

Utah State University

DigitalCommons@USU

---

Faculty Honor Lectures

Lectures

---

4-17-1968

## Protein and the Pill- A Pivotal Partnership

B. Delworth Gardner  
*Utah State University*

Follow this and additional works at: [https://digitalcommons.usu.edu/honor\\_lectures](https://digitalcommons.usu.edu/honor_lectures)



Part of the [Life Sciences Commons](#)

---

### Recommended Citation

Gardner, B. Delworth, "Protein and the Pill- A Pivotal Partnership" (1968). *Faculty Honor Lectures*. Paper 73.

[https://digitalcommons.usu.edu/honor\\_lectures/73](https://digitalcommons.usu.edu/honor_lectures/73)

This Presentation is brought to you for free and open access by the Lectures at DigitalCommons@USU. It has been accepted for inclusion in Faculty Honor Lectures by an authorized administrator of DigitalCommons@USU. For more information, please contact [digitalcommons@usu.edu](mailto:digitalcommons@usu.edu).



Utah State University



Logan, Utah 84321

PROTEIN AND THE PILL - A PIVOTAL PARTNERSHIP

B.  
DELWORTH  
GARDNER

Honor Lecture 37

April 17, 1968

Honor Lecture 37

April 17, 1968

9.2  
no. 37



**C O N T E N T S**

	Page
ACKNOWLEDGMENT .....	2
INTRODUCTION .....	3
<b>THE HYPOTHESIS THAT POPULATION WILL</b>	
<b>OUTRUN FOOD SUPPLIES .....</b>	<b>4</b>
Some Facts On Population Growth .....	4
Reasons For The Explosion .....	5
The Gloomy Forecasts .....	6
A Dissenting View .....	7
The Problem in the Short and Long Runs .....	10
<b>THE PROSPECTS FOR POPULATION CONTROL .....</b>	<b>11</b>
Shifts in Attitudes Regarding Birth Control .....	11
<b>TECHNOLOGICAL AND ECONOMIC</b>	
<b>FACTORS OF CONTRACEPTION .....</b>	<b>11</b>
The Impact of Abortion .....	16
The Interaction of Economic Conditions and Birth Rates .....	17
Fertility and Educational Level .....	19
Foreign Aid in Birth Control .....	20
Prospects for Increased Food Production .....	22
The Extent of Malnutrition and	
Undernourishment in the World .....	22
Other Possible Resource Shortages .....	25
<b>RELATIONSHIPS BETWEEN FOOD PRODUCTION</b>	
<b>AND GENERAL ECONOMIC DEVELOPMENT .....</b>	<b>27</b>
Increasing Land, Acreage and Irrigation Water .....	30
The Impact of Fertilization .....	31
Developments in Plant Breeding .....	33
Shifts from Animals to Plants .....	35
Food from the Sea .....	37
Aid from Developed to Less-Developed Countries .....	38
<b>CONCLUSIONS .....</b>	<b>42</b>
<b>REFERENCES CITED .....</b>	<b>43</b>
<b>PUBLICATIONS .....</b>	<b>47</b>

### ACKNOWLEDGMENT

My colleague, Stuart H. Richards, and one of my graduate students, Keith Wilde assisted me in reviewing the literature and preparing the bibliography. My associate, Lois Cox, was most unselfish with her time and great talents in improving the readability of the manuscript. A word of appreciation is insufficient to express the gratitude I owe those co-workers.

My greatest debt is to my wife, Kathryn Christensen Gardner, for her generous and unflagging encouragement and inspiration over the period of preparation. It is to her and our children that I affectionately dedicate this lecture.

# **PROTEIN AND THE PILL - A PIVOTAL PARTNERSHIP**

B. Delworth Gardner

## **INTRODUCTION**

Two fearsome possibilities preoccupy thoughtful men everywhere in the world. These worries are unique to our own age and time. Lord Russell puts it succinctly, "The world is faced, at the present day, with two antithetical dangers: (a) the human race may put an end to itself by a too lavish use of H bombs; and (b) the human population of our planet may increase to the point where only a starved and miserable existence is possible, except for a minority of powerful people." [78, p. 1].

Each of these dangers has its own characteristics, its own special perils, and its own possibilities for prevention. Nuclear war would bring swift and complete destruction of life as we know it. Whether or not such a war occurs, seemingly depends upon the wisdom of a few trusted leaders. On the other hand, so it is said, starvation is a gradual and agonizing phenomenon, already stealthily engulfing the world. The extent to which we endure the slow and dehumanizing destruction that is synonymous with starvation, depends on the individual decisions of literally billions of human beings.

The two threats are inter-related. A world in which one-third of the people live in extravagant opulence while two-thirds live in oppressive squalor is not conducive to political stability. Such a world is particularly susceptible to violence, including mass nuclear destruction. There is little question that, as a rule, man's inclination towards aggressiveness declines in proportion to the spaciousness and comforts of his life.

This lecture probes the questions of man's desire and ability to control his own numbers and to adequately provide himself with food. Over the past decade extensive literature has appeared on these problems. Much of it presents population growth trends since World War II and describes their implications for the future of mankind on this planet. Most observers are moderately to extremely pessimistic and forecast acute famine across the globe. The first major section of the lecture discusses these forecasts and the rationale underlying them. The second deals with the likelihood of a decreasing rate of population growth in the next few decades. The third explores the possibilities of increasing the world's food supplies.

The general position taken throughout is that we have more promising options than is often thought, both for limiting population and for increasing food production. The facts do not warrant the prevailing pessimism. On the other hand, man has been known to ignore facts until it is often too late. In the past we have not automatically recognized and exercised the best options. Effective research and education programs are indispensable if the future is to disprove our harbingers of doom and gloom. Diverse people must indulge in dialogues when problems are not properly identified and solutions are unclear. It is in the spirit of broaching basic issues and beginning the dialogue, rather than of providing definitive answers, that this lecture is undertaken.

## **THE HYPOTHESIS THAT POPULATION WILL OUTFEED FOOD SUPPLIES**

### **Some Facts on Population Growth**

Rates of world population growth remained low up to the 16th and 17th centuries due to epidemics, war and pillage, erosion, flooding, and crop failures [27, p. 63]. From 850 B.C. to 1650 A.D. the growth rate was about .07 percent per year [18, p. 8]. Between 1650 and 1850 the annual rate of increase doubled, and by 1920 it had doubled again. World population increased 1.1 percent per year in each of the three decades between 1920 and 1950 and 1.9 percent per year in the decade of the '50's and the first half of the '60's [31, p. 11]. In terms of numbers there were approximately 30 million people living in 3500 B. C. [18, p. 18]. The 100 million mark was likely passed during the period 1000-500 B. C., and 200 million was reached during the early Roman period. World population grew slowly during the first millenium of the Christian era and was about 275 million by 1000 A. D. By 1650 it was estimated at 500 million; by 1880 about 925 million; by 1900 about 1,525 million; and by 1964 well over 3 billion people [72, p. 1].

These world totals obscure the most significant developments in population growth, especially in the last 30 years. A sharp difference exists between the so-called developed world and the less-developed world in population growth rates. The developed world includes the United States and Canada, Western Europe, Eastern Europe including the USSR, Oceania, and Japan. The less-developed world is Asia, Africa, and Latin America. The less-developed countries are growing

in population much more rapidly than the developed ones. No developed countries have reproduction rates above 2 percent while none of the less-developed countries have rates under 2 percent [97, p. 194].

In 1900 the population of the less-developed regions was about 67 percent of the world's total [46, p. 4]. In 1960 it was 70 percent. In 2000, if trends continue, it will be nearly 80 percent. Numerically this would represent an addition of almost 3 billion to the less-developed countries and only 436 million to the developed countries. The world population is presently growing at slightly less than 2 percent per year. In the developed nations the rate of increase is about 1.1 percent, while the less-developed nations are growing at about 2.4 percent per year [31, p. 11]. Rates of growth in the advanced countries of Western Europe are less than 1 percent. Even in the United States, birth rates are rapidly declining. During the decade of the 1950's the growth rate in the U. S. was between 1.7 and 1.8 percent per year. By 1962 the growth rate had dropped to 1.5 percent, and 1966 it was only 1.1 percent. Last year the growth rate was 1 percent, the lowest in this century. It is clear, therefore, that the celebrated "population explosion" is primarily a characteristic of poor countries.

### Reasons for the Explosion

In peasant societies, crude birth rates are virtually everywhere above 40 per thousand [44, p. 310]. Rates of 45 per thousand approach the practical maximum, although higher levels are biologically possible. Historically, death rates have been almost as high. Population growth occurs in such societies when death rates fall, as they have in the last 15 years because of the introduction of modern medical measures. It is as simple as that.

This phenomenon is not new. Earlier in this century, Western Europe, Japan, the United States, and Canada experienced comparable reductions in death rates relative to birth rates. When this happened, the population in these countries increased. Rapid growth in the less-developed world today, however, poses a more dangerous problem because it is occurring in conjunction with such a preliminary state of economic development [27, p. 69]. One and one-half percent was the maximum population growth rate attained in the developed world, whereas in today's less-developed countries, 2.5 to 3.8 percent are common. At an average annual increase of 3 percent, a population



doubles in 23 years. Where economies are relatively undeveloped, present rates of growth seriously constrain potential rises in the level of living.

Over the long-run, even a 1 percent growth rate is unacceptable for both developed and poor countries. A demographer, Professor Hauser, points out:

“One hundred persons multiplying at one percent per year for the 5,000 years of human history would have produced a contemporary population of 2.7 billion persons per square foot of land surface on the earth. Such an exercise in arithmetic, although admittedly dramatic and propagandistic, is also a conclusive way of demonstrating that a one percent per year increase in world population could not have taken place for very long in the past, nor can it continue for very long into the future” [47, p. 164].

### The Gloomy Forecasts

Most authorities agree that much, but by no means all, of the expected impact from modern medicine and sanitation has already occurred. Even so, some forecasts call for higher rates of population growth in the next few decades than at present. These projections acknowledge that birth rates are beginning to fall in less-developed nations just as they have in the developed world. The critical point is whether they will fall so slowly, that they will lag behind continued decreases in death rates.

A number of recent books and articles are extremely pessimistic about our ability to continue feeding ourselves [102], [74], [68], [50], [98], [55]. For example, Dr. Raymond Ewell, a Vice President of the State University of New York at Buffalo and an eminent scientist, says:

“If trends continue, it seems likely that famine will reach serious proportions in India, Pakistan, and Communist China in the early 1970's. Indonesia, Iran, Turkey, Egypt, Brazil, and several other countries will follow within a few years, and most other countries will fall in this category by 1980. Such a famine would be of massive proportions affecting hundreds of millions, possibly even billions of people. If this happens, as now appears probable, it will be the most colossal catastrophe in history.” [34, p. 1].

It was just about a year ago that President Johnson said in his State of the Union Message, “Next to the pursuit of peace, the really greatest challenge to the human family is the race between food supply and population increase. That race tonight is being lost.”

Senator George McGovern (D., South Dakota ) amplifies on the same theme:

“The world is running out of food. That is a fact of life and of death. Not just death for the hundreds of thousands who are starving routinely today,

but for hundreds of millions, a scale comparable only to nuclear holocaust, within the next three decades. Horrified historians may record that as the world sped on a collision course with starvation, its great powers fiddled with the war in Viet Nam, a crisis in Berlin, a contest in arsenal building and a race to the moon" [63, p. 86].

Nor is this depressing view confined to this side of the Atlantic. Sir Charles Darwin, a great grandson of the famous biologist of the same name says:

"It is curious how long the world is taking to perceive that we are living in what is a fantastically abnormal period of history, and one which must inevitably end soon. It is the high rate of population increase already noted more than a century ago that makes the present time so abnormal. We can say with confidence that all our present conditions in life cannot continue for more than two centuries, and this is most likely a great over-estimate. We have, within what historians would call an exceedingly short period, to revert to a mode of life which in one way or another will keep numbers of the human race roughly constant" [25, p. 30].

One of the longest books on the subject and the most pessimistic is called **Famine 1875**, by William and Paul Paddock.

"Ten years from now (1975), parts of the underdeveloped world will be suffering from famine. In 15 years the famine will be catastrophic and revolutions and social turmoil and economic upheavals will sweep areas of Asia, Africa, and Latin America" [68, p. 8].

The Paddocks contend that some parts of the world have already passed the point of no return; their course towards starvation has been irrevocably charted, and not even the power and resources of the rich nations can change the inevitable and horrible destruction [68, p. 207]. The Paddocks argue that aid should be extended only to those nations which still have a chance (and for most even this is remote) to bring food and people into balance.

The foregoing are only examples of the prevalent point of view. Many, many others could be cited.

### **A Dissenting View**

I do not believe the best evidence supports such a fatalistic, alarmist, and pessimistic prognostication of the future. This is not to say that our problems are not urgently grave. Certainly the political and social implications of the ever-widening disparity in the economic wealth of rich and poor nations are closely related to the steady deterioration of the physical and natural environments in which men live in both rich and poor countries. But billions of people dying from starvation? I think not. Why?

In brief, people in rich nations and poor have hardly begun to recognize, much less utilize, the arsenal of weapons available to them for solving population and food problems. I believe that before famine threatens on a large scale mankind shall have taken the necessary action to curtail population growth and increase food production. Moreover, the stock of useful weapons that can be employed in the battle will increase in both quality and quantity as time passes. The remainder of this lecture attempts to establish the validity of my optimism.

My views on these matters are inextricably linked with my professional discipline, among other things. In fact, the correlation between a man's professional field and his views on these questions is strikingly demonstrated in the literature. Almost invariably the physical and biological scientists predict disaster, whereas the economists are the most optimistic that the problems will be resolved. The remainder of the social scientists, including the majority of demographers, seem to categorize at about the middle of the continuum.

In many ways this is an ironic about-face from an earlier period. It was an economist, the Reverend Thomas R. Malthus, about 150 years ago, who thoroughly frightened everyone with his theory predicting the "doom" of mankind in his **An Essay on Population**. His theory effectively captured economics for so long a period that the Scottish writer, Thomas Carlyle, dubbed economics the "dismal science." Generations of students would probably agree that Carlyle's appellation was apt.

But Malthus was wrong in his predictions. To some extent in nearly all nations, but especially in the Western world, man has made steady progress in bettering his economic well-being as well as the quality of his life.

Then how do we explain the current resurrection of Malthus' doctrine. One interpretation, perhaps comforting to economists, would be that as a prophet, Malthus was indeed perceptive but born too soon. Finally, after 150 years, he is being proved right, as evidenced by the disciple scientists, demographers, politicians, etc., climbing on the Malthusian bandwagon.

Despite the temptation to further promulgate this point of view and help exonerate Malthus and nearly a century of the "dismal science," I believe it would be folly to do so. Malthus' theory was error-ridden in his own time, and I think it is no less vulnerable today.

Our current group of pessimists are just as likely to be wrong, besides being 150 years late in coming around to Malthus' point of view.

It is admittedly disturbing to attack a brother economist. I am reluctant to contribute to the "credibility gap" that has persistently afflicted economists. As a profession we have erred so often that we have a reputation for being wrong much of the time. This means that I cannot appeal to a blind faith in the authority of my profession, but am forced to depend strictly on the factual evidence that I can marshal to support my point of view.

Hindsight permits easy recognition of where and how Malthus went wrong. His arithmetic was impeccable as he showed that man has the capacity to perpetuate himself at a geometric rate. Malthus must have seen the declining death rates in Western Europe at the time as indicating that burgeoning numbers of people were inevitable. He reasoned that man's capacity to produce food was limited by the quantity of tillable land, and that increases in food production could at best proceed at an arithmetic rate. The unavoidable prognosis was that population would grow until food supplies per capita would not be sufficient to sustain life. Starvation would reduce man's numbers to levels where food capacity could sustain life at a kind of equilibrium precisely at the starvation level.

Instead, over a large portion of the earth, man has improved his level of living substantially and almost continuously since Malthus' day both in terms of general wealth and in terms of per capita food production. Malthus has developed a logical theory, apparently grounded thoroughly on the significant explanatory variables. Why didn't it prove out? Essentially because the world changed in ways that were impossible for him to foresee. His theory would have been valid if the world were static and unchanging.

Dramatic changes in two vital areas were especially influential: (a) the rapid fall in birth rates primarily because of contraception, and (b) the sharp advances in agricultural and industrial technology. Although the latter factor produced the more impressive changes in the 19th century, the former promises to be equally effective in the 20th in generating a different world than Malthus knew.

It is my opinion that our current group of neo-Malthusians are equally guilty of failing to foresee the advances in technology that are almost certain to occur in the kind of world in which we live. Chancellor Murphy of UCLA says it well:

“Essential to survival and progress for the remainder of the 20th Century is acceptance of the fact that we live in the midst of revolution — a period of unprecedented and rapid change without end in sight” [61, p.74].

Change and revolution do not automatically equate with improvement, however, especially if they are unanticipated. With adequate planning, at least some of the changes we will experience in the next 100 years could be deliberately designed to mitigate man's food problems.

The difficulty in making valid projections is essentially methodological. University of Chicago demographer, Professor Donald Bogue, sums it up well:

“For more than a century demographers have terrorized themselves, each other, and the public at large with the essential hopelessness, inevitability, and morale-breaking pessimism of the population explosion via exponential growth. These prophecies have all been dependent upon one premise, ‘if recent trends continue.’ It is an ancient statistical fallacy to perform extrapolation upon this premise when, in fact, the premise is invalid” [8, p. 74].

Professor Bogue seems to be saying that when technological and attitudinal factors are changing as rapidly as they are now, it is unrealistic to predict the future by extrapolating past trends in such large aggregate variables as population growth and food production. We will derive more accurate predictions by analyzing growth and food production.

Besides, even if it were valid to extrapolate trends in population growth and food production, it would be patently unwise to choose the period of the 1950's and early 1960's for such purposes. Dramatically effective measures were being taken for the first time to reduce death rates in the less-developed countries. The initial impact cannot possibly be extended far into the future. Besides, there is no indication that current rates of population growth are desired by the people in the less-developed nations now. In fact, as argued in the next major section, the evidence is quite the opposite.

### **The Problem in the Short and Long Runs**

Saying that the gloomy forecasts of world starvation are wrong, however, does not mean that programs to reduce population and increase food supplies should be abandoned or even slackened. Quite the contrary, if we want to negate the gloom, we must advance and augment these programs. The excellent prospects for eliminating hunger from the face of the earth should spur us to vigorously push ahead with the task of bringing this eventuality to reality.

Specific programs should get top, national priority now. The high birth rates of the 50's and 60's produced children whose presence already requires large increases in food supplies. Reductions in birth rates are likely to occur somewhat slowly. Our first priority, short-run objective, therefore, must be to increase world-wide food production.

Over the long-run, however, it is essential that the world's population be stabilized at some equilibrium level that will allow the resources of the earth to provide an abundant and healthy life for the earth's population. It is of crucial importance that advanced nations promote and give adequate support to voluntary birth control programs throughout the world. Because many decades will be required to define and stabilize desirable population levels, under even exceptionally favorable conditions, a real burst of effort to simply lower birth rates should be expended now. The more progress we can make in reducing population growth, the more manageable will be our food problems.

### **THE PROSPECTS FOR POPULATION CONTROL**

Population control is one of the most urgent needs of mankind. If it isn't achieved by controlled birth it will eventually be accomplished by uncontrolled death. Since population control could mean an abundant life for everyone, I believe that when the options are clear, rational man must choose the course of birth control. The options, other than world starvation or nuclear war seem to be these — logically calculated numbers of people living under conditions that permit dignity and beauty to the individual life versus larger numbers of people whose lives are severely restricted in scope and satisfaction.

Many of the earth's people now oppose birth control for various moral reasons. Space does not permit a full treatment of the issues here. But I see all the moral issues as basically reducible to a choice between controlling births now and increasing the death rate at some time in the future. To me, increasing the death rate by any conceivable means is morally repugnant in the extreme. Therefore, I hold that restricting births is the least morally objectionable way of limiting population.

#### **Shifts in Attitudes Regarding Birth Control**

From the aggregate social point of view, certain circumstances

routinely result when population growth exceeds available food supplies. The most obvious are food scarcities, higher food prices, and decreased living standards. From the individual point of view, however, where birth decisions are actually made, the rationale rarely incorporates all these factors. Each family is an infinitesimally small segment of society. An individual couple is rarely inclined to think that the number of children they decide to have will vitally influence the national or world scene. Moral suasion campaigns to convince individual families to restrict births, therefore, have little effect unless accompanied by economic incentives. There will always be a tendency to "pass the buck" and expect other families to do the restricting as long as the given family can hold its living standards at some acceptable level. In other words, if a family planning program in any part of the world is to be effective, it must provide direct, tangible incentives to the individual family to reduce births. Programs are now being mounted all around the globe that give families such incentives.

The president of the Population Council, Dr. Frank W. Notestein, recently said,

"We now have a basis for expecting that a rapid decline in birth rates can be achieved in the next decade. In this hopeful judgment four elements are important: (1) the development of national policies favoring family planning, (2) the demonstrated public interest in limited child bearing, (3) the improvement of contraceptive technology, and (4) the fact that for the first time in history, several Oriental populations have begun to count their birth rates as a result of governmental programs to spread the practice of birth control" [64, p. 170].

These factors have also persuaded Professor Bogue to be very optimistic,

"Recent developments in the world wide movement to bring runaway birth rates under control are such that it is now possible to assert with considerable confidence that the prospects for rapid fertility control are excellent. In fact, it is quite reasonable to assume that the world population crisis is a phenomenon of the twentieth century and will be largely, if not entirely, a matter of history when humanity moves into the 21st Century. No doubt, there will be isolated pockets of population hardship in the year 2000, but the outlook is that they will be confined to a few nations that were too prejudiced, too bureaucratic, or too disorganized to take action sooner, or will be confined to small regions within some countries where particular ethnic, economic, or religious groups will not yet have received adequate fertility control services and information for a sufficient span of time to complete the demographic transition to lower fertility" [8, p.72].

The experience of the developed nations demonstrates that attitudes are the most important factor in birth control. Access to better birth control methods appears to have influenced the decline in birth rates in Europe. But the people had to be willing to use the methods.

Strong evidence from studies over the last 25 years in the United States, Great Britain, and Scandinavia, indicates that many millions of couples have and do practice *coitus interruptus* to successfully control fertility [66, p. 128]. This method has been known and practiced for thousands of years. The failure of birth rates to fall in other countries indicates a persistent lack of strong motivations to control family size.

Much of the absence of motivation in the less-developed countries in times past can be explained by the traditional role of children in the family unit. In these societies there were no social security programs and children, especially sons, were expected to care for their parents in old age. Where child mortality rates were about 50 percent, and two sons were deemed necessary to share the old-age burden of the parents, eight child births would be required on the average, assuming a 50-50 split of male and female babies. Also, in peasant societies where children do not go to school, but instead work on the farm, a child becomes an economic asset early in life. These factors suggest that children, far from being unwanted by parents, were deemed essential for economic reasons. But times change, and these factors no longer exert the force they once did.

Almost two-thirds of the people in developing regions of the world now have contact with government-sponsored family planning programs [8, p. 64]. These programs exist in India, Pakistan, China, South Korea, Hong Kong, Singapore, Malasia, Ceylon, Turkey, the United Arab Republic, Tunisia, Morocco, Honduras, and Jamaica, and more are being initiated every year.

Not only do government programs exist, they are effective and promise to be even more effective in the future. The majority of couples with three living children uniformly wish to have no more. A 1965 national survey of family planning in South Korea provides a good example [8, p. 79]. The following are results from that survey: (a) 89 percent of the wives and 79 percent of the husbands approved of family planning; (b) the rate of approval was only slightly lower in the rural than in the urban areas; (c) of the minority who disapproved, only 8 percent gave religion or morals as the reason; (d) inability to read was no barrier, 81 percent of those unable to read nevertheless approved of family planning; (e) on the verbal level, the majority declared themselves willing to practice family planning if given services; (f) unwillingness to practice family planning was con-



centrated primarily among young couples who had not yet had the number of children they desired and older couples who were approaching the end of their childbearing; (g) as a result of a national information program, 85 percent of the urban and 83 percent of the rural population had heard of family planning, and 67 percent of the urban and 64 percent of the rural population knew of at least one contraceptive method; (h) at the time of the interview, 21 percent of the urban and 14 percent of the rural couples were practicing family planning. Even among the illiterate population, 10 percent were currently practicing family planning.

The experience in Korea is not atypical. Survey data from some 20 less-developed countries show that, without exception, substantial majorities of married couples want to restrict their childbearing [64, p. 171]. It seems clear, therefore, that if contraceptive devices were available at low cost, people in less-developed countries the world over would actively participate in population control programs.

The estimate of interest is based on much more than responses to surveys. In many societies a large number of crude and illegal abortions eloquently testify to the desire to restrict population [64, p. 172].

The problem of children and old-age security is being gradually offset by declining child mortality rates, which assure that many fewer births are necessary than in times past to provide this security. In addition, more and more countries are initiating governmental programs for old age care as a substitute for family care. This justification for large families is therefore much less compelling than it once was.

## TECHNOLOGICAL AND ECONOMIC FACTORS OF CONTRACEPTION

Contraceptive devices have been used for hundreds of years, and in the developed countries are widely employed today. The less-developed countries, however, are far behind in birth control. They now need a method that is both effective and inexpensive. The two devices that seem most promising are the intra-uterine device (IUD) and the steroid pills, although at present the latter are far too costly to be practical in the poorer nations [64, p. 173]. Other methods such as condoms, diaphragms, vaginal jellies, sterilization of both male and female, and abortions are often used to prevent births, but for one reason or another do not seem to offer the long-run promise of the pill and the IUD.

The IUD, a small plastic device which is inserted in the uterine opening, seems to be especially suitable. In a recent test in India, pregnancies were reported by only one out of every 611 women who used the device over a 2-year study period [57, p. 2]. In addition, expulsion of the device, earlier a rather serious shortcoming, occurred only with 6 percent of the women who participated in the test. Both the degree of effectiveness and the low rate of expulsion make this device technically feasible for less-developed countries.

It is truly extraordinary how rapidly these devices are being adopted. Over 2 million IUDs had been inserted prior to June, 1966 in Taiwan, South Korea, Hong Kong, and Singapore. The current rate is over 3 million per year, and the rate is accelerating [34, p. 3].

At long last, India has begun to move forward on a massive program of IUD use. Over 1 million IUDs had been inserted by June, 1966 and the number reached 3 million by early 1967. India is planning 10 million insertions per year by 1969 or 1970.

India, Pakistan, Turkey, and Egypt began producing IUDs in 1965 and 1966, making these countries independent of sources of supply from the developed world [34, p. 3].

Most significant is the fact that each IUD costs only a few cents. If the devices are produced by the government and distributed through a government program by doctors, the cost to the individual family is almost zero. The major constraint on the use of this device in many less-developed countries could be the number of physicians required. It has been found, however, that one doctor can insert at least 40 devices in one day, which works out to be about 10,000 per year [57, p.2]. This means that 1,000 doctors could fit 10 million women in a single year. Few nations could not provide the doctors required, assuming these programs received high national priority.

Reliable sources also indicate that Communist China is vigorously promoting birth control by a variety of medical, economic, and social means. These reports have led many demographers to guess that China's birth rate and population growth rate are declining and are already much lower than India's [35, p. 10].

Whereas the IUD has been used primarily in Asia, both the pill and IUD have been used with increasing frequency in Latin America. The pill is absolutely effective when taken correctly [64, p. 173]. Presently, however, it has two drawbacks: (a) it is difficult for illiterate

people, who cannot count beyond a few numbers, to take the pill as systematically as is necessary; (b) costs of the pill are now prohibitive for most people in the poor countries. It has recently been reported, however, that the pill can be produced for about 15¢ per monthly cycle [64, p. 173]. If it could be distributed to less-developed countries at this price, it might provide a good alternative to the IUD.

Nor is the whole story on the contraceptive front. Further technological advances are highly probable. Several possibilities are now being studied by using animals. One of the most promising is an injection or implant that will prevent pregnancy for a year or more at a cost well under 50¢ per year [64, p. 173].

Clearly man has the technology with which he can reduce the birth rate at a cost that is well within reach of nearly all nations. The time is obviously right to push forward with all kinds of encouragement for birth prevention. This must include massive aid from the developed nations in terms of financial resources, educational programs, and the technology of birth control.

### **The Impact of Abortion**

The countries of Western Europe, the United States, Canada, Australia, New Zealand, Argentina, Uruguay and Israel have reduced their birth rates mainly by contraception, although legal and/or illegal abortion has been a significant factor in all cases. In the USSR, the Eastern European countries, and Japan, birth rates have been significantly reduced primarily by legal abortion, although contraceptive devices have also been used. Abortion is probably a more important factor than contraception on a world-wide basis in keeping birth rates down to their present levels [34, p. 3]. Certainly where abortion is common, it provides convincing evidence of ample motivation for family planning. The problem is that oftentimes abortion is performed, especially in the less-developed nations, with such primitive and unsanitary methods that many maternal deaths occur and much pain and suffering result.

The case of Japan is one of the most dramatic examples in history of a country drastically reducing its birth rate in a short time. The Japanese have done it with legalized abortion. Japan reduced her birth rate between 1947 and 1959 from 34.3 to 17.5 per thousand [53, p.52]. She thus moved from a country with one of the highest birth rates in the world to one of the lowest. Of course, Japan now has the wealth and the medical expertise to make abortion safe as well as practical.

Certainly for the majority of the less-developed nations, abortion is not a recommended alternative at the present time for purely medical reasons, even if the religious beliefs of the country would permit it.

On the question of morality, a great many people in the world regard abortion as being synonymous with murder. They will accept it, if at all, only as a last resort. But even here in the United States where this view is prevalent, opinions can change rather quickly, as indicated by new abortion laws in Colorado, North Carolina and California.

### **The Interaction of Economic Conditions and Birth Rates**

Economic factors and birth rates interact in many ways. According to one study, about 47 percent of inter-country differences in birth rates can be accounted for by social and cultural factors associated with urbanization and industrialization [4, p. 142]. The more urbanized the country is, the more likely it is to have low birth rates. The relationship between per capita incomes and birth rates among countries is inverse.

Results of another study indicated that within a country the higher the income of the husband, the smaller is the family size likely to be. If the wife works outside the home, child spacing tends to be affected more than total family size, although a long work history is associated with fewer children [41, p. 419].

With a given level of family income, it is axiomatic that a large family means lower per capita income than a small family. High population growth rates thus effectively constrain improvement in living standards.

There are many reasons why heavy population growth can be expected to curtail economic development. If a country is to develop industrially, it must first find enough new investment for agriculture to increase productivity and create excess labor which can move to non-farm employment. Concurrently there must be new investment in industry to create the demand for labor and relieve population pressure on the land [53, p.8]. A necessary prerequisite for a progressive urban society is governmental revenues that will permit adequate expenditures for education and health and a variety of other public services. High birth rates generally operate to reduce savings and per capita incomes, all of which increase the burden of taxation to finance governmental expenditures. A large number of births produces high percentages of dependent children, who decrease the proportion of family

income that can be used for purposes other than subsistence. High birth rates are often associated with overcrowding and disease, and when health is undermined economic productivity is reduced.

Technological development also tends to be slow when population growth is high because stagnant per capita incomes are not conducive to the growth of those sectors which require capital and modern techniques [36, p. 301]. There is not enough slack above subsistence to permit more advanced and risky entrepreneurship, and there are no markets for goods that are produced. With two exceptions [20, p. 438] [48, p. 176], economists agree that high population growth rates, such as those existing in many of the less-developed nations today, severely constrain economic development.

The recent increases in per capita incomes in most of the less-developed nations have occurred despite high population growth rates, and not because of them. Increases in income have resulted from technological advances in the main. When they came to realize that population growth actually reduces per capita incomes and living standards, I believe that most couples throughout the world would rather limit family size than suffer decreases in their standards of living. This is certainly what happened in Ireland after the great potato famine in the last century. It would be especially true now if family planning services and contraceptives were available at low cost.

Many of the apparent food shortages in the less-developed nations may be more illusory than real. Food shortages can co-exist with increased per capita food consumption. How can this be so? One of the important implications of increases in per capita income throughout the world is that the demand for food is increased. The income elasticity for food is much higher in the undeveloped than in the developed world. It runs from .5 to .8 in the poor countries [59, p. 4]. This means that an increase in income of \$1 will increase expenditures on food from 50¢ to 80¢. Rising incomes, therefore, increase the demand for food relative to the supply, and food shortages appear. But in terms of nutrients consumed per person, the increased demand does not actually reduce the supply. If as usually happens, the increased income is unevenly distributed over the whole population, absolute and acute shortages of food may exist for those who do not participate in the income growth. Average per capita consumption of food, however, may remain unchanged or perhaps even advance even though food shortages exist.

There is one rather salutary result from increasing incomes, even if they are not uniformly distributed. More real productive resources can be available to the economy to convert into food supplies if the decision makers opt for more food at the expense of other things.

Direct economic incentives can be used deliberately as a brake on population growth. I believe that governments and international agencies should have relied to a much greater extent on these devices to penalize families which get excessively large. Rather, in almost all countries around the world, governmental policies encourage population growth. There are often direct subsidies for having children, such as governmental social services calculated on the basis of the number of children in the family. Examples include the standard exemption per child in income tax laws, welfare benefits, and the free educational and other social services available to all children.

Suppose that a substantial tax were levied on each child born to a family beyond some stipulated number — say three. Such a policy would almost certainly produce a drastic decline in birth rates, and is entirely ethical. Since children impose cost on society as well as on the family, society is justified in attempting to recover the costs in the form of a tax. Couples that desire large families could still have them if they were willing to pay the price. Such a tax would be no more unethical than any other kind of tax. Many similar economic schemes could be used and would be effective. People obviously respond to these kinds of incentives in other decisions regarding the expenditure of family resources. It is a universally accepted economic law that as the price of a commodity (and children can be regarded for our purposes here as such a commodity) goes up, the quantity demanded goes down.

### **Fertility and Educational Level**

Nations that have low levels of literacy and education inevitably also have high birth rates and low per capita incomes [56, p. 216]. In developed countries, declines in fertility occurred as concomitants of economic and social development among people whose levels of education were appreciable and increasing.

Countries that have a high percentage of all children in school typically have a low birth rate which has followed a generally declining trend. On the other hand, countries that have yet to develop desirable school enrollments typically have high birth rates which have generally been tending upwards during the preceding 10 to 15 years [51, p. 207].

Studies on the relative effects of religion and education on women relative to birth rates in Latin America showed education to be the stronger factor [51, p. 209]. Reproduction among the more religiously devout women proved to be significantly lessened as educational achievement increased. The experience of most countries seems to be that the years of education that the wife has are inversely related to the number of children born [51, p. 208].

Data on primary and secondary school enrollment and birth rates for 49 countries gave correlation coefficients showing a strong negative relationship between education and birth rates [51, p. 209].

The trouble is that countries whose populations are growing fastest, are having equally impressive difficulty in increasing their educational attainments. Some are actually declining in percentages of children in school. It will be many years before several will have literary rates of 50 percent. Still, almost all seem to be making a major effort to educate their people. This will undoubtedly have a desirable effect on population in the long-run. Some countries that can hardly be called rich, such as Taiwan, Japan and Cuba have greatly increased their country-wide educational levels in a short period of time and this has no doubt contributed to reduced birth rates. For most countries, however, a high level of educational attainment requires a long time to achieve. The poorest nations, therefore, cannot rely on education alone to stabilize population levels.

### **Foreign Aid in Birth Control**

Given the fact that attitudes around the world seem to favor family planning and the use of contraceptives, the time is propitious for the developed world to increase its support of family planning programs in the less-developed nations. The less-developed countries simply are not now in a position to provide all the resources needed for an effective campaign to stabilize population. Professor Steven Enke has shown that 1 dollar spent in the less-developed countries for contraceptives is worth about \$100 in other forms of aid associated with economic development [84, p.16]. President Johnson in his San Francisco message commemorating the 20th anniversary of the United Nations said: "Let us act on the fact that less than \$5 invested in population control is worth \$100 invested in economic growth" [8, p. 6]. If either Professor Enke or President Johnson are near the mark, the evidence is very strong that aid in this form should be greatly increased, if economic development is our primary goal.

Many private foundations such as Ford and Rockefeller and other private groups, such as the Population Council and the International Planned Parenthood Federation, are active abroad in promoting family planning. Just last November (1967), the 50-nation International Planned Parenthood Federation approved a crash program in Latin America calling for 6½ billion dollars, double its 1967 budget, to establish and equip clinics, train doctors and paramedical staff, supply contraceptives, develop educational materials and publicity, and support research projects at universities and hospitals.

But the foundations and private groups cannot hope to do all that must be done. National governments must join hands with private groups and international agencies to provide the necessary help. The most powerful effort imaginable to encourage birth control could not cost anything like 1 percent as much as is being poured into economic development. Indeed, the cost of preventing one birth, even if as much as \$20.00, falls far short of the cost for 1 year of schooling [64, p. 179].

Our own country has given lip service to helping developing nations reduce their birth rates since the early Kennedy years, but only this fiscal year has Congress and the Agency for International Development (AID) begun to mount a significant program. During fiscal 1968, AID expects to spend \$35 million on family planning programs as opposed to \$4.2 million in the previous year [17, p. 611]. These resources will provide contraceptives (both IUDs and the pill), professional experts in family planning, and other equipment needed for programs. AID has thus become, almost overnight, the largest single supporter in the advanced nations of family-planning programs in less-developed countries. This development is an impressive beginning, but only a beginning.

To summarize, the shifts in attitudes taking place around the world relating to family planning, the availability of effective and cheap contraceptives, the increasing acceptance of abortion, the generally rising economic well-being of the world, and the increasing educational levels, all are operating now to reduce birth rates. In addition, the developed nations seem inclined to assist less-developed nations promote family planning programs. The total effect must surely suggest declining birth rates and perhaps eventual stabilization of population levels. This conclusion is supported by Professor Bogue when he says:



“The following generalizations appear to be justified. The trend of the world-wide movement toward fertility control has already reached a state where declines in death rates are being surpassed by declines in birth rates. Because progress in death control is slackening and progress in birth control is accelerating, the world has already entered a situation where the pace of population growth has begun to slacken. The exact time at which this switch over took place cannot be known exactly, but we estimate it to have occurred about 1965. From 1965 onward, therefore, the rate of world population growth may be expected to decline with each passing year. The rate of growth will slacken at such a pace that it will be zero at about the year 2000 so that population growth will not be regarded as a major social problem except in isolated and small retarded areas” [8, p. 83].

Other demographers seem to agree. Dudley Kirk has said: “Grounds for optimism that birth rates can be brought down in time to avert a rise in death rates has . . . never been more hopeful than it is today” [91, p. 49]. Mr. Kirk and Gavin Jones said at a 1967 conference: “With the knowledge that we now have, it seems possible to reduce the annual increase in population by one-third within 10 years at a cost less than that of a national campaign against malaria.” [8, p. 65].

### **Prospects for Increased Food Production**

The excellent prospects for stabilizing population over the long-run does not obviate the short-run necessity of feeding the people who are presently on the earth and those who will be born while population control is being realized. In many parts of the world an acute food shortage has existed for centuries and ways must be found to alleviate it [101, p. 14]. Since population growth rates will probably decline with the passage of time, the next decade or two are the most critical. If the food problem can be alleviated for that period it will likely also be manageable thereafter.

### **The Extent of Malnutrition and Undernourishment in the World**

Undernourishment is inadequacy of the diet in terms of calories. If continued over a long period of time, undernourishment results in loss of normal body weight or reduction of physical activity or both. Malnutrition refers to inadequacy of the nutritional quality of the diet. The protein content of the diet, especially animal protein, is a widely accepted indicator of nutritional quality, while total calories consumed reflects the degree of nourishment.

The Third World Food Survey conducted by FAO suggested that average calorie consumption in Europe, North America, and Oceania exceeded daily requirements of people in these areas by some 20 per-

cent. In the Near East, Africa, and Latin America, average consumption was about equal to requirements. Since calorie consumption is not distributed equally among people, there must have been some undernourishment in these areas. In the Far East, calorie consumption fell short of requirements by some 10 percent. A considerable proportion of people in this region, therefore, must be going hungry at least part of the time. One estimate of the proportion of undernourished people in the world as a whole is between 10 and 15 percent, of 325 to 450 million [96, p. 4].

The situation is quite different when it comes to malnutrition. The Economic and Social Council Committee on Levels of Living states that if the proportion of calories taken from cereals, starchy roots, and sugar exceeds two-thirds, malnutrition exists. The incidence of malnutrition in less-developed regions is estimated at 60 percent [96, p. 7]. Since some people in the developed countries are also ill-fed by this standard, it is likely that up to half of the people (1.5 billion) in the world are suffering from lack of sufficient nutrients.

Substantial disparities in both nutrition and nourishment distinguish the developed and less-developed nations. The billion people in the developed nations have half again as many total calories and 5 times as much high-quality animal protein per person as the 2 billion people in the developing nations [39, p. 308]. For example, a typical Indian eats his grain directly as human food, and gets about 2000 calories per day from this source. In addition, he may or may not get another 400 calories in vegetables, making a total of from 2000-2400 calories per day. In the United States, at the other extreme, most edible plants are fed to livestock, and the average American obtains one-third of his diet calories from meat, milk, and eggs. Although his actual calorie consumption is about 3000 per day, the American actually consumes about 11,000 plant-equivalent calories, which is about 5 times his Indian counterpart.

Dr. B. R. Sen, Director-General of FAO has said:

“It would appear that the gap in available food supplies per capita between the rich and the poor nations is widening rather than narrowing, and this in spite of all the efforts that have been made by national governments and international agencies in promoting economic development” [90, p. 285].

This widening gap between rich and poor countries may be at least partially responsible for the prevalent view that the world food situation is growing progressively worse with time and that famine is inevitable. It is easy for people getting fatter and fatter to attribute

famine to those areas where people are becoming relatively but not absolutely thinner and thinner. From the best data we have from the less-developed countries, food production increased substantially faster than population in 21 of 26 less-developed countries from the period 1948 to 1963. From 1955 to 1963, population increases exceeded food production in only 2 of 26 countries [8, p. 160]. If the people-food balance has deteriorated significantly, it should have shown up in this period of maximum population growth. A book just published (November, 1967) [59, p.11] indicates that increases in food production have been at about 3 percent per year for the last 20 years, despite bad droughts in Asia in 1965 and 1966. It will be recalled from the previous section that the world's population growth has been slightly less than 2 percent over the same period. Thus, there have been significant gains in per capita food production in the world as a whole. A continued rate of growth of food production of 3 percent will be quite adequate in reducing malnutrition and undernourishment as population growth rates decline in the future, providing food distribution can be effectuated to areas of deficiency.

Dr. A. T. Mosher, President of the Agricultural Development Council, said late last year:

“At the moment we are holding our own in food production. There have been fewer widespread famines in recent years than in previous eras and major technological breakthroughs with respect to food production are probable” [52, p. 22].

Another indirect test as to whether food is becoming increasingly scarce is the relative price of food over time. Prices of commodities that are in relatively short supply as related to demand tend to rise. With all the available income and wealth, even in poor countries, which could be used to purchase food, scarcities would drive prices up. A recent report of the National Advisory Commission on Food and Fiber [5, p. II-46] indicates that over the study period 1955 through 1964, the relative price of food rose in only 9 of the 26 developed countries. Only 33 of 69 less-developed countries, less than half, had food prices rising faster than other prices. This result would be highly unlikely if food shortages were becoming more acute.

Whether or not famine problems are intensifying, however, the status quo is intolerable. Inadequacy or imbalance in the supply of nutrients (especially essential amino acids) has been found to retard both physical and mental development in children [39, p. 308] [59, p. 3]. As long as hunger exists anywhere in the world, we who are

more fortunate should vigorously strive to overcome it. People suffering either from malnourishment or malnutrition, especially the latter, are pathetic and miserable.

Recent calculations show that the typical worker in southeast Brazil, because of improved health and increased life expectancy, will produce nearly 5 times as much during his lifetime as his average compatriot in nutritionally deficient northeast Brazil [11, p. 128]. The body, weak from lack of proper nutrients, protects itself by avoiding the expenditure of energy.

The countries with the lowest per capita daily protein consumption invariably are those with lowest productivity. An interesting demonstration of this was noted during the construction of the Pan-American Highway in Ecuador where the disappointing output of local laborers was quickly remedied with the provision of three well-balanced daily meals. Within a few weeks, workers averaged an increase in concrete paving from 1.8 to 5.9 cubic yards per day [11, p. 128].

Unfortunately, about the only thing that lack of protein does not seem to affect deleteriously is the ability to procreate. It has been found that there is an almost perfect negative correlation between protein consumption and fertility rates among countries [12, p. 73].

### **Other Possible Resource Shortages**

If food is not becoming increasingly scarce it would seem to be relevant at this stage of the argument to inquire whether or not supplies of other resources might eventually restrict the earth's ability to support life as we know it. It is my interpretation of the published reports I have seen that we have a rather long period of grace before we have much to worry about.

An obvious concern must be energy production since such vast quantities are consumed in our mechanized world. Conservative estimates of coal reserves show enough to meet world energy demands far into the future, well past 2100 A.D. If we add oil-shale and tar-sand reserves to known liquid petroleum reserves, the world is amply stocked for several hundred years. Atomic energy would not be needed for well over 100 years.

During 1966, 60 percent of all new power capacity contracted for in the United States was nuclear [92, p. 14]. Obviously, the development of atomic energy need not wait until the fossil fuels are

used up. The uranium potential of the United States alone for atomic energy production is a figure in energy equivalents much greater than the combined total of the world's known resources of recoverable coal and potential resources of oil and natural gas [81, p. 124]. Knowledgeable people at Oak Ridge are now talking seriously of atomic power costs of the order of 1.5 mills per kwh [92, p. 14]. In comparison, the average power cost in Logan is about 20 mills at the present time. This development is truly revolutionary in its implications. These power costs make previously impossible things possible, such as distillation of sea water for urban and agricultural use, sewage treatment by distillation, and perhaps the electric automobile [92, p. 14]. The energy picture would appear to be very bright indeed.

The discovery and proving up of metallic mineral reserves is rarely projected more than 2 or 3 decades in advance. But enough is known in a rough sort of way to provide a fair degree of assurance of adequate supplies to year 2000 without any increase in relative cost of exploitation [37, p. 60].

Not so in the case of forestry products. The relative price of lumber has risen 300 percent since 1870. It is dubious that world forests can sustain the drain that is projected for the future [37, p. 50]. Fortunately, relatively good substitutes are abundantly available and inexpensive. The future of the world does not hang on the branch of a tree.

Water shortages are essentially regional in scope and many ways exist to augment effective supplies [37, p. 63]. In most parts of the world it is primarily a question of maintaining quality and this can be done with available technology, if the will to invest is adequate. No serious national shortages are anticipated to the year 2000, and, with the advent of cheap power, all foreseeable needs can likely be met.

Some scientists at Cal Tech have already pointed out [92, p. 20] that the ultimate constraint on human life may be the heat that is generated by our increasingly urbanized and mechanized society. In the Los Angeles area, for example, the amount of energy produced now is 2 to 3 percent of the solar energy received. If this were increased by a factor of 10, everyone in the area would literally be cooking. The absolute limit to human population would be reached when there are enough urbanized, technically advanced people that people-generated heat boils the water of the oceans. This constraint is hopefully some years in the future.

In light of the above it is rather clear that food production is our most critical short-term resource problem in the world. Ultimately, perhaps, man may have to find ways to circumvent shortages of some natural resources. But there is nothing alarming in this regard now on the horizon.

## RELATIONSHIPS BETWEEN FOOD PRODUCTION AND GENERAL ECONOMIC DEVELOPMENT

A logical way to begin discussing increased food production is to point out that this is simply one component of general economic development. The problems and constraints resemble those in nearly all kinds of production. Any production (including agricultural) involves utilization of resources and inputs of technology and management, and must be accompanied by incentives to produce.

Agriculture is also related to the general economy in another crucial way. If agricultural production is increased beyond the needs of producer families, markets must be available. Almost all countries with a growing industrial class also have a prospering agricultural sector. When both sectors develop together, there is much mutual reinforcement and the total economy grows faster than if only one sector were moving forward.

Along this line Dr. A. T. Mosher said:

“In the last analysis the world’s food problem is not a food problem at all. It is a problem of expanding productivity, no matter what form that productivity may take coupled with achievement of an income distribution in each country that can convert the food needs of all people into an economic demand. In light of this, food supply per capita is only a barometer. The problem is opportunities for rising productivity per worker” [52, p.25].

In countries where farming has been at subsistence levels for centuries, the problems of getting farmers to become a commercial class, where inputs are market purchased and outputs are market sold, are indeed formidable and cannot be validly glossed over. Yet, we have not adequate space nor time to explore problems of economic development in detail here. Suffice it to say that growth of the non-farm economy is essential to a profitable agriculture. Farmers are able to purchase fertilizer, tools, high yielding seeds, pesticides, and irrigation water only if the non-farm economy is vigorous and provides markets for agricultural output [43, p. 4] [101, p. 15]. Thus, it is significant in projecting potential agricultural prosperity that practically all nations in the world have been making progress in per capita productivity.

Farmers producing under subsistence conditions are extremely hesitant to assume new risks. They live so close to real hunger that if they make a mistake, it could cause them and their families extreme hardship and even death. If a farmer is to invest in modern inputs such as improved seeds, fertilizer, and pesticides, they must be easily acquired, and there must be no possibility of crop failure. Also, credit must be available as very few subsistence farmers have cash with which to finance input purchases.

The matter of incentives is especially vital. A great economist, Professor T. W. Schultz, has argued that lack of incentives explains lagging food production in the less-developed nations.

“A typical refrain runs thus: Farmers farm badly; they are not industrious; they loaf too much; they squander their savings; and they prefer not to improve their economic lot. So a doctrine is born which has misled us badly. We have been blind to the plain fact that farmers in poor countries are shrewd, hardheaded, calculating people in their economic affairs. Whenever there is a real payoff, they respond” [79, p.21].

This fundamental and important fact has been dramatically evident to our own team of Utah State University scientists in Boliva, working with farmers as poor and ill-trained as almost any in the world. When cash was offered on the spot for their wool, the Bolivian campesino not only was eager to shear his sheep and sell his wool, which he had never done before, but wanted to know how he could improve his flock.

In reality, economic policies administered in poor countries have almost invariably been the opposite of those required to increase food output. Farm product prices have been held at artificially low levels in an attempt to foster industrial development and to check inflation. This shifts the terms of trade against agriculture and induces capital movement away from farming. The process provides low food prices to urban consumers, and thus aids the process of industrialization, but at the expense of the farmer.

Moreover, the modern inputs which are needed to increase production are very expensive and often alien to the farmer. In fact, the input prices are distorted also, but on the high side. Competition in the input markets is weak and is much impaired by artificial barriers on imports in order to protect inefficient domestic producers. Chile is a good example. She is one of the world's largest exporters of nitrogenous fertilizer and yet they are very expensive to her own farmers. The Chileans reason as follows: The fertilizer which is exported must be sold at the world price. Since it is low, it is presumed it must be sold at a loss. To offset this loss Chilean farmers

must be charged a price that is far above world market levels. Thus, Chilean farmers, and eventually Chilean food consumers, bear the burden of this perverted policy [79, p. 20].

I believe the importance of incentives is inescapable, even at present levels of technology in poor countries. The response of farmers to favorable farm prices and low input prices would astound us all. During World War II we saw what farmers can do if food prices rise rapidly. Our American farmers responded by increasing output by fully one-third in 5 years, and with much less labor. The large quantities of under-utilized labor in the less-developed countries could and would be used if incentives were present.

Of course, technology will not remain at present levels. Most of us are well-acquainted with the fantastic and largely unforeseen technological advances that took place in American agriculture over the past quarter century. I know of no reasons why the rate of advance should slow down in the foreseeable future. Much of this technology might be ultimately transferable to less-developed countries, but 20 years of technical assistance has shown us that there are many problems in trying to adapt our technology in the poor countries. Much more research is needed to make sure that a given technology is applicable and economically feasible. Then management training and extension programs will be required to implement that which is feasible.

Training for competent technicians who can mount programs of technological advance in the rural areas is an acute need in the poor countries. In all of Africa 10 years ago, only 10 college graduates in agriculture were produced each year, and even now the number is only 150. Ten years ago all of Latin America produced only 750 trained agriculturists per year, and only 1,100 now. By contrast, Japan alone produces 7,000 per year. In Japan there is one farm advisor for every 600 farms. In Colombia the ratio is one for 10,000 farms, and in Indonesia, one for perhaps 100,000 farms [92, p. 34]. In satisfying this training need, the developed countries could have help immeasurably, but our best efforts have not been spent in this direction.

No discussion of institutions and incentives is complete without considering land reform. As generally defined, land reform consists of changing the cultivator's relation to the land in a land-tenure system. In most less-developed countries, a reasonable reward is denied the cultivator who works under extremely adverse conditions. Existing tenure systems promote the concentration of land ownership among a few people, low yields but high rents, poor farmers but



expensive farms, too many people living on too little land. In Asia, rents of up to 70 percent are common even when the landlord provides only the land [59, p. 91]. Meaningful land reform encompasses all or most of the following elements: more equitable distribution of land among the citizens, security of tenure and fair rents, better methods of cultivation through technological improvement, and adequate credit and marketing services.

This matter of land reform is closely akin to the basic question of political power. Lack of land tenure and production incentives often result from the fact that the rural masses have little political power and are victimized by the ruling oligarchy. There needs to be a major overhauling of political institutions in many of the poor nations.

The temptation is to look at the admittedly sorry state of the world's political, social, and economic institutions and conclude that little progress is likely in food production. I contend, however, that exactly the opposite conclusion is more warranted. If technology, institutions, incentives, etc., were all optimal and we had trouble feeding the earth's people, then indeed the situation would appear to be hopeless. But so many improvements can be made on so many fronts, virtually all of which can be readily manipulated by man if he has the will, that we should not be discouraged. We must rather press on with the task of making progress where we can. Let us see what some of the more promising possibilities are.

### **Increasing Land Acreage and Irrigation Water**

Authorities differ in estimates of idle agricultural land that might be brought into production. One study published in 1964 reports that only 25 percent of the world's potentially productive arable lands are unused [37, p. 54].

Another estimate states that crop production could be expanded to three times the present acreage [86, p. 102]. Still another indicates that the world has approximately 6.6 billion acres of potentially tillable land and about 3.3 billion are presently under the plow [39, p. 316]. It is agreed, however, that nearly 90 percent of the additional lands involve tropical soils, which have some limitations when used for food production.

I have no way of judging which of the acreage estimates is most reliable. If any are near the mark, it is evident that considerable expansion in cropland is possible if the need becomes critical.

In the United States we have withdrawn from production about 56 million acres of our best cropland under various governmental programs. A recent Conservation Needs Survey classifies 638 million acres as class I, II, or III, classes that indicate suitability for cropping. In reality we are now harvesting crops from slightly more than 300 million acres, a little of which is class IV land. We also have vast areas that could be drained or irrigated and made into productive land [8, p. 218].

Immense potentialities exist in the world for providing irrigation water to thirsty cropland. The most promising possibilities are in the Indus River Valley, the Tigris-Euphrates River Valley, the Nile Valley, and several places in the Soviet Union. India and Pakistan, it is argued, could multiply their production of food many times by intelligent development of the Indus, Ganges, and Brahmaputra river systems [76, p. 104]. Some of the largest aquifers in the world underlie areas of India and Pakistan which have perennial drought problems [87, p. 15]. In North Africa, exciting new possibilities have been opened up by recent evidence indicating that large areas in the Sahara are underlined by an enormous lake of fresh water, perhaps as much as 100 billion acre-feet, enough to irrigate many billions of acres for centuries.

There are also limitless possibilities for improving irrigation efficiency on lands that are now irrigated. Such improvements will permit more productive and more valuable crops to be grown and might allow double cropping in a single year in some tropical areas.

Of course, bringing new lands into production and building irrigation works require large sums of capital. At this time capital is very scarce in the poor countries. The point is, however, that the world has much unused land and undeveloped water that might be used whenever those in power decide that they are needed to increase food production.

### **The Impact of Fertilization**

The factor having the greatest impact on increasing food production in the developed countries over the past 25 years has been the use of chemical fertilizers. The incentive to use them has been obvious as the price of fertilizer has declined by about one-half relative to the price of major farm products [8, p. 229]. Unfortunately, this decline in the price has not been extended to the less-developed countries. Often fertilizers are not available there at

any price. But if they are available, farmers find them too expensive. Let me give a few comparisons in fertilizer use.

Developed countries use 5 times as much fertilizer per acre as do less-developed ones. Europe uses about 20 times as much as do Africa and Asia, and 9 times as much as does Latin America. Japan uses over 100 times as much as do India and Pakistan [84, p. 19].

Despite the fact that the less-developed countries have been slow to apply fertilizer, real progress has been made in the last few years. The accepted yardstick of 10 tons of grain produced for each ton of nitrogen applied indicates that the food grain production base in 1967 is perhaps 7 or 8 million tons greater than in 1964 [54, p. 110]. The severe droughts in Asia in 1965 and 1966 obscured the real gains that would have occurred if the weather had permitted the effect of increased fertilizer use to be realized. With favorable weather, the food grain yields would have risen about 3 percent per year in 1965 and 1966. Government projections for the next 3 years suggest that enough fertilizer will be used in the less-developed countries to sustain a rate of growth in grain yields of about 3 percent a year. A 10:1 ratio of yields to fertilizers is conservative. It is based on old seed varieties, and even for them the tested response for relatively small applications is greater than 10 to 1. New seeds with substantially larger potential responses bring another dimension to the prospects for a faster rate of agricultural production through fertilizer use [54, p. 1110].

Completed research clearly demonstrates the economics of fertilizer use. The FAO Freedom from Hunger Campaign has recently completed a series of 95,000 fertilizer demonstrations and field trials in 14 less-developed countries. These trials involved many crops; wheat, barley, rice, corn, beans, cotton, potatoes, yams, sugarbeets, peanuts, and other vegetables. Substantial increases in yields were obtained with moderate dosages of fertilizer, even when no other technical factors were changed. For example, the increases in yields in grains and beans were about the lowest of crops tested and yet ran from 30 to 120 percent, with benefit-cost ratios running from 2.3:1 to 7.0:1 [33, p. 112].

To see how easily fertilizer use could alter the food production picture in the world, consider the following relationships. One ton of plant nutrients will produce about 10 tons of cereals, 36 million calories, which would be enough to provide 2,400 calories to 40 people for 1 year. One fertilizer plant producing 1,000 tons of nutrients per day would, therefore, ultimately provide 2,400 calories per day for

about 15 million people for 1 year. The fertilizer factory would cost in the neighborhood of 60 million dollars, or approximately \$4 for each person provided with food. With these kinds of payoffs, it is expected that fertilizer use will grow very rapidly in the less-developed world and will make a substantial contribution to increased food production despite the unwise price and institutional policies in many countries [69, p. 80].

### Developments in Plant Breeding

Because insufficient protein is the greatest contributing factor to malnutrition in the less-developed countries, some recent results in breeding high-protein grains qualify as a momentous advance in the field of nutrition. Scientists at Purdue University have discovered that the protein quality of some corn varieties can be increased to about 90 percent of that contained in milk. Surveys from Latin America show that the proportion of the total calorie intake from corn runs as high as 72 percent in some villages of Guatemala [82]. Thus, a substantial increase in the protein quality content of corn could considerably upgrade the nutrition of people in corn-consuming countries.

The increase in protein quality in corn equates with an increase in its lysine (an essential amino acid) content. Working with adult human beings, Purdue researchers have shown that high-lysine corn is twice as good for supplying protein for man as in normal corn. Children could grow normally with high-lysine corn as the sole source of carbohydrates and protein if they received supplements of vitamins and minerals [75 pp. 27-28]. Since approximately one-half of the world's corn supply is eaten by human beings, this development will have a direct and uplifting effect on world nutrition [45, p. 2].

High-lysine corn in animal rations will be especially valuable in swine rations because of the amino acid relationships in swine nutrition. Young pigs that were fed this corn for 21 days gained weight over 3 times faster than did pigs fed normal corn [45, p. 2]. Research in Illinois indicates that high-lysine corn, even in a dry year produces yields 85 percent of that of regular corn. Some lines produced more than 90 percent. In addition, most of these hybrids were free of ergot, and standability compared favorably with regular corn. A hybrid containing this trait could conceivably be ready for commercial production by 1971 [45, p. 3].

Other grains may incorporate similar potentials, and an intensive effort is being made to identify traits in sorghum, wheat, rice, and other members of the grass family. It is only a question of time until our plant scientists improve the protein quantity and quality of all our cereals. Already researchers at the University of Idaho have succeeded in isolating strains of a wild-oat species, closely related to cultivated oats, that run as high as 30 percent protein, which is almost double the normal amount [70, p. 11]. With more than half of the 80 odd million tons of protein consumed in the world every year being eaten in the form of grain, the significance of these developments is obvious [11, p. 130].

Other spectacular developments in plant breeding are equally relevant to my contention that the world starvation is far from inevitable. The work in Mexico, undertaken jointly by the Rockefeller Foundation and the Mexican government, is a notable case in point. New dwarf varieties of wheat are being grown in Mexico that produce 3 times more per acre than Mexican farmers realized in 1943 with other varieties, and are now among the highest yielding in the world. Under research conditions these seeds outproduce the old varieties by 40 to 100 percent or more at the same level of fertilizer application and are more responsive to higher rates of fertilization [54, p. 1110]. This single development has been instrumental in Mexico's successfully and sharply increasing her per capita food production despite heavy population growth. The international dimension of the dwarf wheats are being seen in 1967 and 1968, as the Mexican dwarfs are being introduced on an estimated 12 to 15 billion acres in 15 different countries [75, p. 55]. These countries will thus be able to increase their wheat yields in 5 years to a level that required 15 years to accomplish in Mexico.

One of the 15 countries, Pakistan, has already imported 42,000 tons of wheat seed of the dwarf varieties from Mexico. This transaction was the largest single purchase of wheat seed negotiated anywhere in the world [75, pp. 64-65]. One scientist working with the International Wheat Program opines that yields of wheat will be doubled within a decade all around the world [85, p. 284].

Perhaps even more impressive, is what is happening with rice in the Far East. Rice is the staple food of approximately half of the human race [95, p. 137]. For hundreds of millions of people in Asia, it constitutes virtually the whole diet. It occupies between one-half and two-thirds of the total arable land in major rice producing countries and a much larger proportion of the most fertile soils.

The Rockefeller and Ford Foundations working in the Philippines at Los Banos have made fantastic progress in developing more productive rice [8, p. 17]. In practically every yield test from the Philippines to Pakistan, the new rice variety was either at the top or near the top with yields usually ranging from 2.5-4.0 tons per acre [85, p. 299]. In countries where yields commonly average from .4 to .8 tons per acre, these increases open up possibilities previously undreamed of.

A good example is a recent report from Viet Nam:

“The recent experiences in Vo Dat district indicate that IR-8 seeds produce over 16,000 pounds of rice per hectare as compared with 4,800 pounds per hectare from the variety previously planted. And because IR-8 can be harvested from three to seven weeks earlier than most of the 454 Vietnamese varieties, farmers can easily get two crops a year, whereas 95 percent of Vietnamese farmers now only get one crop” [77, p. A17].

These kinds of field results led a USDA economist, who has spent the last year studying the food situation in India and the Far East, to report that the evidence suggests that the rate of food production in that part of the world will increase about 3½ percent each year in the immediate years ahead [54, p. 1112]. His prognostication is based on programs and technology already in hand. The rate he estimates is substantially ahead of the rate of population growth, and in a very few years could well be double the population growth in this area where it is commonly alleged that famine problems are most pressing.

### Shifts from Animals to Plants

In the more developed countries man has acquired a palate which is attuned to animal products as the basis of his diet. Although there is no biological requirement for animal protein in the human diet [92, p. 51], we omnivores do like the taste of meat. The extravagance in the use of resources that is necessary to produce edible meat may be tolerated in well-fed countries, but not in those that are short of food. The husbandry of animals for meat may not even be tolerated in rich countries when animal products can be perfectly simulated by plant products at lower cost.

Judicious mixing of different kinds of cereals and oil seeds can produce a perfectly adequate source of protein for the human diet. The versatility of foods incorporating just oil-seed protein is almost unlimited. They can be made to taste like almost any kind of meat, and of course are free of cholesterol. Tenderness or toughness can

be varied at will, and the level of nutrition can be adjusted as desired. These pre-cooked products require no refrigeration, and have good keeping properties if they are protected from moisture [8, p. 142].

The potential effect upon the world hunger spectre that might result from substitution of plant for animal foods is suggested in the following quotation:

“The residue that is left when oil is compressed from soya, ground nut, cotton seed, and sunflower material is now, for the most part, used as animal feed for fertilizer, or is simply discarded. It contains about 20 million tons of protein, which is twice the world’s present estimated deficit. If we could all turn vegetarian in this country (the USA) we would be able to export an amount of food each day which would be 1.5 times as great as the daily production of foods by India” [92, p. 37].

The American yearly output of potential food calories is about 11,000 calories per person per day, almost 9,000 of which are wasted, in a sense, by being put through animals.

The most extreme example of the inefficiency of foods from animals in relation to food from plants is the case of fish taken from the sea.

“Fish do not eat plants, they eat animals, or even worse, they eat animals that eat animals that eat animals. At each step in the food chain, 90 percent of the input calories are lost in supporting the activities of that link. It takes 100 pounds of original plant to make 1 pound of codfish” [92, p. 37].

Of course, the example is not highly relevant at present since man hasn’t found a way as yet to use the plant life of the ocean directly for food.

The conversion of plants into synthetic foods resembling those from animals requires a high input of technology and capital. Although synthetic foods are now produced at competitive costs in the rich countries, they are a long way from being competitive in the poor countries. The important factor will ultimately be the relative costs of the various inputs. When capital is cheap and land expensive, man will necessarily seek to maximize the product per unit of land. The least costly alternative could then well be the synthetic foods which are efficient in the use of land. If land is plentiful and capital is expensive, however, man may continue to indulge his liking for animal products. On a long-run basis, however, the economic relationships and the directions of technological change seems to clearly favor plant simulation of animal products.

Another dramatic breakthrough which is just beginning to be reported is the production of edible protein by growing single cell organisms on natural gas, petroleum, vegetable wastes, or even coal.

The Dutch Shell Company, for example, has found a bacterium, containing about 50 percent protein, which uses methane, a natural gas, as its sole source of energy for reproduction. The expectation is that wholesome and nutritious products, utilizing energy from petroleum or natural gas, can be developed and produced in almost unlimited quantities within a decade [11, p. 133]. The oil pumped out of the earth's crust each day contains approximately the same number of calories as are contained in the food used by the entire human race. It is simply a question of learning to convert petroleum to something digestible [92, p. 37]. Now we know what to do with the petroleum reserves that might be rendered valueless for energy production by nuclear power.

The potential advantages of producing food by this method are many: the abundance of petroleum even in many food-short countries, the independence from climatic uncertainties, the small space requirement, and the need for only a few agricultural technicians. Most of the world's major petroleum producing countries are deeply committed to food research projects, and it is only a matter of time until the technology and economics are worked out to permit commercial production to take place.

Scientific imagination has gone even further. Milk has been produced from water-soaked leaves, seaweed, and algae. A French company recently discovered an entire West African village successfully using algae as its basic protein source [11, p. 133].

These few examples must suffice to demonstrate that the possibilities for producing calories and protein are almost unlimited.

### **Food from the Sea**

Food from the sea has often been proposed as the solution to man's food problems if all else fails. The oceans and the seas cover more than 70 percent of the surface of the earth and contain untold quantities of protein material, yet this abundance has scarcely been touched by man. Most of the known fish populations of commercial value in the Northern Hemisphere have been fished intensively. Even in these areas however, the catch is generally a small proportion of the total biological material that the sea produces. With a few exceptions, the tropical and Southern Hemisphere waters are relatively unexploited [8, p. 147].

The contribution which a wisely managed world fishery could make to better diets has never been adequately explored, but it is



undoubtedly large. Presently fish supplies contribute only about 10 percent of the total world animal protein consumption and amount to 1 percent of the total food [37, p. 57]. Potentially, the greatest contribution may come from relatively unfamiliar but abundant fishes that can be turned into an edible product containing 80 percent protein. The United States Congress has recently authorized a pilot plant that will produce a fish-protein concentrate for an estimated 13.9 cents per pound. This is considerably less than the cost of obtaining protein from dry milk solids. Aside from the cost, fishermen would be able to sell under-utilized species of fish, and fishing efficiency could be much improved [8, p. 157]. This, to be sure, does offer exciting opportunities if the nations seeking to exploit the resource will establish regulations and proceed on an orderly and rational basis.

### **Aid from Developed to Less-Developed Countries**

We now come to those issues that should directly concern all of us, the assistance that developed countries can and should give to less-developed ones.

The economies of rich and poor countries have grown at about the same rate during the last decade—about 4 percent per year. But because of differences in population growth, the per capita growth is nearly 3 percentage points more for rich countries as in poor ones and the gap is widening every year. The crisis of our day is not the food problem *per se*, but the widening gap in per capita incomes. Mrs. Dorothy Jacobson, Assistant Secretary of Agriculture, has compiled some illustrative statistics recently.

“There are only some 33 countries in the world where per capita incomes exceed \$500 per person per year. About 30 have per capita incomes ranging between \$200 to \$500 per year. Fifty nations have per capita incomes of less than \$200, and 12 of these have average per capita incomes of less than \$100 per year. In these 12 countries live about half of the population of the world” [87, p. 8].

If we are to live in a peaceful, stable world, substantial economic and technical aid must flow from rich to poor countries.

Developed countries can and do provide support in many ways to the less-developed countries in the food production area. These can be roughly classified into direct food aid, direct aid in capital resources, and aid in technical research, education, and extension programs.

Aid is proffered by an extremely diverse group of institutions,

international agencies, national governments, private foundations, universities, business firms, churches, and labor unions to name only a few of the most important. Each group has its own interests to satisfy and contribution to make, and obviously the job is big enough to utilize all who have the resources and the will to assist. Let us look first at the effort being expended in direct food shipments.

The United States has been the principal donor country in direct food aid. We shipped \$19 billion worth of food overseas between the enactment of Public Law 480 in 1954 and the end of 1966. Our primary motivation has been to reduce the stocks of surpluses that resulted from our unwise domestic agricultural programs. About one-half of our food shipments were paid for in the "soft" currencies of the recipient countries [8, p. 189]. Shipments have been sent primarily to the Middle East, Africa, Latin America, and the Far East. India has received more food aid than any other country, with tremendous quantities of wheat being sent to carry her over the droughts in 1965 and 1966.

As recently as 1966, President Johnson announced the Food for Freedom Program. The Food for Freedom bill changes the emphasis from Public Law 480 days of direct food shipments. The new doctrine emphasized self-help to accelerate food production within the poor nations themselves. In four places, the bill refers to assistance to those countries that are determined to meet their population problems. I believe these developments are on the right track and should produce progress on both population and food fronts.

Most economists are critical of our direct food aid programs as a helpful factor in economic development. Food aid serves to depress producer prices and discourages the development of local agriculture [8, p. 191] [80, p. 230]. Now that our surpluses are almost gone we are relying almost entirely on sales of food in exchange for dollars at world market prices. Thus present food shipments can hardly be called aid.

The food producing capacities of developed countries are vastly greater, even under present technology, than current production would indicate. For many years our farm policies have had to deal with surpluses, and various supply-control measures have been used to reduce production. If, however, food prices were rising because of food shortages and expanding markets, or if production incentives were given to farmers, there is little doubt that output would be significantly increased. This increased output would be available to

the less-developed nations in the form of sales or aid, whichever seems most desirable under the circumstances.

On the question of aid in the form of capital resources, data assembled for 36 developing countries for the years 1962 to 1964 on net investment in relation to gross domestic production indicate a median ratio of 11 percent. Eight percent was provided from domestic and 3 percent from foreign sources [5, pp. 1-19]. In 1965 it was estimated that the total flow of financial resources to less-developed countries bi-laterally and through international agencies totaled almost exactly a mere 1 percent of the total national income of the developed countries. This amounts to approximately \$6 billion per year [92, p. 15]. Of this total, public resources amounted to just under two-thirds and private sources just over one-third [5, pp. 1-19]. The United States stood very near the average for the group of donor countries.

The United States extended loans and grants for non-military aid to the extent of 1.3 percent of our gross national product in 1950. By 1960 this had dropped to .4 percent and by 1965 to only .3 percent, and over 50 percent of this was in the form of loans [14, p. 17].

George D. Woods, President of the World Bank, estimates that \$3 to \$4 billion more could be effectively used for development by the world's poor countries at the present time [92, p. 15]. As time goes by, considerably more than this could be absorbed.

My own view is that the rich countries can well afford to expend a substantially greater total effort in offering aid of all kinds than is now being made. Also, a much greater proportion should be given as technical, educational, and economic aid, with a much smaller proportion than now as military aid. We must think primarily of long-run development. Top priority should be given to increasing the productivity of agriculture. We must increase the investment in education and basic research. The less-developed nations have very few first-rate research stations, and those that exist are generally managed by foreign foundations and employ foreign technicians. This situation persists despite 2 decades of technical aid.

If anything, the disparity in numbers of trained personnel between the developed and under-developed world has widened. From 1956 to 1960, for example, we imported 1,765 medical doctors from Latin America as a means of partially satisfying our tremendous need for trained physicians. From 1961 to 1965 we imported 2,500 more. We exported very few. In the 1965-66 Foreign Exchange Program,

125,000 students were participating from countries outside the U. S., already 11,000 of them have chosen to remain here. "We have the ironic and tragic phenomenon of a flow of high quality brain power out of the less-developed countries where they are most needed into the developed countries, especially the United States, the most developed of all" [92, p. 64].

Yet another important point must be made in this discussion of relationships between rich and poor nations. It is vital for the developed world to move increasingly toward free trade in its commercial dealings with the under-developed world. Less-developed nations would likely follow, since it would be to their advantage to do so. Countries could specialize in producing commodities that provide the greatest comparative advantage. Perhaps even more important, free trade allows the smallest of countries to capture the rewards of economies of large scale production. Thus little Switzerland, which has hardly any natural resources prospers as the watchmaker of the world.

The protectionist policies of the less-developed countries, known as imported substitution, have been very costly. These countries have protected their domestic producers of commodities that could be acquired more cheaply from abroad. They have done this because they have been short on foreign exchange. The only way the less-developed countries can get foreign exchange to make purchases in the international market is for the developed countries to open up their own domestic markets to goods from the poorer countries. And this applies to inputs of agricultural production as well as outputs. The Common Market and other free-trade arrangements have clearly shown what elimination of trade barriers can do. Much less direct aid would be needed if trade could be improved, and political relations between trading partners tend to be better than relations between donor and recipient of charity.

To summarize briefly, the prospects for producing more food are indeed so promising and so diverse that wide-spread recognition of them may lead to complacency. Agriculture is a complex productive system, and increasing agricultural production is actually a problem in systems analysis. Advocates of each of the separate areas where sizeable gains can be made, will be tempted to believe that his diagnosis of the problem and his prescription for overcoming it should have top priority. This is mistaken strategy. A wide range of interacting institutional, social, and economic conditions must be simultaneously satisfied if production increases are to be optimized. Progress must be made simultaneously on all relevant fronts. Fertilizer

cannot solve all our problems, neither can land reform, nor birth control, nor substitution of plant protein for animal protein in our diets. All can help and progress in one area is likely to reinforce progress in other areas. If we have the technology and resources to make the kind of progress we need, then we must alter the impeding institutions so that it can occur. This is where our real challenge lies.

## CONCLUSIONS

Perhaps I have surprised you with my basically optimistic view that man will find ways to stabilize population and eliminate hunger. Lest any of you reject my argument out of hand on the basis of youthful naivete, let me hasten to add that I believe man has problems aplenty to fully challenge his tremendous capacities. Indeed, the population-food problems which I have discussed will offer challenge enough, but I am confident that man will be able to successfully conquer these problems.

I am much less confident that man can save himself and his civilization from nuclear destruction, but I profess no particular expertise in this area, and perchance this accounts for my pessimism. I have read that laboratory experiments with animals have conclusively proved that over-crowding produces uncontrollable aggressiveness [60, p. 177]. If I am wrong about population stabilization, it is possible, even likely, in my opinion, that social stresses and tensions will shatter our social and political institutions, and violence will bring us down long before we starve to death. This eventuality is no less terrifying than famine, maybe even more so.

If we learn to control our numbers and provide for our nutritional needs, we will have made only a beginning, albeit, a very important beginning toward solving more vexing problems. Man simply must learn to cope with problems of crowding in significant ways. Even if population should become static at present levels, we will be happier if we scatter ourselves out so that it appears that we are less crowded than we really are. Most of our cities are already far too large [92 pp. 151-156] to be either manageable or pleasantly habitable. Ready access to outdoor recreation could allow people to experience the exhilarating freedom of space and room. Many would welcome wilderness-type experiences as a way to maintain our links with the rest of nature. Our working and living quarters should be spacious and saturated with plant and animal life to give us the feeling of being close to nature. The deplorable quality of our air and water resources attests to over-

crowding and unwise technology. In a physically satisfying environment man might fulfill his promise. He could perhaps create the institutions — local, national and international — that would assure a high level of resource productivity, material prosperity and comfort for all who crave them, along with a tranquil international environment, where man can pursue the bounties of the mind and the spirit while living in serenity amidst beauty.

### REFERENCES CITED

1. Ackerman, Edward A. Population and Natural Resources, World Population Conference, 1965, Belgrade, Vol. 1, Summary Report, United Nations.
2. Acock, A. M. The World Food Program: An Experiment in Multilateral Food Aid, *Agricultural Economics and Statistics*, Vol. 41, No. 1, Jan. 1967.
3. Adelman, Irma. An Econometric Analysis of Population Growth, *American Economic Review*, Vol. 53, June 1963.
4. Adelman, Irma and Morris, Cynthia Tass. A Quantitative Study of Social and Political Determinants of Fertility, *Economic Development and Cultural Change*, Vol. 14, Jan. 1966.
5. Agriculture and Foreign Economic Development, Technical Papers, Vol. 7, National Advisory Commission on Food and Fiber, Aug. 1967.
6. Agriculture and Industrialization, Food and Agricultural Organization of the United Nations, Basic Study No. 17, Rome 1967.
7. Agricultural Commodity Projections for 1975 and 1985, *Agricultural Economics and Statistics*, Vol. 16, Food and Agricultural Organization, Sept. 1967.
8. Alternatives for Balancing World Food Production Needs, Iowa State University Center for Agricultural and Economic Development, Iowa State University Press, Ames, Iowa, 1967.
9. Barnett, Harold J. Malthusianism and the Conservation, Resources for the Future, Reprint No. 12, Mar. 1959.
10. Bates, Marston. Man as a Member of a Biological Community, Our Crowded Planet, Fairfield Osborn, ed., Doubleday, Garden City, N. Y., 1962.
11. Berg, Allen D. Malnutrition and National Development, *Foreign Affairs and American Quarterly Review*, Vol. 46, No. 1, Oct. 1967.
12. Blyn, George. Contraversal Views on the Geography of Nutrition, *Economic Geography*, Vol. 37, No. 74, Jan. 1961.
13. Bowles, Chester. International Letter, No. 29, Oct. 31, 1967.
14. Brown, Harrison. Combustibility of Humans, *Saturday Review*, June 24, 1967.
15. Burton, Ian and Kates, Robert W. Slaying the Malthusian Dragon, A Review, *Economic Geography*, Vol. 40, Jan. 1964.
16. Can Mass Starvation be Prevented, International Planned Parenthood Federation, Report No. 7, Fall 1967.
17. Carter, Luther J. Population Control, U. S. Aid Program Leaps Forward, *Science*, Vol 159, No. 3815, Feb. 9, 1968.
18. Chen, Kuan I. World Population Growth and Living Standards, Bookman Associates, New York, 1960.
19. Christensen, Raymond P. Man's Historic Struggle for Food, *USDA Yearbook of Agriculture* for 1966.

20. Clark, Colin. Demographic Problems on a World Scale, *World Justice*, June 1965.
21. Clark, Colin. Population Growth and Living Standards, *International Labor Review*, Reprinted in the *Economics of Underdevelopment*, Agarwala and Singh ed., Aug. 1953.
22. Coale, Ansley J. Population in Economic Development, *World Population Conference*, Vol. 1, Summary Report, United Nations, 1965.
23. Combs, G. F. Long Range Implications of the World Food Problem, *Maryland Nutrition Conference for Feed Manufacturers*, Mar. 1967.
24. Daedalus, Report of the American Academy's Commission on the Year 2000, *Journal of the American Academy of Sciences*, Summer 1967.
25. Darwin, Sir Charles G. The Law of Population Increase, Our Crowded Planet. Fairfield Osborn, ed., Doubleday, Garden City, N. Y., 1962.
26. Davis, Joseph F. Food Alarmism, Famine Forecast, *Michigan Business Review*, Vol. 17, May 1965.
27. Davis, Kingsley. Population, *Scientific American*, Sept. 1963.
28. Davis, Kingsley. The Urbanization of the Human Population, *Scientific American*, Sept. 1965.
29. Deevey, Edward S. Jr. The Human Population, *Scientific American*, Sept. 1960.
30. Dorn, Harold F. World Population Growth; an International Dilemma, Stuart Mudd, ed., *Population Crises and Use of World Resources*, W. Junk — Hague, 1964.
31. El Badry, M. A. Population Projections for the World: Developed and Developing Regions 1965-2000, *The Annals of the American Academy of Political and Social Sciences*, Vol. 369, Jan. 1967.
32. Ewell, Raymond. Agriculture's Critical Role in the Next Decade, Paper delivered at the 10th Annual Convention of the National Plant Food Institute, June 7, 1965.
33. Ewell, Raymond. Famine and Fertilizer. *Chemical and Engineering News*, Vol. 42, Dec. 14, 1964.
34. Ewell, Raymond. Population Growth and Birth Control, *Journal of International Health*, Vol. 2, No. 1, Fall 1966.
35. Ewell, Raymond. Population Outlook in Developing Countries, Proceedings of the 15th Annual meeting of Agricultural Research Institute, National Academy of Sciences, National Research Council, Washington, D. C., Oct. 10, 1966.
36. Faaland, J. Demographic Aspects of Savings, Investments, Technological Development and Industrialization, *World Population Conference*, Vol. 1, Summary Report, United Nations, 1965.
37. Fisher, Joseph L. and Potter, Neil. *World Prospects for Natural Resources*, Resources for the Future, Inc., The John Hopkins Press, Baltimore, Maryland, 1964.
38. Foerster, Heinz, Mora, Patricia M., Amiot, Lawrence W. Doomsday; Friday, November A. D. 2026, *Science*, American Association for the Advancement of Science, Oct. 20, 1960.
39. Food and Fiber for the Future, Report of the National Advisory Commission on Food and Fiber, July 1967.
40. Food Needs and U. S. Agriculture in 1980, Technical Papers, Vol. 1. National Advisory Commission on Food and Fiber, Washington, D. C., Aug. 1967.

41. Freedman, Deborah S. The Relation of Economic Status to Fertility, *American Economic Review*, Vol. 53, June 1963.
42. Friedman, Milton. Myths that Keep People Hungry, *Harper's Magazine*, April 1967.
43. Freeman, Orville L. Waging War on Hunger, Speech before the Biennial Conference of Foreign Agricultural Organization, *Foreign Agriculture*, Dec. 4, 1967.
44. Hagen, Everett E. Population in Economic Growth, *American Economic Review*, June 1959.
45. Hankin, B. J. A New Corn, Purdue University and Cooperative Extension Service, State of Indiana, 1966.
46. Harrer, J. George. The Race Between Procreation and Food Production, Paper delivered to the American Philosophical Society in Philadelphia, 1965.
47. Hauser, Philip M. Demographic Dimensions of World Politics, *Science*, June 3, 1960.
48. Hirshman, Albert O. The Strategy of Economic Development, Yale Press, New Haven, 1958.
49. Huxley, Sir Julian. The Impending Crisis. The Population Crisis and the Use of World Resources, Stuart Mudd, ed., W. Junk, The Hague, 1964.
50. Huxley, Sir Julian. The Human Crisis, University of Washington Press, Seattle, 1963.
51. Idenburg, P. J. Demographic Aspects of Educational Development, World Population Conference, Vol. 1, Summery Report, United Nations, 1965.
52. Increasing Understanding of Public Problems and Politics, Farm Foundation, Chicago, Illinois, 1967.
53. Jones, Joseph Marion. Does Over Population Mean Poverty, Center for International Economic Growth, Washington, D. C., 1962.
54. Koffsky, Nathan M. The Food Potential of Developing Nations, *Journal of Farm Economics*, Vol. 49, No. 5, Dec. 1967.
55. Krutch, Joseph Wood. Naturalist Looks at Over Population, Our Crowded Planet. Fairfield Osborn, ed., Garden City, N. Y., Doubleday, 1962.
56. Kuznets, Simon S. Demographic Aspects of Economic Growth, World Population Conference, 1965, Vol. 1, Summary Report.
57. Lippes, Jack. Intrauterine Contraception; History and World Impact, *Journal of International Health*, Vol. 2, No. 1, Fall 1966.
58. Man, Land and Food. Looking Ahead at World Food Needs, Foreign Agricultural Economics Report No. 11, USDA, ERS, Regional Analysis Division, Nov. 1963.
59. Millikan, Max F. and Hapgood, David. No Easy Harvest. Little, Brown and Company, Boston, 1967.
60. Morris, Desmond. The Naked Ape, McGraw Hill, New York, 1967.
61. Murphy, Franklin D. The Delicate Balance, *Saturday Review*, Jan. 13, 1968.
62. McGovern, George E. The Challenge of World Hunger, Speech at the World Agriculture Forum of the National Fertilizers Solution Ass'n., Dec. 5, 1966.
63. McGovern, George E. We are Losing the Race Against Hunger, *Look*, Mar. 7, 1967.
64. Notestein, Frank W. The Population Crisis, Reasons for Hope, *Foreign Affairs*, Oct. 1967, Vol. 46, No. 1.



65. Notestein, Frank W. World Population and Food Supplies, 1980, American Society of Agronomy, Feb. 1965.
66. Notestein, Frank W., Kirk, Dudley, and Segal, Sheldon. The Problem of Population Control – The Population Dilemma, Prentice Hall, Inc., 1963.
67. Orr, Lord Boyd. Mankind's Supply of Food, Our Crowded Planet. Fairfield Osborn, ed., Doubleday, Garden City, N. Y., 1962.
68. Paddock, William and Paul. Famine 1975. Little-Brown, Boston, 1966.
69. Parker, Frank W. and Nelson, Lewis B. More Fertilizers for More Food, Prospects of the World Food Supply, A Symposium, National Academy of Sciences, Washington, D. C., 1966.
70. Parker, Kipp. Oats Offer Hope for Protein Short World, Utah Farmer, Sept. 21, 1967.
71. Pirie, N. W. Unorthodox and Orthodox Methods of Meeting World Food Needs, Scientific American, Feb. 1967.
72. Population and Food Supplies. Monthly Bulletin of Agricultural Economics and Statistics, Vol. 14, Nos. 7-8, July, Aug. 1965.
73. Production Yearbook, 1961. Food and Agricultural Organization, United Nations.
74. Prospects of the World Food Supply. A Symposium, National Academy of Sciences, Washington, D. C., 1966.
75. Report of CIMMYT, 1966-67. International Maize and Wheat Improvement Center, Londres 40 Apartado Postal 6-641, Mexico 6 DF, Mexico.
76. Revelle, Roger. Water, Scientific American, Vol. 209, Sept. 1963.
77. Rowan, Carl T. U. S., S. Viet Look for Victory on the Rice Production Front, Salt Lake Tribune, A17, Jan. 25, 1968.
78. Russell, Earl Bertrand. Population Pressure and War, The Population Crisis and the Use of World Resources, W. Junk, The Hague, 1964.
79. Schultz, Theodore W. Increasing World Food Supplies, The Economic Requirements, Prospects of the World Food Supply, A Symposium, National Academy of Sciences, Washington, D. C., 1966.
80. Schultz, Theodore W. United State's Malinvestment in Food for the World, presented at Ames Conference on Balancing Future World Production Needs.
81. Schurr, Sam H. Energy, Scientific American, Vol. 209, Sept. 1963.
82. Scott, John T. Jr. Economic Use of Modified Protein Corn. Department of Agricultural Economics, Agricultural Experiment Station, University of Illinois, Oct. 1967.
83. Scrinshaw, Nevin S. Food, Scientific American, Vol. 209, Sept. 1963.
84. Spengler, Joseph J. The Economist and the Population Question, American Economic Review, Vol. LVI, No. 1, Mar. 1966.
85. Stakman, E. C., Bradfield, Richard, Manglesdorf, Paul C.. Campaigns Against Hunger. The Belknap Press of Harvard Univ. Press, 1967.
86. Stamp, L. Dudley. World Resources and Technology, Readings in Resource Management and Conservation, Ian Burton and Robert W. Kates, University of Chicago Press, 1965.
87. Steiner, Michael P. and Marousek, Gerald E., editors. Food for Freedom. Proceedings on the Causes of War and the Conditions of Peace, Wm. E. Borah Foundation, University of Idaho, 1967.
88. Stevenson, Adlai E. Extracts from Address at Planned Parenthood World Population, Oct. 15, 1963, The Population Crisis and the Use of World Resources. Stuart Mudd, ed., W. Junk, The Hague, 1964.

89. Sukhatme, P. V. The World's Hunger and Future Needs in Food Supplies, *Journal of the Royal Statistical Society*, Vol. 124, 1961.
90. Taeuber, Conrad. Demographic Aspects of Agricultural Development and Food Supply, *World Population Conference*, Vol. 1, Summary Report, United Nations, 1965.
91. *The Annals of the American Academy of Political and Social Sciences*, Vol. 369, Jan. 1967. Prospects for Reducing Natality in the Underdeveloped World. Kirk, Dudley.
92. The Next Ninety Years, Proceedings of a Conference held at the California Institute of Technology, California Institute of Technology, Mar. 1967.
93. The Population Dilemma. 23rd American Assembly on the Columbia University Campus, Philip M. Hauser, ed., May 2-5, 1963.
94. The State of Food and Agriculture, 1967. Food and Agriculture Organization, United Nations, Rome, 1967.
95. The State of Food and Agriculture, 1966. Food and Agriculture Organization of the United Nations.
96. The World Food Situation. The monthly bulletin of Agricultural Economics and Statistics, Vol. 12, April 1963.
97. Taeuber, Irene B. Mrs. Summary of History of Demographic Thoughts Since Last World Population Conference in 1954, *World Population Conference*, Vol. 1, Summary Report, United Nations, 1965.
98. USDA, ERS. Increasing World Food Output, Problems and Prospects, *Foreign Agricultural Economic Report No. 25*, Foreign Regional Analysis Division, April 1965.
99. West, Quentin M. World Food Needs. Foreign Regional Analysis Division, USDA, ERS, Feb. 16, 1966.
100. White, C. Langdon. Geography and the World Population, The Population Crisis and the Use of World Resources, Stuart Mudd, ed., W. Junk, The Hague, 1964.
101. World Food Problem. A report of the President's Science Advisory Committee, Vol. 1, Report of the Panel on the World Food Supply, The White House, May 1967.
102. World Population and Food Supplies, 1980. ASA. Special publication No. 6, Published by American Society of Agronomy, Feb. 1965.
103. World Population Prospects as Assessed in 1963. Population Studies No. 41, United Nations.

## PUBLICATIONS

by B. Delworth Gardner

1. The Pricing of Livestock Forage on Federal Range Lands, *West. Agr. Econ. Res. Counc. Com. on Econ. of Range Use and Dev. Rep. No. 2*, 103-117, 1959.
2. Price Policies and the Changing West, *West. Farm Economic Assoc. Proceedings*, 1959: 228-243, Logan, Utah.
3. Measuring Inputs in Agriculture, *J. Farm Econ.* 42: 1430-1434, Dec., 1960.
4. Pricing Publicly Owned Range and Water Resources, *West. Agr. Econ. Res. Counc. Com. on Econ. of Water Res. Devel. Conf. Proceedings*, Report No. 9, 97-101, 1961.

5. Costs and Returns from Sagebrush Improvement in Colorado, Colorado Agr. Exp. Sta. Bul. 511-S, p. 1-18, 1961.
6. Transfer Restrictions and Misallocation in Grazing Public Range, J. Farm Econ., 43: 50-63, 1962.
7. Rates of Return to Improvement Practices on Private and Public Ranges, Land Economics, 38: 42-50, 1962.
8. Ranchers' Losing Fight for Forest Grazing, National Livestock Products, 40: 18, 26, March 1962.
9. Wealth Losses to Ranchers from Reduced Forest Grazing, National Wool Growers, 52: 20-21, March 1962.
10. What Does the Rancher Pay for His Permit? American Cattle Producer, 43: 12, April, 1962.
11. Good Dividends from Range Improvement, Utah Farmer, 81: 5-7, May 17, 1962, Idaho Farmer, 80: 61-17, June 21, 1962.
12. Ranchers, It Pays to Improve Your Range, National Wool Grower, 52: 18-19, 51, September 1962.
13. Capitalized Values and Misallocation in Grazing Public Range: A Reply, Journal of Farm Economics, 43 (4): 1100-1102, 1962.
14. A Program to Stabilize Livestock Grazing on the Public Lands, National Wool Grower, 52: 18-19, November, 1962.
15. Designing Research for Inter-Use Studies, West. Farm Econ. Assoc. Proceedings, 1962: 182-195, Reno, Nevada, West. Agr. Econ. Res. Coun. Com. on Econ. of Range Use and Devel., Report No. 4: 147-172, 1962.
16. A Proposal to Reduce Misallocation of Grazing Permits on Public Range Lands, Journal of Farm Economics, 45 (1): 107-120, 1963.
17. The Economics of Range Improvement in Northwestern Colorado, Journal of Range Management, Abstract of Papers, 16th Annual Meetings, 1963.
18. Improving Irrigation Efficiency by Land Leveling and Ditch Lining, (with F. J. Wagstaff), Farm and Home Science, 24:40-43, 52, 1963.
19. Water Resources Development: A Review of the New Federal Evaluation Procedures, (with E. Castle and M. M. Kelso), Journal of Farm Economics, 48:693-704, November 1963.
20. The Internal Rate of Return and Decisions to Improve the Range, West. Agr. Econ. Res. Coun. Com. on Econ. of Range Use and Devel., Proceedings, Report No. 5:87-110, 1963.
21. Government Grazing Policy and the Beef Industry in the West, (with N. K. Roberts), Future for Beef, Iowa State University Center of Agr. and Econ. Adj., Report No. 15:217-235, 1963.
22. Agriculture as a Competitive Segment of Multiple Use, Land and Water Use, American Assoc. for the Adv. of Science, Washington, D. C., pp. 99-115, 1963.
23. Livestock and the Public Lands, (with N. K. Roberts), Utah Historical Quarterly, 32,(2): 285-300, Summer 1964.
24. Some Why's of Household Water Use, (with Lois Cox), Utah Farm and Home Science, 25(3):82-83, 88, September 1964.
25. Discussion of In-Place Uses of Puget Sound Waters and Water Quality: Economic Aspects, West. Agr. Econ. Res. Coun. Com. on Econ. of Water Res. Devel., Proceedings, Report No. 12:43-45.
26. Optimum Water Use in Utah, (with Lois Cox), Utah Farm and Home Science, 25(4):96-98, December 1964.

27. Discussion of The Implications of Changing International Markets for United States Agriculture, West. Farm Econ. Assoc. Proceedings, San Louis Obispo, California, 1964.
28. Factors Affecting Household Water Consumption in Northern Utah, Utah Agr. Exp. Sta. Bul. 449, p. 1-25, 1964.
29. Discussion of Simulation Systems in Making Water Resource Decisions, West. Agr. Econ. Res. Council Com. on Econ. of Water Res., Annual Conference, Proceedings, Report No. 13:121-123.
30. Oil Shale: The Where, When, and Why of World's Richest Deposit, (with Lois Cox, Intermountain Industry, May 1965 pp. 6-12.
31. Comprehensive Watershed Planning—An Economists Viewpoint, What's Happening Around Us, Pacific Region of the Am. Assoc. of Agr. Eng., Conference Proceedings, 1965.
32. The Economics of Recreation: Progress and Problems—Comment, (with E. Boyd Wennergren), Western Economics Journal, 4(2):166-168, Spring 1966.
33. Dividing America's Water, (with Lois M. Cox), Think, 23-27, May-June 1966.
34. Water for Utah—By Plan or Accident, Utah Farm and Home Science, 27(2): 78-82, June 1966.
35. The Proposed Grazing Fee Increase—Likelihood and Impact, Utah Wool Grower, 3(3):1-3, April 1966.
36. Toward Excellence in Research, Proceedings of the Agr. Exp. Station Research Day, 1966, Utah State University, 1-5, February 1966.
37. The Economics of an Increase in Wheat Production in Bolivia, Analysis of the Wheat and Flour Business in Bolivia, Mimeographed report, USAID Bolivia, 1-60, May 1966.
33. The Effects of Resource Policies on Income Distribution, Journal of Farm Economics, 48:1242-1253, December 1966.
39. State Water Planning—Goals and Analytical Approaches, Utah State Agr. Exp. Sta. Bulletin 463, 1-45, November 1966.
40. Studies of the Value of Water in Alternative Uses, Developing a State Water Plan, Status of Water Planning in Utah, Utah Water and Power Board Special Publication No. 1, 70-75, April 1966.
41. Public Responsibility in Use of Natural Resources, Future Use of Utah's Public Land Resources, Technical Proceedings, Utah Chapter Soil Conservation Society of America, 1-10, January 1967.
42. Toward a Disposal Policy for Federally Owned Oil Shales, Chapter 8, Extractive Resources and Taxation, Mason Gaffney, ed., University of Wisconsin Press, Madison, Wisconsin, 169-195, 1967.
43. The Economic Issues in Inter-basin Water Diversions. Proceedings of the Western Farm Economics Association, 1967, 43-52 Las Cruces, New Mexico.
44. Analytical Issues in Demand Analysis for Outdoor Recreation. Journal of Farm Economics, 49(5):1125-1129, December 1967.
45. Can Recreation Save Ranching, (with Darwin B. Nielsen) National Wool Grower, 57(12):8-11, December 1967.
46. Transfer Mobility and Value of Water, (with Herbert H. Fullerton), Western Agr. Econ. Res. Council Committee on Economics of Water Resource Development, Proceedings Report No. 16:1-22, December 1967.

**THIRTY-SEVENTH FACULTY HONOR LECTURE  
DELIVERED AT THE UNIVERSITY**

April 17, 1968

A basic objective of The Faculty Association of the Utah State University, in the words of its constitution, is:

to encourage intellectual growth and development of its members by sponsoring and arranging for the publication of two annual faculty research lectures in the fields, or (1) the biological and exact sciences, including engineering, called the Annual Faculty Honor Lecture in the National Sciences; and (2) the humanities and social sciences, including education and business administration, called the Annual Faculty Honor Lecture in the Humanities.

The administration of the University is sympathetic with these aims and shares the costs of publishing and distributing these lectures.

Lecturers are chosen by a standing committee of the Faculty Association. Among the factors considered by the committee in choosing lecturers are, in the words of the constitution:

(1) creative activity in the field of the proposed lecture; (2) publication of research through recognized channels in the field of the proposed lecture; (3) outstanding teaching over an extended period of years; (4) personal influence in developing the character of the students.

Dr. Gardner was selected by the committee to deliver the Annual Faculty Honor Lecture in the Humanities. On behalf of the members of the Association we are happy to present Dr. Gardner's paper:

**PROTEIN AND THE PILL – A PIVOTAL PARTNERSHIP**

Committee on Faculty Honor Lecture

**OTHER LECTURES IN THE SERIES**

**THE SCIENTISTS CONCEPT OF THE PHYSICAL WORLD**  
by Willard Gardner

**IRRIGATION SCIENCE: THE FOUNDATION OF PERMANENT  
AGRICULTURE IN ARID REGIONS**  
By Orson W. Israelson

**NUTRITIONAL STATUS OF SOME UTAH POPULATION  
GROUPS**  
by Almeda Perry Brown

**RANGE LAND OF AMERICA AND SOME RESEARCH ON ITS  
MANAGEMENT**  
by Laurence A. Stoddart

**MIRID-BUG INJURY AS A FACTOR IN DECLINING  
ALFALFA-SEED YIELDS**  
by Charles J. Sorenson

**THE FUTURE UTAH'S AGRICULTURE**  
by W. Preston Thomas

**GEOLOGICAL STUDIES IN UTAH**  
by J. Stewart Williams

**INSTITUTION BUILDING IN UTAH**  
by Joseph A. Geddes

**THE BUNT PROBLEM IN RELATION TO WINTER  
WHEAT BREEDING**  
by Delmar C. Tingey

**THE DESERT SHALL BLOSSOM AS THE ROSE**  
by D. Wynne Thorne

**THE TEACHING OF SCIENCE**  
by Sherwin Maeser

**THE BEGINNINGS OF SETTLEMENT IN CACHE VALLEY**  
by Joel Edward Ricks

**GENETICS OF CANCER AND OTHER ABNORMAL GROWTHS**  
by Eldon J. Gardner

**OBLIGATIONS OF HIGHER EDUCATION TO THE  
SOCIAL ORDER**  
by Ernest A. Jacobsen

SOME EFFECTS OF FLUORIDES ON PLANTS,  
ANIMALS AND MAN  
by Delbert A. Greenwood

THE POLITICAL PROCESS  
by M. R. Merrill

RANGE LIVESTOCK NUTRITION AND ITS IMPORTANCE IN  
THE INTERMOUNTAIN REGION  
by C. Wayne Cook

SOME ECONOMIC FALLACIES AND THE CITIZEN  
by Evan B. Murray

UTAH'S FUTURE WATER PROBLEMS  
by Wayne D. Criddle

MOTIVATION IN LEARNING  
by Arden N. Frandsen  
(not published in this series)

GOOD NUTRITION FOR THE FAMILY  
by Ethelwyn B. Wilcox

ZION IN PARADISE — EARLY MORMONS  
IN THE SOUTH SEAS  
by S. George Ellsworth

STUDIES IN EXPERIMENTAL EVOLUTION  
by William Sidney Boyle

WATER FOR MAN  
by Sterling A. Taylor

THE SEMANTICS OF STRESS AND PITCH IN ENGLISH  
by George A. Meyer

THE PRICE OF PREJUDICE  
by Leonard J. Arrington

BEAR LAKE AND ITS FUTURE  
by William F. Sigler

THE RESPONSIBLE EXERCISE OF CREATIVE POWER  
by Carlton Culmsee

THE SECRETS OF VIRAL REPRODUCTION  
by George W. Cochran

THE SEARCH FOR CONSENSUS

by M. Judd Harmon

COCCIDIOSIS OF CATTLE — SOME UNSOLVED PROBLEMS

by Datus M. Hammond

COMMITMENTS IN MARRIAGE

by Don C. Carter

MAN AND HIS WATER RESOURCE

by Dean F. Peterson

JACK LONDON: MASTER CRAFTSMAN OF THE  
SHORT STORY

by King Hendricks

A MODERN PHILOSOPHER'S STONE

by Grant Gill Smith

NATIONAL GOALS AND HUMAN RESOURCES  
DEVELOPMENT

by Vernon L. Israelsen

RANGE NUTRITION IN AN ARID REGION

by Lorin E. Harris





