example, India plans no major increase in area cultivated lands. The 5-year plan from 1966 to 1971 called only for a 2 percent expansion of cultivated land; however, during this same period, food requirements are expected to increase by 20 percent. In 1959 this writer traveled over much of the "virgin lands" which the Soviets brought into cultivation in the late 1950's and heard these people express the capabilities of meeting their food needs by cultivating these lands. They are now being abandoned.

There remain, however, two major areas which do offer prospects for expansion of cultivated area: the sub-Saharan Africa and the Amazon Basin in Brazil. However, there are major problems to overcome in each area, and the major one concerns the lack of specific information on the management of such soils when used for crop production over an extended period. Research efforts must be increased in this direction before these lands can be used for large-scale production.

Another possibility concerns desalinization of sea water for irrigation purposes. At the present time cost prohibits its wide-scale usage, but there is hope that the cost may be low enough for its usage by the late 1970's or perhaps early 1980's. Research efforts in this important area also must be increased by the advanced countries.

Farmland in the United States and elsewhere is being lost because of expanding urban areas, new highways, and industrial expansions. Even the United States, which is the only country in the world having ready reserves of idled cropland, is feeling the effects of such expansions. In 1966 the United States harvested crops on about 300 million acres and at this time idled about 50 million acres. The need for imported food in the U.S.S.R., China, Japan, India, and Western Europe is bringing much of the idle land back into production. And it is estimated that about one-third of the idled croplands in the United States came back into production in 1967. Undoubtedly, some of the remaining will return to production before 1980. Further expansion beyond these lands depends upon inputs needed to cultivate specific lands and expected returns from these.

It appears that for the next 10 to 20 years the expanding world food production cannot be met by solely expanding the area of cropland in the world even though this phase cannot be ignored and that consideration of the possibilities of increasing the productivity of the land already under cultivation must be given.

Greater Yields Per Unit Land Are Needed. When one considers the history of crop yields per unit land, he finds that no great changes took place until the 20th century when many advanced countries obtained rapid and continuing increases. For example, Japan has obtained great increases in yields of rice, while most of the countries in Western Europe, Canada, and the United States have also obtained great increases in yields of many other crops. A significant question concerns how sustained will this rate of increase be. The challenge, of course, is to keep these increasing.

Those countries which have increased yields per unit land have employed changes in cultural practices, increase in inputs, or a combination of these. Increased capital input has been required in every case and, unless increased mechanization accompanied these changes, increased labor was also necessary.

Brown, in evaluating future prospects for continuing expansion of yields per acre, divided sources of increased productivity into those that recur and those that do not.[4] Nonrecurring inputs are those which initially cause an increase in productivity, but once put in full operation no further increases in productivity occur; recurring inputs offer further annual increases in yields if more intensive application is made. An illustration of these sources can be made by using corn: Yields of this cereal grain in the United States have increased rapidly during the last 30 years because of two nonrecurring inputs. These were herbicide usage and the planting of hybrid varieties. The increases in yields resulting from the use of hybrids and herbicides were initially great but appear to be a thing of the past because most farmers are employing both of these near the top level. In other words, virtually all the weeds are now controlled, thus no future gain in productivity is expected from this source, even though the hybrids in use today appear to be somewhat superior to those introduced 30 years ago, the increases so obtained are extremely small when compared to the initial increase.

Increase in yield of plants resulting from use of fertilizers is a recurring source of productivity. Most authorities believe there remain plenty of opportunities for increasing yields of most crops by the intelligent use of this input. For example, increasing plant populations, if light and moisture are present in adequate levels, will respond favorably to increased levels of fertilizers. It appears that there will always be an upper economic limit for fertilizer usage, but it is not yet clear what the upper practical limit would be if economic limitations were loosened or removed completely. Some authorities feel that we are already approaching the upper limit in corn production in the Corn Belt of the United States. It is pertinent for us to ask the same questions of six other crops in the advanced countries. For example, how much more can wheat and barley yields be increased in Western Europe, Canada, and the United States?

Many of the phenomenal increases in yields of specific crops have resulted from the use of nonrecurring sources of productivity. It is expected that as these sources of productivity are reduced or are used up the familiar S-shaped curve which explains growth phenomena will dominate yields per acre. This growth curve for most biologic systems is first characterized by an ever-increasing phase, an exponential one. However, the expansion cannot continue indefinitely, thus the curve flattens out. Even though we do not know with precision the growth curve on our major food crops, there are some good approximations, and it is apparent that the rate of expansion which we are presently experiencing cannot continue indefinitely. Again, we should begin to ask questions regarding how near we are to the slowdown point in major crops in major countries. Perhaps, as Brown suggests, we should also ask if the slowdown be gradual or abrupt. What are the most important factors affecting the practical production of these crops? What can we do about these? What kinds of research should be initiated now in hope of solving this problem?

The ultimate factor limiting yield per land unit is the photosynthetic efficiency of the crop in question. If we define this efficiency as that amount of solar energy used by plants relative to that available for a specific crop on a specific land unit, we find that photosynthetic efficiency for most plants is low, averaging about 3 percent or less. Bonner feels that we are already approaching the upper limit in those regions with highest level of agricultural development: these areas being Japan, Western Europe, and certain areas of the United States.[5]

We must increase our research efforts for developing plants which have greater photosynthetic efficiency. For example, it might be possible to change the shapes of leaves and other plant characteristics which would allow the plants to utilize more of the available solar energy. Cultural practices must also change in accord with the use of new plant varieties: Effective weed and grass control might make it possible to develop smaller and more efficient plants which require little or no tillage during the growing season. Advances in this direction, of course, will allow an increase in the number of plants per acre, which in itself might lead to increased photosynthetic efficiency. Such factors are significant when one considers that width of rows in many parts of the world are still set by the width of animals used to pull the cultivators.

The major cereals of the Western World have been the subject of much research in the developed countries. The importance of hybrid corn and grain sorghums in present-day production of these grains is great. The "small grains" (wheat, barley, oats, etc.) are a bit more difficult, but more productive wheat hybrids have been developed and offer the promise of going into production in the near future. What can be done using crossbreeding and other techniques can be illustrated by telling of the success of the Rockefeller Foundation in Mexico. In 1943, this group established a research program for wheat in Mexico. At that time Mexico's 21 million people averaged only 1,700 calories per day, and yields of wheat were only 11 bushels per acre. The varieties were tall and susceptible to diseases, and use of fertilizers did not pay. Mexico was importing over one-half of the wheat it consumed. By 1964 yields had climbed to 39 bushels per acre, and consumption of calories had increased to 2,700. The Rockefeller scientists first developed a new, short, stiff-strawed wheat variety which was disease resistant. Perhaps just as important, they developed management practices to be used with the wheat. The Foundation also concentrated upon training young Mexicans to continue and expand the program started by this group.

It is now estimated that almost all wheat grown in Mexico is of the new variety. Fortunately, some of the short, stiff-strawed Mexican wheat varieties were found to be insensitive to length of day, thus are being exported to many parts of the world. Food prospects in India, Pakistan, and countries of the Middle East are being improved by the wide usage of these short wheat varieties from Mexico. Many young Mexican scientists are developing these programs in the other countries.

Currently, there is much interest in the mutant strains of corn developed by scientists at Purdue University. This corn has greater nutritive value than present-day varieties; pigs fed the mutant variety as the sole protein source gained three times as fast as those fed the best present-day Indiana hybrids. This discovery has great possibilities if these corn varieties can be produced efficiently in areas where corn is the major diet of the indigenous populations. This drastic change in nutritional value is the result of a single mutant gene and has spurred on research work to uncover such mutants in barley, grain sorghums, rice, wheat, and other grains.

Rice is the main cereal in Asia, thus is the basic cereal for 60 percent of the world's population, yet in tropical Asia yields have been very low and static for centuries. In India, Pakistan, Indonesia, the Philippines, Vietnam, Burma, and Thailand, yields have averaged about one ton per hectare (One hectare = 2.47 acres), while in Japan, the United States, and Australia average yields are 4 to 5 times that. Some years ago Japanese farmers were sent to these areas to teach local farmers to raise yields using Japanese "know-how." They failed completely. This and other failures have made the Asian farmer a skeptic of modern methods and unwilling to change. In 1960 the Rockefeller and Ford Foundations, in cooperation with the Philippine Government, established a Rice Research Institute in the Philippines. By 1966 the 20 major agricultural research scientists developed and released a new rice variety. It is a short, stiff-strawed variety which will respond to nitrogen fertilization. Whereas the old varieties responded to nitrogen fertilization by increased yields of straw, the new varieties yield more grain. In addition, they appear to be insensitive to day length; thus, if water and fertilizers are present more crops can be produced per year, and yields double to triple present ones are possible. In fact, it may be possible now to grow three crops per year if machinery is made available during the dry season; the carabao cannot pull a plow through hard soil during the dry season.

Many diseases, especially those of viral cause, affect plants. Research in this important area is being intensified, but further expansion is costly and requires highly trained scientists.

We must increase yields of agricultural products using all possible means. The achieving of dramatic gains in increased yields per acre, however, requires massive investment of capital and widespread adoption of technology new to the people of the developing areas. The advanced countries must take the lead in this endeavor and, too, must not fail in the further development of their own agriculture. The advanced countries must also take the lead in development of protein sources other than that from conventional farm crops. Such items as growth of algae, extraction of protein from leaves, growing of bacteria and yeast on petroleum products are possibilities that must be investigated, developed, and used if practical. Not to be overlooked are the possibilities of producing in chemical factories pure amino acids which can be fed as protein sources to humans.

The emphasis upon the production of cereals and the nonagricultural production of food has tended to relegate animal agriculture to a passive position as a contributor to world food deficits as regards protein. This emphasis has made many of those concerned with the world food problem to overlook the importance of feed inputs into livestock production. It is a serious mistake, the author believes, to overlook the potential protein supply from livestock production. While it is true that livestock convert the protein of the cereals and the oilseed meals to meat and milk proteins with efficiencies of about 10 and 30 percent, respectively, the complete story is not unfolded unless one looks at the total feed resources and calculates the total conversion of feed resources to food resources. In other words, livestock are not exclusively grain consuming animals.

Ruminants, which have a large fermentation fat, the rumen, at the head of their digestive tract, can convert forages, which cannot be consumed by humans, to meat and milk. These animals also serve as scavengers for byproducts produced on the farm or in the processing of human foods. In the United States about 70 percent of the protein of the dairy cow is derived from forages; beef cattle derive about 60 percent, while sheep obtain up to 90 percent; figures for all animals are higher in most other countries. With over 25 percent of the world's surface being unsuitable for cultivation and suitable only for grazing, we have the obligation to develop to its fullest extent livestock production which will allow us to utilize efficiently this land mass which otherwise would contribute nothing. In most areas of the world ruminants grazed on indigenous forages require supplemental grain which could be consumed by humans at some time in their productive cycle. If one only considers the efficiency by which that animal converts the grain to food, it would be a mistake to feed supplemental grain to this productive unit. It has been shown that, under Wisconsin conditions, dairy cows produced 171 units of milk protein from only 124 units of protein from the cereals and oilmeals. In other words, the dairy cow, which converts dietary protein to milk protein with an efficiency of about 33 percent, when fed forages plus urea and some of the cereal grains, returns more protein for the small input of grain than if this supplement had been consumed by humans directly. A similar story can be told for beef cattle and sheep. It must be emphasized, again, that animals can serve as scavengers for byproducts in the production of human food. We must increase our research inputs regarding possible chemical treatment of industrial by-products to make these new sources of animal feeds. For example, the hemicelluloses in wood are extractable with high steam pressure resulting in an acceptable wood product, pressboard. The extractable hemicelluloses are valuable sources of energy for animals. Many tons of sawdust from the wood industry are burned each year adding only to our problem of air pollution. Properly treated with steam and acid or alkali these could be converted to ruminant feeds. There are many more examples.

Livestock production can be increased. Production in the developing countries is only a fraction of that in the United States. In Africa the average age of animals for beef production is 7 years compared to less than 2 in the United States. Milk yields are so low that it requires 15 to 20 cows in parts of Africa to produce as much milk as one Holstein cow in Wisconsin. The average yield of beef per cow in the United States is about 167 pounds while in Asia it is about 26 pounds. The reasons for such poor returns are many and complex, and to improve the situation would involve the use of available technology plus an understanding of cultural and religious roots found in the people. Poor methods in disease control and lack of knowledge regarding management of livestock as regards a supply of human food appear to be major factors.

The distribution of major epizootic diseases of livestock today is about the same as when Columbus found America, except that rinderpest is not found in Europe and parts of Asia and, on the negative side, foot-and-mouth disease is now firmly established in South America. The major epizootic diseases are rinderpest, foot-and-mouth disease, contagious pleuro-pneumonia, African horse sickness, Newcastle disease, fowl plague, African swine fever, trypanosomiasis, piroplasmosis, and East Coast fever. It is impossible to develop a fully productive livestock industry where these diseases are not controlled. Highly trained specialists are needed for treatment and control and these require high capital inputs in countries which do not now have the capital and are not fully cognizant of the values.

It is common knowledge that the nutritive value of proteins depends upon its amino acid balance; those protein systems having a balance of dietary essential amino acids similar to requirements are considered to be of high quality. The best sources of quality protein are animal products, meat, milk, and eggs. Animal products are also rich in other nutrients. It is now estimated that 70 percent of the world's supply of human dietary protein comes from vegetable sources and 30 percent from animal sources, varying from 70 percent from animal sources in the United States and 12 percent in India. Quantitatively and qualitatively, animal products constitute an important part of the diet of the people in the world.

The FAO short-term target for animal protein in the diet is 15 grams of animal protein per day with a long-term target of 21 grams. Currently, the world's animal protein provides about 20 grams per day, but it is 44 grams in the developed and only 9 in the developing countries. We shall need to increase livestock production to its maximum potential on the noncultivatable grasslands of the world, using grain only to supplement the feeding of these animals when high returns can be expected from grain inputs.

Without question, plant proteins and other sources can be supplemented with amino acids and other products to make these have protein value similar to that of the animal proteins. Plant proteins will cost less; however, most people prefer animal products, except in areas where consumption is not acceptable because of law or social customs. Because of this preference for animal proteins, there must be consideration of the sociological relationship between the developed and developing countries. When the populations of the developing countries earn more, they will demand more meat products. If these products are available only in the affluent societies of the developed countries, this symbol of affluence could aggravate the sociological relationship between the have and have not countries. Thus, we have another incentive for developing as fast as possible an efficient animal agriculture. This can be done by increasing an understanding of efficiency of the ruminant animal to produce food on lands where little or none is produced at the present time. Intensification of basic and applied research in this area is indicated.

Assistance Programs to the Developing Countries. Education of Americans as well as those in the developing countries regarding the complexity of modern agriculture is the first step in selling a national program which has as its goal increased food production for the world. Such a program will cost our taxpayers; thus, a genuine need must be apparent to the majority of voters for any continuing program. Most Americans look upon the practice of modern medicine or physics as highly scientific professions and do not attempt to second-guess professionals in either field. I do not wish to argue the merits of this attitude but would contrast it to the attitude toward agriculture. Most Americans assume that they are knowledgable about farmers and farming. They feel that farming requires only soil, seeds, moisture, perhaps a small bit of fertilizer, and much *hard work.* Reason for this attitude stems from their experience in home gardening, which requires much hard work and is a money-losing form of home exercise. The best garden in the neighborhood belongs to the one who works the hardest. This uncontested relationship of productivity to hard work is easily perceived by all who will look; thus, it becomes easy to believe that the inability of the subsistence farmers in the traditional societies of the undeveloped nations to produce enough food for their population is caused by *laziness.* The substance of the agricultural sciences, its possibilities and its limitations; the importance of inputs; the importance of longtime adaptive research; the market structure; methods of processing; necessity for capitalization, fertilization, storage, and distribution do not enter minds of many who must make decisions, as voters or administrators, on this important question.

Americans must analyze the situation which has allowed American farmers to be the most productive this world has ever seen. Today, our 200 million Americans are provided with an abundance of food and fiber by only 6 percent of their fellow citizens. In addition, our exports feed many other people in Europe and Asia and contribute significantly to our balance of payments and to this nation's humanitarian responsibilities at home and abroad. How did this happen? This question will receive attention as we develop the following. In this connection, the author believes that the hungry countries need increased quantities of fertilizers, farm chemicals such as pesticides and herbicides, better varieties of seeds, increased water in certain regions, added credit to farmers, productive price policies, improved marketing facilities, improved transportation, and expanded research and education. They need all of these things at the *same time and place.*

The two key items in the above list are productive price policies and expanded research and education, and these are considered in that order.

Obsessed with farm surpluses, Americans became very shortsighted in the 1950's and early 1960's. Public Law 480, which made it easy for us to sell our farm surpluses for soft currency, also made it easy for rulers in country after country to adopt cheap food policies without regard to the function of farm prices as economic incentives for increased agricultural production by their own farmers. The reasons for low farm prices are many, and some are deep. There is still the monolithic pursuit of industrialization at the expense of agriculture. Country after country has paid the price for this kind of unbalanced economic growth. In contrast, we can cite the economic policies of the United States, Mexico, Israel, and Taiwan as models of successful agricultural and industrial growth.

It is quite evident that too many developing countries have underplayed the importance of agriculture in economic development. India has only recently adopted a policy which places much heavier emphasis upon food production. The use of economic incentives to boost agricultural inputs is starting to yield results to this troubled country, and hopes for recovery become brighter as these are put into effect. The United States must supply food when the people in the developing countries are starving; however, to use our imported foods to maintain a policy of cheap foods would, in the long term, be disastrous. Our Government must be against such policies even though it may seem harsh to increase food prices at some given time.

Education and research is the second key to increased agricultural production. The United States initiated the land-grant colleges under President Lincoln during the American Civil War. In the more than 100 years since we have built up the basic research facts and the trained personnel necessary to develop and expand a viable agriculture. There are trained specialists in land-grant universities, in 3,100 counties of the country, in Federal laboratories, and in industry. The training of these people represents the expenditure of millions of hours of the best scientific brains in the world, and the cost runs into billions of dollars but has paid off.

Until the less-developed countries can build up cadres of highly trained scientific personnel, we must help in the training of these people to work on their problems. In the interim we must provide our own expertise. The former is difficult in countries where freedom to move is a way of life. Because citizens of the United States have recognized the value of science in everyday living, they support large research and training programs in many areas. Expenditures for research and development have increased so rapidly in the United States that there are not enough trained people for all scientific programs; therefore, we are recruiting highly trained personnel wherever available. The United States is now draining scientists, engineers, medicine doctors, and technicians from all countries at an increasing rate: In 1963 we imported nearly 6,000 of these specialists, of which 900 came from Great Britain and 1,200 from Canada. Other countries are so concerned that they coined the term "brain drain." Unless something drastic is done the drain will increase. It has been estimated that over 90 percent of the Asian students who come to the United States for education never return. Over 11,000 trained men left

Argentina between the years 1951 and 1963 and came to the United States to work in our research programs. In 1964-65, over 25 percent of the medical internes in the U.S. hospitals were filled by foreign graduates, largely from the developing countries. They don't return.

In the matter of recruiting talent from the poorer countries, England and Canada and others are just as active as the United States. Nearly one-half of the junior staff in the English Hospital Service come from abroad and primarily from the developing countries.

The supply of grain now going to India might be considered partial payment for the many thousands of Indian scientists now working in our scientific laboratories. In this connection it is interesting that the United States is now suffering an internal brain drain: Federal expeditures for research and development have shifted scientific talent from the Central States to those on the east and west coasts, and the possible effects of such a shift upon fundamental research in agriculture and other fields is causing political repercussions in Washington. The siting of the world's largest facility for experimental work in high-energy physics in Illinois can be regarded as part of a deliberate plan to reverse the internal brain drain and restore to the Central States some of their earlier scientific prestige. This is probably only one of many moves in this direction. The Soviets must have had this in mind when they created their new "Science City" at Novo Sibirsk in Siberia.

There is no doubt that the shift of personnel from the poorer countries to the richer ones is causing similar repercussions in the poorer countries and is of great concern to the thinking people of Western Europe and the United States. The author believes that the whole world must be concerned about this shift of scientific personnel from the poorer to the more affluent nations and submits the following idea for a possible alleviation of this condition: It is recommended that the richer nations establish first-class research centers in the developing countries, which would act as the focal point for the training, concentration, and retention of the native talent. The excellent scientists from these countries who were trained in the richer countries and remained would

BIOGRAPHIC SUMMARY

Dr. Allen D. Tillman, who has the rank of Commander, USNR-R, holds degrees in Nutritional Biochemistry from University of Southwestern Louisiana (B.S.), Louisiana State (M.S.), and Pennsylvania State (Ph.D.). He has been a faculty member on the State Universities of Louisiana, Pennsylvania, and Oklahoma and has served as Research Professor of Animal Nutrition at the Oklahoma State University since 1952 where he directs the Animal Nutrition Research Laboratories. He has been active in research for 27 years and is the author of over 100 publications in the field of nutrition.

In 1959 he was chosen as a member of an exchange team to study animal agriculture in the Soviet Union. He has made similar studies in Argentina, Libya, and Ethiopia and has spent one year as a Fulbright Exchange Professor at the National University of Ireland in Dublin.

Commander Tillman was Commanding Officer of Naval Reserve Research Company 8-13 during the 1966-67 fiscal year, and his unit was judged the outstanding unit in the 8th Naval District during his command.

He is a graduate of the Naval War College Correspondence Course in International Relations and has an abiding interest in this field. He views food production, and the science disciplines necessary for its successful accomplishment, as an important part of international relations.

have challenging positions at home. The richer countries would have to finance these centers for as much as 25 years and be prepared to send many of their best people to such centers for long periods in order to establish and maintain the highest possible standards in these first-class research centers. The modest success of the Rockefeller Foundation in Mexico can be attributed to the organization of such a group. Requests for such laboratories are beginning to come from the developing countries[6] and the author believes that we must respond to these calls immediately.

FOOTNOTES

1. Lester R. Brown, "The World Outlook for Conventional Agriculture," *Science*, 3 November 1967, p. 605.
2. *Ibid.*
3. *Ibid.*, p. 606.
4. *Ibid.*, p. 604-611.
5. James Bonner, "The Upper Limit of Crop Yield," *Science*, 6 July 1962, p. 11-15.
6. Thomas R. Odhiambo, "East Africa: Science for Development," *Science*, 17 November 1967, p. 876-881.

The Congress shall have power . . . To raise and support Armies, but no Appropriation of Money to that Use shall be for a longer Term than two Years; To provide and maintain a Navy; To make Rules for the Government and Regulation of the land and naval Forces; To provide for calling forth the Militia to execute the Laws of the Union, suppress Insurrections and repel Invasions . . . .

Constitution of the United States,
I, 8, 1789