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World Revolution in Agriculture

BY NORMAN E. BORLAUG AND CHRISTOPHER R. DOWSWELL

In recent years the international news media have focused on the cruel realities of famine in drought-stricken Africa. To most citizens of the affluent nations—who have never personally known hunger—the tragic scenes of starving people and their dying animals are deplorable and incomprehensible. The situation seems especially paradoxical when parts of the world are awash in surplus food and farmers in many of the developed countries are struggling with the economic consequences of overproduction. Though many individuals, organizations, and governments have responded generously with emergency food aid, these are only stopgap measures. The only long-term solution is sustained agricultural development in areas where food is in short supply.

Agriculture and Population. In geologic terms, the domestication of plant and animal species is a recent event. Archaeological evidence indicates that all the major cereals, economically important legumes, root crops, and animal species that are still our principal sources of food were domesticated over a period of only 2,000–3,000 years. The process may well have begun when Neolithic women, faced with shortages when their menfolk failed to bring home enough food from hunting forays, decided that something had to be done and began searching for a means to assure a more permanent and reliable supply. It was achieved by sowing seed of the same wild grain species they had been collecting for untold millennia to supplement their meat diet. Thus, agriculture was born. With the development of agriculture some 8,000 to 10,000 years ago, the condition of humankind began to improve markedly, and human numbers, estimated to have been 15 million at that time, began to increase at an accelerated rate. A more stable food supply resulted in better nutrition and the development of a settled way of life, leading to higher survival rates and yet more rapid population growth.

World population presumably doubled four times from the beginning of agriculture to the start of the Christian era (to about 250 million). It had doubled again, to 500 million, by about 1650. The next doubling required only 200 years, producing a population of one billion by 1850. At about that time the discovery of the nature and cause of infectious diseases—the dawn of modern medicine—began to lower death rates. It took only 80 years for the next doubling, to two billion, which occurred about 1930. Shortly thereafter, the development of sulfa drugs, antibiotics, and improved vaccines led to a further substantial reduction in death rates, especially among infants and children. The next doubling of population took only 45 years—to about 1975, when the global population reached four billion, representing a 256-fold increase since the discovery of agriculture.

While the growth of world population overall has begun to slow, the current rates in the less developed world remain frighteningly high. In 1985, with world population approaching the five billion mark, global food production of all types stood at about 4.3 billion metric tons, representing some 2.2 billion tons of edible dry matter. (*See* TABLE I.) Of this total, 98% was produced on the land; only 1% came from the oceans and the inland waters. (A third source of food, microbial fermentation, is used primarily to produce certain vitamins and amino acids. These products are important nutritionally, but the quantity is small, and they are not included in this survey.)

Plant products constituted 92% of the human diet, with about 30 crop species providing most of the world's calories and protein. These included eight species of cereals, which collectively accounted for 52% of the world food supply. Animal products, constituting 7% of the world's diet, come indirectly from plants.

Production, Distribution, and the Role of Science. There are two aspects to the problem of feeding the world's people. The first is the complex task of producing sufficient quantities of the desired foods to satisfy

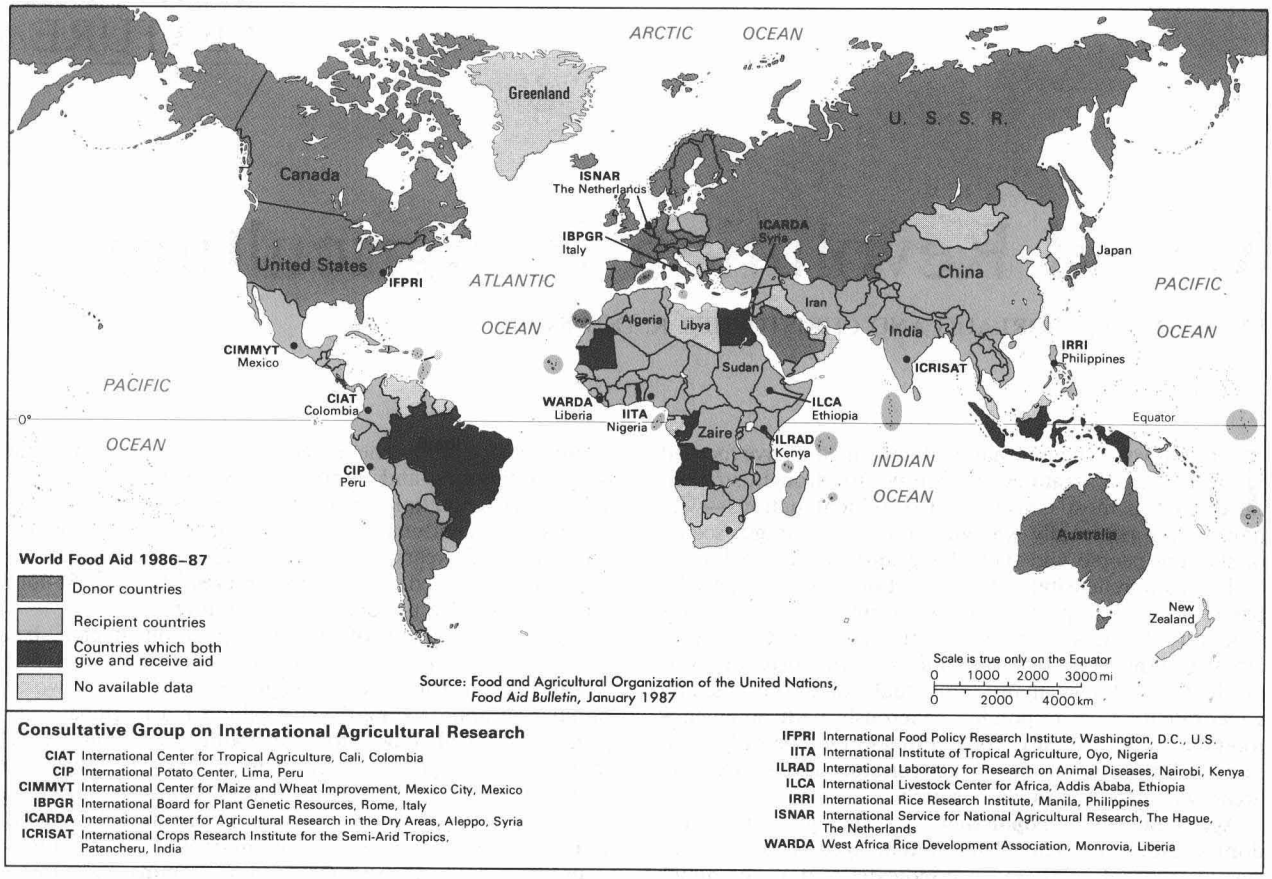
Table I. World Food Production, 1984

In 000 metric tons

Commodity	Gross	Edible dry matter[1]	Protein[1]	% increase 1979–84
Cereals	1,802	1,500	155	16
Wheat	522	459	54	23
Corn (maize)	449	395	41	14
Rice, rough	470	319	27	24
Barley	172	151	15	0
Sorghum/millet	103	92	8	3
Roots and tubers	593	160	10	8
Potato	312	68	7	10
Sweet potato	117	35	2	3
Cassava	129	47	1	10
Legumes, oilseeds, nuts	243	162	55	10
Sugarcane and sugar beets (sugar content only)	113	113	0	11
Vegetables and melons	387	47	5	14
Fruits	300	39	2	5
Animal products	936	180	77	40
Milk, meat, eggs	856	158	59	37
Fish	80	21	14	7
All food	4,374	2,201	297	17

[1]At zero moisture content, excluding inedible hulls and shells.
Source: FAO *Production Yearbook*. Format adapted from L. T. Evans (ed.), *Crop Physiology* (1975).

Norman E. Borlaug, Distinguished Professor of International Agriculture at Texas A & M University, was awarded the Nobel Prize for Peace in 1970 for his achievement in laying the groundwork for the Green Revolution. Christopher R. Dowswell is a consultant in agricultural communications.



Consultative Group on International Agricultural Research

CIAT International Center for Tropical Agriculture, Cali, Colombia
CIP International Potato Center, Lima, Peru
CIMMYT International Center for Maize and Wheat Improvement, Mexico City, Mexico
IBPGR International Board for Plant Genetic Resources, Rome, Italy
ICARDA International Center for Agricultural Research in the Dry Areas, Aleppo, Syria
ICRISAT International Crops Research Institute for the Semi-Arid Tropics, Patancheru, India
IFPRI International Food Policy Research Institute, Washington, D.C., U.S.
IITA International Institute of Tropical Agriculture, Oyo, Nigeria
ILRAD International Laboratory for Research on Animal Diseases, Nairobi, Kenya
ILCA International Livestock Center for Africa, Addis Ababa, Ethiopia
IRRI International Rice Research Institute, Manila, Philippines
ISNAR International Service for National Agricultural Research, The Hague, The Netherlands
WARDA West Africa Rice Development Association, Monrovia, Liberia

people's needs. The second task, equally or even more complex, is to distribute the food equitably. The chief impediment to equitable food distribution is poverty—lack of purchasing power—resulting from unemployment or underemployment, which, in turn, is made more severe by rapid population growth. We feel that only by increasing agricultural productivity in food-deficient areas can both aspects of the world food problem be ameliorated. Further, we are convinced that science-based, high-yielding, sustainable agriculture is the key to the required increase.

This type of agriculture is a 20th-century invention. It is important to understand the role it has already played in increasing food production and reducing food prices for consumers. For without a continuing stream of productivity improvements, especially in areas with food shortages, an adequate diet for all humankind cannot be assured.

Until the 19th century, crop improvement was in the hands of farmers who selected seed from the most desirable plant types for sowing the following season. By the early decades of the 19th century, a number of progressive farmers in North America were busy developing and selling seeds from superior varieties based on their individual plant selections. The groundwork for more sophisticated genetic improvement of crop-plant species was laid by Charles Darwin in his writings on the variation of life species (published in 1859) and by Gregor Mendel through his discovery of the laws of genetic inheritance (reported in 1865). While Darwin's book immediately generated a great deal of interest, discussion, and controversy, Mendel's work was largely ignored for 35 years. The rediscovery in 1900 of the laws he had uncovered, however, provoked tremendous scientific interest and research in plant genetics. Armed with a growing knowledge of genetics, soil chemistry and physics, plant physiology, plant pathology, and entomology, 20th-century agricultural scientists have made enormous contributions to increased food production throughout the world.

As recently as the 1930s, U.S. agriculture followed a traditional pattern for increasing food production. As sons and daughters of farm families married and formed new families, and as immigrants moved to the United States, they opened new land to cultivation. During much of the country's history there was an abundance of available land, and the demand for agricultural products was rising. Improvements in farm machinery expanded the size of a farm that could be cultivated by one family. They also made possible better seedbed preparation, conservation and utilization of moisture, timing of plantings, and weed control, resulting in modest increases in yield per hectare.

The institutional foundations for the development of high-yield agriculture in the United States were laid in the latter half of the 19th century and the early part of the 20th. In 1862 Pres. Abraham Lincoln signed into law three bills that played a vital role in raising U.S. agriculture to its current preeminent position: a law establishing the U.S. Department of Agriculture (USDA), a government agency charged with responsibilities for guiding and coordinating agricultural development; the Morrill Act, which established the publicly supported land-grant colleges of agricultural and mechanical arts in every state; and the Homestead Act, which made land available to landless persons who committed themselves to living on the property and developing it. These laws were supplemented in 1887 by the Hatch Act, which provided

for the establishment of agricultural colleges, as well as for closer collaboration between the colleges and the USDA. In 1889 the USDA was raised to Cabinet status. In 1914 a final key organization, the Extension Service, was set up as the educational agency of the USDA and was charged with the responsibility of introducing new technologies to farmers and ranchers.

By the 1930s much of the scientific knowledge needed for high-yield agricultural production was available, but its utilization was delayed by the Great Depression of the 1930s, which paralyzed the agricultural economy. It was not until World War II brought a great demand for food to support the Allied war effort that these research findings began to be applied widely in the United States. Between 1940 and 1980 the combined production of 17 major food crops in the United States rose 142%—from 252 million to 610 million metric tons—with only a 3% increase in cultivated land. Had the 1940 yield levels persisted, an additional 177 million ha (437 million ac) of good quality cropland—an area almost equal in size to all the land east of the Mississippi River minus Illinois, Michigan, and Wisconsin—would have been needed to produce the 1985 harvest. The most impressive gain in the U.S. has been the 251% increase in corn (maize) yields, due in large part to the introduction of high-yielding hybrid varieties. As a result of the new technology, U.S. farmers in 1980 produced 120 million metric tons more corn from 6.6 million ha (16.3 million ac) less land than in 1940. The yields of wheat and other crops have also risen dramatically.

The driving forces behind these production gains have been new practices based on scientific research. They include the use of newly developed high-yielding crop varieties, increased reliance on irrigation and improved techniques for conserving moisture, a 14-fold increase since 1938 in the use of chemical fertilizers to restore soil fertility, more effective weed control through the use of improved cultural practices and herbicides, improved control of diseases and insects, and economic incentives to farmers to adopt these new practices. While the agricultural universities provided much of the basic scientific information underpinning the new technologies, it was the private sector that played the major role in the development, introduction, and distribution of improved seed, fertilizer, weed killers, and pesticides, as well as in the development of better farm machinery. Today U.S. farmers and ranchers, representing less than 2% of the country's economically active population, provide the nation with abundant food supplies that cost consumers only 12% of their disposable income, besides producing a huge exportable surplus.

During the past several decades, improved agricultural technology has also reached the farmers of Western Europe, Oceania, Canada, and Japan, as well as Eastern Europe and the U.S.S.R. Surprisingly, from 1950 to the early 1970s, agricultural production—starting from a low base—grew more rapidly in Eastern Europe and the Soviet Union than in Western Europe and North America, as mechanization and expanded use of fertilizers and pesticides were given high priority in the centrally planned economies. After the mid-1970s, however, this situation changed markedly, with agricultural production increasing sharply in the market-oriented countries and stagnating in the centrally planned, Communist bloc countries, the notable exception being the People's Republic of China. Today, the cereal-yield levels of the developed market economies are the highest in the world. They have been achieved through a combination of private-sector initiatives—aggressive agribusiness development and efficient, independent farmers and ranchers—and the research and policy support from public-sector organizations and government needed to stimulate the development and adoption of ever improving technology. In contrast, the lack of individual incentives, inefficient government planning, and government control over agriculture have held back progress in many Communist bloc countries.

The Third World's Green Revolution. For a variety of reasons, agricultural development, especially of food crops, was given a low priority in much of the third world until quite recently. In many cases, colonial powers had emphasized the production of cash crops such as cocoa, tea, coffee, and rubber, grown chiefly for export, and little attention had been paid to food crops. Following independence, the governments of the new nations tended to identify economic development with growth of the industrial sector. Despite the fact that 70–90% of the work force in most less developed countries was engaged in agriculture, development funds were channeled into industrial projects, many of them nonviable. Those agricultural development efforts that did occur usually met little success, since they attempted to transfer directly from high-income, temperate zone countries agricultural technologies that were unsuited to the labour-intensive, tropical and semitropical farming systems of the third world.

By the early 1960s declining per capita cereal production—the result of rapid population growth and stagnant agricultural output compounded by several years of drought—had led to acute food shortages in the third world, especially Asia. Most of the affected countries were too poor to purchase imports. It appeared that without perpetual food aid from the developed nations, millions of people in the third world faced continuing, and probably worsening, famine. With their backs to the wall, political leaders became more receptive to focusing on their nations' agricultural problems. In doing so they began to accept some views they had previously rejected. These included the possibility that productive agriculture was essential to economic growth and that supposedly tradition-bound peasant farmers would ultimately accept new technologies, if the technologies were appropriate.

Evidence to support this "radical" thinking about agricultural development was first produced in Mexico, where the Rockefeller Foundation, in conjunction with the government of Mexico, initiated the first cooperative international agricultural research program in 1943. During the 1950s Mexican farmers made great strides in applying new technology—improved varieties and modern cultivation techniques—developed by the foundation to increase yields, and by the late 1950s the country had become self-sufficient in most food commodities.

In 1960, after helping to develop a well-trained corps of agricultural scientists and a national research infrastructure that would provide a continuing flow of new technologies for Mexico's farmers, the Rockefeller Foundation joined forces with the Ford Foundation to create the first full-fledged international agricultural research organization, the International Rice Research Institute (IRRI), located in the Philippines. Shortly thereafter, the international parts of the Rockefeller Foundation corn and wheat programs in Mexico were reorganized, leading to the creation in 1966 of the International Center for Maize and Wheat Improvement (CIMMYT), with headquarters in Mexico.

With their commodity-oriented, interdisciplinary research and training programs focused on solving the most pressing food-production problems in the third world,

Various strains of rice grow at the International Rice Research Institute (IRRI) in Los Bãnos, Philippines. The IRRI has developed high-yield rice plants with high disease resistance and the ability to withstand strong winds.

GENE HETTEL

CIMMYT and IRRI were unique research institutions. They became the models for other international research centres, each concerned with major commodities and food-production problems relevant to third world agricultural development. This network, which has grown to 13 international agricultural research centres, has been a vital force in stimulating appropriate technology development for the major food crops and farming systems in the less developed world.

By the mid-1960s CIMMYT and IRRI scientists had developed disease-resistant, semidwarf wheat and rice varieties with radically improved yields. These new short varieties were much more efficient than their tall predecessor varieties in converting sunlight and nutrients into grain production. Furthermore, their superior plant architecture provided resistance against lodging (falling over) in heavy winds and under improved conditions of soil fertility and moisture. Even when farmers used traditional methods of cultivation, the new wheats and rices yielded more grain than the traditional local varieties. However, when these new varieties were grown with adequate moisture and soil fertility, they yielded up to four times as much. Nevertheless, many agricultural scientists were skeptical about the willingness of farmers to accept the new varieties. Not only did they look different from the traditional types, but they also required substantially different care, especially in the use of fertilizer, in water management, and in weed control.

Despite the misgivings of many local researchers, national leaders in India and Pakistan, facing desperate and deteriorating food situations, decided to embark on major programs to introduce the new varieties and farming techniques as quickly as possible. In the beginning they authorized the purchase of large quantities of the new seeds and massive amounts of fertilizer. Extensive farm demonstration programs were established, and once farmers saw the results of the new technologies, they themselves became the major spokesmen for the new methods. At the same time, national leaders radically changed national investment policies in order to build up domestic seed- and fertilizer-production facilities and assure farmers a price for their grain at harvest similar to that prevailing on the international market, all critical factors for sustaining growth in food production.

The gamble taken by courageous leaders in India and Pakistan—and later in many other countries—has paid off handsomely. The combined rice and wheat output of the less developed countries increased by 220 million tons, or 74%, between 1965 and 1980, with only a 20% increase in the area planted. (*See* TABLE II.) High-yielding crop varieties, much higher levels of fertilization, markedly higher investments in agriculture, more efficient use of irrigation, and fair prices for grain at harvest were the driving forces behind the improvement. Productivity gains on the farm, in combination with improved systems for delivering fertilizers, pesticides, and other inputs to farmers and for conveying their produce to the markets, greatly expanded the availability of food for consumers while reducing its real price. In addition, rural economic development was stimulated as more bountiful harvests brought expanded job opportunities and higher wage levels.

This breakthrough in wheat and rice production has come to be known as the Green Revolution. Many early reports of the Green Revolution depicted it as a wholesale transfer of high-yield technology from developed countries to peasant farmers in the third world. This was incorrect. In reality, the Green Revolution was the start of a process of using principles of modern agricultural science to develop technologies appropriate to the conditions of third world farmers.

While India, Pakistan, and the Philippines received world attention for their agricultural progress during the 1960s and 1970s, the greatest third world success story of the 1980s has been China, home to one-fifth of the world's people. By changing from a system of centralized planning and control over agricultural production to a regional system based on market incentives, and by making widespread use of appropriate high-yield technology, China has moved ahead of the U.S. and the U.S.S.R. to become the world's biggest food producer. New agricultural policies have brought farmers higher prices, wider markets, and greater individual freedom to decide what to produce. The reform, called the production responsibility system, has resulted in what amounts to a de facto privatization of Chinese farming. While farmland is still collectively owned and the government continues to set production targets for basic crops, the rewards that a farmer receives are now directly linked to output. This encourages initiative, innovation, investment, efficiency, and risk-taking by individuals.

CIMMYT

Wheat researchers in India work with the International Center for Maize and Wheat Improvement. CIMMYT cooperates with scientists in each country where its research is being implemented, exchanging information and training agricultural workers.

Table II. Estimated Changes in Production, Yield, and Use of Inputs for Wheat and Rice Production in Less Developed Countries, 1965–80

	1965	1975	1980	% change 1965–80
Wheat and rice production (000,000 tons)	303	451	527	74
Yield (t/ha)	1.54	1.77	2.25	46
Area (000,000 ha)	196	228	234	20
Fertilizer (000,000 tons)	1.8	6.7	10.3	572
Machinery (000,000 units)	0.319	0.763	1.12	351
Draft animals (000,000)	301	317	332	10
Labour (000,000 person-yrs)	230	242	234	9

Source: CGIAR Impact Study, 1985.

A second factor in China's agricultural success story is the rapid increase in agricultural research since the end of the Cultural Revolution in 1977. This has led to the development and widespread adoption of high-yielding modern varieties, much higher levels of fertilizer use, improved water management, and more effective practices of weed, disease, and insect control. Since 1978 agricultural production in China has risen by nearly 8% a year—the highest rate in the world—and average incomes in rural areas have grown by about 70%; without much fanfare, 800 million Chinese peasants have become 70% richer.

The Green Revolution, however, has not progressed at the same rate everywhere, nor has it reached all crops or all farming areas. Crop yields in many areas in less developed countries—generally, regions with precarious growing environments and no irrigation facilities—remain abysmally low. While the environmental problems in some of these regions are too great for science to overcome with current technologies, many marginal farming areas could be made substantially more productive through a combination of wise scientific methods and government policies.

Prospects for World Agriculture. Future world food demand will be determined by two factors: expanding population and increases in per capita food consumption. Sometime in 1987 world population reached the five billion mark, and by the year 2000 it will have passed six billion. Eighty percent of this growth will occur in less developed nations, in rural areas, and among the poor.

In the more developed market economies, such as the United States, Canada, and the European Communities (EC), population is growing very slowly. The people are already well fed, and little increase in per capita food consumption is expected. In the more developed centrally planned countries of Eastern Europe and the U.S.S.R., population is also growing slowly, although per capita food consumption, especially of meat products, continues to increase. More feed grain will be required if per capita meat consumption there is to rise.

In much of the less developed world—in both market-oriented and centrally planned economies—the population is continuing to grow rapidly, and substantial increases in per capita food consumption are still needed, especially for the poor. It is projected that between 1987 and the year 2000 the population of the third world will grow by more than one billion people, or 20%. Thus, total food supplies in the less developed world will have to increase by at least 33% just to maintain current—and often inadequate—per capita food-consumption levels. If economic development succeeds and incomes rise, demand for food in the third world will be much higher. A considerable portion of this increased demand, if it materializes, will be for poultry and livestock products, commodities that are typically associated with higher living standards. This will require much larger quantities of cereals, grain legumes, and oilseeds for feed.

During the period 1979–81, world grain production stood at some 1,590,000,000 tons. In 1983 the Winrock International Institute for Agricultural Development, an independent research organization with headquarters in Arkansas, published *World Agriculture: Review and Prospects into the 1990s.* The study estimates that between 1979–81 and 1993 world grain production will rise by 30%, or 446 million tons, with half of this growth occurring in the third world. The projections made in this study, while only a few years old, are already out of date for some regions, especially the Far East, where China, India, and Indonesia have achieved much greater than expected growth in cereal production since the late 1970s. (*See* TABLE III.)

Approximately 80% of the projected gains will occur on farmlands currently in production. There are still some vast, largely unpopulated tracts, especially in sub-Saharan Africa and South America, that may eventually come into agricultural production. However, the cost of settling these areas, with their generally fragile ecosystems, makes them unlikely candidates for significant food production during the remainder of the century.

In all the more developed countries—both market-oriented and centrally planned—population growth is very modest. These nations should be able to increase per capita production relatively easily without expanding the area under cultivation, provided suitable technologies continue to be introduced. However, the spectacular increases in crop yields achieved during the 1960s and 1970s probably will not be matched in the 1980s and 1990s. In the United States, Australia, and Argentina—countries that currently export much of their agricultural products—considerable capacity exists to increase grain surpluses provided reasonable prices can be obtained in international markets. In the United States, the prairies and Corn Belt of the Midwest contain some of the best farmland in the world for growing grain. The U.S. government has attempted to avoid overproduction and the collapse of world grain prices through programs designed to keep land out of production. In 1984, 11 million ha (30 million ac) were lying fallow, enrolled in special government programs to set aside land.

The current surpluses of grain, meat, and dairy products in the EC countries are the result of an expensive program of subsidies to European farmers provided through the EC's common agricultural policy (CAP). To encourage self-sufficiency in basic food supplies, the CAP established domestic producer prices for grain, meats, and dairy products that are considerably above world prices. When world prices fall, as they have in recent years, the cost of the farm subsidies to EC taxpayers becomes exorbitant. Currently the subsidized surpluses are sold primarily in the third world, often at prices so low that third world farmers are discouraged from increasing their own output. While the EC remains committed to subsidizing European farmers in order to achieve self-sufficiency, it did not intend the CAP to promote costly overproduction for export, and it seems unlikely that the EC will allow this overproduction to continue. Already a quota system has been imposed on dairy farmers, and the introduction of similar quotas for grain and meat production seems probable. Under such quotas, each EC country would have a predetermined amount of agricultural output authorized at official prices. Any excess would have to be sold on world markets at international prices.

Table III. Cereal Production, by Regions, Between 1976–78 and 1982–84

In 000 metric tons

Region	1976–78	1979–81	1982–84
North America	309,893	343,999	333,220
Western Europe	154,484	169,682	188,307
Oceania	19,923	21,921	25,586
Other developed market economies (Japan, Israel, S. Africa)	28,326	28,476	23,280
Eastern Europe and U.S.S.R.	290,789	249,931	264,387
Sub-Saharan Africa (excl. S. Africa)	45,968	49,235	47,748
Latin America	85,919	92,354	104,020
North Africa/Middle East	53,903	56,661	56,245
Far East less developed economies	250,734	271,371	304,369
Asia centrally planned economies	276,870	308,869	369,154
Developed (incl. E. Europe and U.S.S.R.)	803,416	814,010	834,772
Less developed (incl. Asia CPE)	728,717	778,533	881,576
World	1,516,846	1,592,542	1,716,348

Source: FAO 1982–1984 Production Yearbooks.

Agricultural production in the U.S.S.R. and most Eastern European countries has stagnated in recent years, and yields have actually declined in many areas. The rapid growth of grain imports by these nations during the past decade is largely a result of the rising demand for livestock feed. Given the prevailing Soviet bloc policy of maintaining artificially low consumer prices, it is reasonable to expect continued growth of grain imports in these countries in the coming years. While the disappointing performance of Soviet agriculture is partly attributable to difficult climatic conditions and overcentralization in agricultural planning, the lack of incentives for individual farmers is the major factor limiting increases in productivity. The new Soviet leader, Mikhail Gorbachev—who is frequently pictured in the Western press as a reformer—until very recently has given no indication that radical reforms in Soviet agriculture would be forthcoming. Instead of moving toward a free market system, like the "reformed" centrally planned economies of China and Hungary, the U.S.S.R. has emphasized fine tuning of the planning process. If Soviet food production does not begin to show improvement, the U.S.S.R. may be forced to consider a more market-oriented solution. Even if this occurs, however, it seems likely that the U.S.S.R. and Eastern Europe will continue to be large food importers for the remainder of the century and beyond.

In contrast, given appropriate investments and policies, the prospects for increased food production in the less developed world are good, although growth rates over the rest of the century probably will not be as strong as those in the 1970s and 1980s. From a strictly technical standpoint, the third world countries have significant agricultural potential on which to capitalize, if appropriate incentives and the required inputs, such as fertilizer, are provided.

In China, where population growth is slowing and the "market-oriented" incentives introduced since 1978 have spurred spectacular expansion in the agricultural sector, per capita production should continue to increase. Production in most other East Asian countries is also expected to rise faster than population. On the other hand, Latin America will have more difficulty raising per capita production. Considerable yield increases are still attainable if suitable economic incentives are offered to farmers, especially in Argentina, Brazil, and Uruguay. But because of the heavy debt burden of these nations, it is unlikely that yield increases can match the area's rapid population growth.

In Asia and Latin America the critical tasks in agricultural development are to continue broadening the use of high-yielding varieties and improved agronomic practices—especially the use of more fertilizer of the correct kind—expand irrigation potential, maintain food-price stability, and develop more employment opportunities off the farm. Assuming that per capita incomes resume their upward trend, there will be strong growth in the demand for food grains and livestock products. The bulk of this demand can be met through increased domestic production, although cereal grain and livestock imports will probably continue the upward trend of the past 20 years. Growth in agricultural production will help to expand rural employment opportunities, increase per capita incomes, lower food costs (the major expenditure item for the poor), and release scarce resources for other development projects.

Agriculture in North Africa and the Middle East suffers from overcentralization and the uncertainties resulting from political unrest. With population growth rates expected to remain quite high, it is unlikely that food production can outstrip population unless important reforms occur. Assuming that the oil glut is a short-range problem, higher oil revenues should permit many countries to increase their food imports. The Winrock Institute study cited above predicts a 50% increase in food imports in this region between 1979–81 and 1993.

In sub-Saharan Africa extreme poverty, poor soils, low and uncertain rainfall, increasing population pressures, changing ownership patterns for land and cattle, and weak national agricultural research and production systems all make agricultural improvements difficult. Too many officials in African nations—as well as at the international level—seem to think that once the drought that precipitated famine in Ethiopia, The Sudan, and more than 20 other countries is over, agricultural production will promptly recover and harvests will again be sufficient for people's needs. This will not happen automatically, and those holding such views fail to comprehend the magnitude and complexities of the interacting forces—of which drought is only one—that have contributed to the current tragic situation.

For more than 15 years, food production in most sub-Saharan countries has not kept pace with demand, as explosive population growth has overwhelmed the traditional agricultural systems. The present crisis is largely the result of neglect by political leaders. Despite the fact that 70–85% of the people in most African countries are engaged in agriculture, development of agricultural and rural sectors was given a low priority. Investment in distribution and marketing systems and in agricultural research and education was woefully inadequate. Furthermore, many governments pursued a policy of providing cheap food for the politically volatile urban dwellers at the expense of production incentives for farmers.

Despite the formidable challenges in Africa, the elements that worked in Asia and Latin America will also work there. Past experience in other parts of the third world provides us with greater knowledge of what to do. In many cases, researchers have developed improved technologies for sub-Saharan farming systems. Sadly, few of these "research products" are being extended to farmers. If effective seed-production and fertilizer-supply industries are developed, the nations of sub-Saharan Africa can make great strides in improving the nutritional and economic well-being of their desperately poor populations.

To capitalize on the unexploited agricultural potential of the third world—and on the significant new technologies in the pipeline—continued investment in agricultural research, water resource development, input production and distribution systems, and grain marketing and storage

facilities is essential. This must be complemented by economic policies that stimulate agricultural productivity in ways consistent with the wise use of natural resources. It should be stressed, however, that pursuing policies that encourage high production without, at the same time, introducing technologies that will increase yields and reduce costs will defeat the purpose.

The evidence of the Green Revolution is that improved technology and effective policy must go together; manipulation of prices alone will not ensure success in agricultural development. The development of improved technology, moreover, does not necessarily assure its adoption by most farmers. Linking agricultural research and production activities so as to promote the generation and dissemination of more effective technology remains a major institutional challenge facing policymakers in the third world.

A Look in the Research Pipeline. Ten to 15 years usually elapse between the time research and development is funded and the point when the results show up in production figures; thus, gains in the remainder of the 20th century will be largely the result of research investments already made.

In addition to continuing breakthroughs in wheat and rice, improved varieties of corn, field beans, cassava, potatoes, cowpeas, sorghum, and pearl millet are being developed. These varieties have heightened disease and insect resistance, as well as higher yields and greater yield stability under difficult conditions, such as drought and heat. Triticale, a high-yielding, protein-rich hybrid of wheat and rye, has great potential for expanding grain production to such marginal areas as the cool Himalayan foothills and the acid-soil *campos cerrados* of South America. Also in the pipeline are wheat varieties tolerant to high levels of soluble aluminum, characteristic of many tropical soils where wheat traditionally has not flourished. New varieties of rice—the principal food grain in the third world—will make it possible to increase production in upland areas. Research on legume and pasture species, a more recent undertaking, is producing new varieties and production technologies that will permit higher levels of livestock production in the semiarid tropics, particularly the drought-prone zones of Africa and Latin America. The development of faster maturing varieties will allow two or three harvests a year in many areas where only one or two are now possible.

Another promising avenue of research, crossing domesticated crop species with related wild species, may lead to varieties with greater yield potential and dependability in marginal areas. Generally, such "wide crosses" involve breaking down natural barriers between species in order to introduce useful genes from alien plant genera—providing, for example, resistance to certain diseases and insects and tolerance to salinity, high temperatures, and drought—into domesticated species. One probable benefit would be greater year-to-year stability in third world food production.

More efficient methods of tillage and cultivation and more productive crop-rotation patterns are also being developed and made available to farmers; for example, improved production systems to manage heavy impermeable clay soils and soils that are highly oxidized and acidic. These technologies not only stand to increase yield levels markedly, especially in areas dependent on rainfall for their water supply, but can also help to reduce soil erosion. It should be noted, however, that crop-management research in the third world is one of the weakest links in the research chain. Research programs in less developed countries are not easy to organize and direct, since they must contend with a set of difficult and often complex circumstances—environment limitations, poverty, land-ownership patterns, labour, energy/power constraints, shortages of fertilizers and other inputs and of credit. Nevertheless, such research is essential.

International and national research efforts are also under way to increase tropical livestock production, especially in sub-Saharan Africa. The work to develop vaccines or other methods of controlling trypanosomiasis, or sleeping sickness, and East Coast fever, which make large tracts in Africa unusable for livestock raising, is especially important. If successful, it would vastly extend the domain and increase the productivity of livestock in sub-Saharan Africa, as well as reducing the incidence of related human diseases. The male sterile technique of insect control, in which male insects are sterilized by irradiation and then released to mate, was used successfully to eradicate the screwworm from livestock in the United States a decade ago and is now being used to eradicate it from Mexico. It shows promise for control of several fruit flies and possibly the cotton boll weevil and the tsetse fly, the carrier of sleeping sickness.

CIMMYT

Norman Borlaug (right) confers with a CIMMYT wheat pathologist in Ecuador. Research has led to higher crop yields and greater yield stability under difficult conditions, such as drought and heat.

African student examines corn as part of her six-month basic training at CIMMYT. Sub-Saharan Africa needs more agricultural researchers to help offset the effects of its extreme poverty, poor soils, low and uncertain rainfall, and weak national agricultural systems.

CIMMYT

What to Expect from Biotechnology. The new genetic-engineering techniques of tissue culture, cell fusion, and gene splicing and DNA transfer, widely publicized in recent years, open new horizons for solving some of the most frustrating problems of animal, human, and plant health. But how soon will they begin to affect food production?

Great progress has been made in employing these techniques with bacteria and yeasts to produce insulin, interferon, and growth hormones. Current research with somatotrophin bovine hormone indicates it may play an important role in increasing milk production within the next 15 years. Similarly, microbiologically produced growth hormones may increase the production of meat within the next two decades. It will be possible to produce improved vaccines for many bacterial and viral diseases of humans and animals more safely and efficiently, and there is hope that effective vaccines against some of the complex vector-borne parasitic diseases, such as trypanosomiasis and malaria, will be developed within 20 or 30 years.

Some enthusiasts predict that these techniques will make it possible to increase the level of disease and insect resistance in higher plants, decreasing the need for chemical fungicides and insecticides. They also predict the development of cereal varieties that, like legumes, can fix atmospheric nitrogen (*i.e.,* convert nitrogen from the air into usable compounds in the soil), thus substantially reducing the need for chemical nitrogen fertilizer. While significant breakthroughs will undoubtedly come from these new lines of research, it is our view that such achievements will not be realized until well into the 21st century, if then. There is a tendency to overpromise the potential of a new technology; overzealous efforts to secure more research funds are partly responsible.

Researchers have shown that bacteria of the *Azospirillum* species inhabit the root zones of tropical grasses and fix a considerable amount of the nitrogen used by these plants. They are sometimes present in the roots of wheat, corn, and sorghum, and if their presence could be increased, more nitrogen could be fixed biologically for these vitally important cereal crops. There is also interest in a number of other biologic systems for fixing atmospheric nitrogen, such as the *Azolla* floating fern–blue-green alga system for paddy rice, as well as beneficial root fungi. The information generated to date merits additional intensive research, and it may well be that scientists will eventually succeed in developing cereal varieties capable of fixing a substantial portion of the nitrogen they require. However, that day is still far in the future, if, indeed, it ever comes.

As for plant breeding, leaving aside asexually propagated species such as potatoes, there is little or no firm evidence as yet that molecular genetic techniques will produce superior, higher-yielding field crop varieties with greater disease and insect resistance within the next 15 years. Many genes and interactions among genes influence the productive potential of cereal crop species, but far fewer basic studies have been undertaken on the genetic makeup of higher plants than on humans and animals, which have been studied intensively in the course of cancer research. This lack of fundamental knowledge limits the effective use of many biotechnological techniques for plant improvement.

Transfers of genes providing disease and insect resistance into crop species through genetic-engineering techniques, while no doubt quicker than conventional plant breeding, will not necessarily result in more durable resistance than has been achieved with conventional methods. Disease-causing organisms and insect pests, when faced with extinction, mutate into new races capable of attacking previously resistant varieties. This biologic reality will continue in force even in the "new age" of genetic engineering. Fortunately, much can be and is being done to exploit conventional plant-breeding methods to improve disease and insect resistance, enhance tolerance to severe environmental conditions, and increase genetic yield potential in the major food and feed grains. Meanwhile, much remains to be done in making better use of the improved varieties and cultural practices currently available.

Agricultural Trade Prospects. Despite the large surpluses of grain currently in the marketplace, the Winrock study describes a striking picture emerging in the world grain economy. Although the number of countries with exportable food surpluses has risen temporarily, the general trend is toward fewer exporting countries and increasing food deficits in many nations. The United States, Canada, Australia, Argentina, Thailand, and, more recently, the EC account for about 95% of the grain traded in international markets. When these traditional surplus-producing regions are excluded from world grain-production data, the global cereal-grain deficit in 1969–71 equaled 40 million tons or 4.3% of consumption. By 1979–81 this deficit had grown to 133 million tons or 10.7% of consumption, and it is projected at 224 million tons or 13.6% of consumption by 1993.

Recent projections (1986) by the International Food Policy Research Institute on the demand for cereal feed grains in the third world to the year 2000 predict very strong growth in these commodities. By the end of the century the demand for cereal feeds in less developed countries (excluding China) is expected to increase two and a half times, from 100 million tons in 1980 to 245 million tons. On the basis of this analysis, an 86 million-ton feed-grain deficit is forecast for the third world. These

projections point to the vital role that agricultural exports will have to play in future decades.

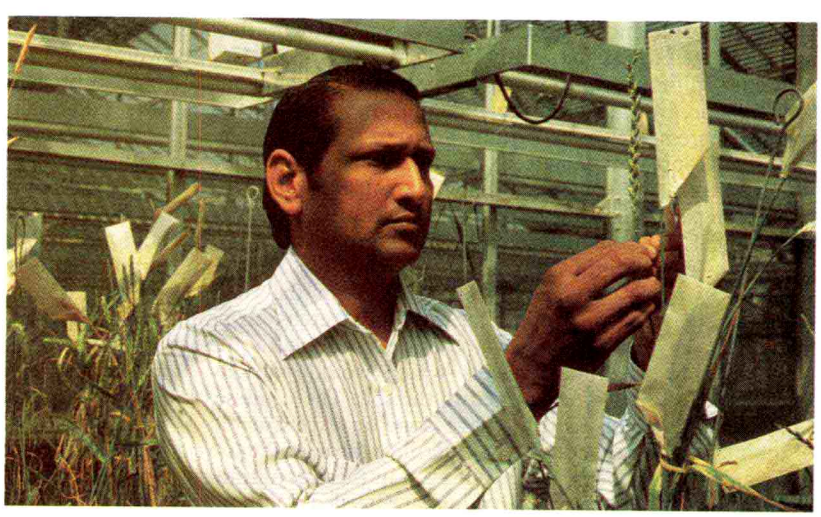
Despite the large surpluses of grains, milk, and butter in the world marketplace—and the resulting depressed agricultural commodity prices—the long-term global trends point to considerably greater agricultural trade volumes in the years ahead. The greatest potential buyers of food commodities are the Pacific Rim countries of Asia, including China; the U.S.S.R. and the Eastern European countries; and the countries of North Africa and the Middle East. Of the countries with domestic shortages, only those in sub-Saharan Africa will be likely to have difficulty financing food imports. According to the Winrock study, domestic food production in sub-Saharan Africa supplied 92% of total demand in the period 1979–81, with the remainder made up through imports; by 1993 domestic production is expected to account for only 75% of demand. It is unlikely that the poor African nations will be able to pay for large amounts of food, so continuing foreign aid will probably be needed at least for the remainder of this decade.

Even with the Green Revolution, less developed countries have been the most significant growth market for U.S. agricultural products during the past 20 years. In 1977 third world countries accounted for only 30% of U.S. food exports. Today they account for almost 50% of total U.S. export trade, with most of the increase going to the newly industrializing nations and the oil-exporting countries. Interestingly, those less developed countries with the highest agricultural growth rates have also increased their agricultural imports the most; rising incomes have sparked a stronger demand for feed grains and livestock products than domestic producers could supply, and increased amounts of agricultural inputs and machinery, as well as other manufactured goods, have been purchased from industrialized nations. In addition, some of the more agriculturally prosperous less developed countries have tended to concentrate on producing those crops they can grow best while relying on imports for commodities produced more efficiently elsewhere—an example of the economic principle of comparative advantage. Brazil is a case in point: while domestic soybean production and exports have increased rapidly, so have Brazilian imports of wheat as traditional wheatlands have been shifted into soybean production. As improved wheat varieties are developed with adequate disease resistance and tolerance to acid soils, Brazilian wheat could become more profitable and production could rebound.

The Environmental Issue. The techniques that made the Green Revolution possible rely heavily on chemicals, mainly fertilizers, and there has been public concern, mostly in the developed countries, about the possible adverse effects of modern, high-yield agricultural technology on the environment, public health, and the survival of wildlife. In our opinion, some members of the environmental movement have played on the public's fears with propaganda campaigns designed to convey the idea that civilization is about to be poisoned out of existence. They often leave the impression that the environment is making us sick, but a look at the record suggests that the opposite is closer to the truth. People today live longer and more pleasant lives than those of any previous generation. In 1900 average life expectancy in the United States at birth was 47.3 years, 46.3 years for males and 48.3 for females. By 1940 average life expectancy at birth had increased to 62.9 years (60.8 for males, 65.2 for females), and by 1982 life expectancy for the entire population had risen to 74.5 years (70.8 for males, 78.2 for females). It continues to increase.

Two factors have added to the confusion: (1) tests used today for detecting the presence of various chemicals in the environment are highly sensitive and thus reveal very small amounts of a contaminant (*e.g.*, a fraction of a part per billion), and (2) testing procedures used to determine safety, based on high dosages of a chemical over a long period of time, tend to magnify the risks of exposure at lower levels. Modern methods of chemical analysis have also shown that many foods included in the human diet since the preagricultural epoch of the hunter-gatherers contain naturally occurring organic compounds that are toxic, mutagenic, carcinogenic, or otherwise harmful at high dosages. On the basis of current knowledge, nevertheless, it appears that at low levels they normally do no harm.

Antitechnology activists seem to imply that the world can, and should, go back to producing its food with pre-World War II technology. However, the agricultural technology of the 1930s, which was adequate to produce food for a world of two billion people, could not produce the food required by five billion. To return to the methods of 50 years ago would be to plunge the world into famine and into social, economic, political, and—yes—environmental chaos. The general public, especially the urban part of it, does not understand the complexities and difficulties of producing and protecting our crops, most of which could not be grown at all or would not



CIMMYT

A Pakistani researcher examines a stalk of wheat. Crossing domestic species with related wild species may lead to domesticated varieties with greater resistance to disease and insects and tolerance for salinity, high temperatures, and drought.

produce reasonable yields without modern husbandry. This ignorance unless corrected poses a serious threat to the food supply of future generations.

An educational program is needed to explain the realities of modern farming to the nonrural public. Such a program should emphasize that the vast tracts of primeval wilderness are gone forever—victims of the encroachment of so-called civilization and humankind's propensity to "be fruitful and multiply." Indeed, we would submit that the "population explosion"—rather than the depredations of materialistic, consumer-oriented, high-income societies—is the greatest environmental threat to planet Earth. If the vestiges of primeval wilderness that remain are to be preserved, all sectors of society must become more supportive of efforts to increase the productivity of land now being used to produce our food and fibre while, at the same time, slowing demographic growth to manageable levels. The protection of our environment against the damage resulting from overpopulation depends in large measure on the ingenuity of scientists in developing new technologies to manage and increase the productivity of our natural resource base.

An attempt to turn back the clock invites disaster. For example, if U.S. farmers used the agricultural technology of the 1930s and 1940s to produce the harvest of 1985, they would have to convert 75% of the permanent pasturelands in the U.S. or 60% of American forests and woodland areas to cropland. Even this may be an underestimation, since the pasture and forestlands are potentially less productive than the land now planted to crops. This would greatly accelerate soil erosion and destroy wildlife habitats and recreational areas. Rather than increasing the amount of land in crop production, the need is to cut back. During the 1970s the cultivated area in the U.S. was expanded by 30%, much of it marginal and highly susceptible to erosion. The environmental damage caused by this land use was recognized in 1985 U.S. farm legislation, which provides a land set-aside program that pays farmers to return these more fragile lands to permanent pasture for at least ten years. This is environmentally sound, but how long it can be sustained politically is another matter.

Without doubt, the single most important factor limiting crop yields worldwide is soil infertility. The use of chemical fertilizers to restore soil fertility is a contentious issue, but unless soil fertility is restored, farmers will gain little benefit from the use of improved varieties and more productive cultural practices. Among the major plant nutrient deficiencies in soils, the lack of sufficient nitrogen is by far the most widespread, although phosphorus and potassium deficiencies are also pervasive. Though they are encountered less frequently, deficiencies of secondary nutrients, sulfur, calcium, magnesium, and minor elements such as zinc, iron, copper, molybdenum, manganese, and boron, depress yields in certain areas, especially where intensive cropping is practiced. Essential nutrients may be removed from the soil as a result of weathering followed by leaching, soil erosion, or "extractive" farming practices, or chemical reactions in the soil may tie up nutrients so that plants cannot utilize them.

Many of the traditional farming systems of the third world are essentially "mining" operations whereby crops are harvested year after year and little or none of the crop residues or animal wastes—which would partially restore soil fertility—are returned to the soil. The Chinese, Japanese, and South Koreans have done an excellent job of maintaining a moderate level of fertility through the use of organic wastes and residues, but even in these countries, large amounts of chemical fertilizers are needed. Without huge quantities of chemical nitrogenous and phosphatic fertilizer, China could not have achieved the spectacular production increases of the last 15 years.

Soil fertility can be restored effectively by applying the right amounts of the right kind of fertilizer—either chemical or organic or, preferably, a combination of the two—according to the requirements of different crops, soil types, and environments. With the per capita base of arable land shrinking in densely populated countries, all the available land must be used for food crops and cannot be allowed to regain fertility by lying fallow. Moreover, in many countries most animal manure is used as a home fuel for cooking and thus is not available as a fertilizer. A recent survey by the U.S. Agency for International Development estimated that 400 million tons of animal manure were being used annually for cooking fires. Hence, if the world's food needs are to be met during the next several decades, it will be necessary to increase the use of chemical fertilizers on the infertile and nutrient-depleted soils of less developed nations. Fortunately, breakthroughs in fertilizer-production technology—especially for nitrogenous fertilizers—during the past 20 years have kept real prices relatively low. Improved methods of application at the farm level can eliminate overuse, reducing costs and also helping to prevent runoff into streams and lakes.

Despite irrefutable scientific evidence that chemical fertilizers, used wisely, do not harm the soil, some organic gardening enthusiasts insist that organic fertilizers could satisfy all our needs. Organic manures are very effective for growing backyard vegetable gardens, but it does not follow that the same procedure can be used to produce food for five billion people in a land-hungry world. It would take about 4.4 billion tons of composted organic animal manure (1.5% nitrogen on a dry-weight basis) to produce the equivalent of the 65 million metric tons of chemical nitrogen used today—quite a dung heap and quite an aroma, were it available. To produce it would require a three- to fourfold increase in world animal production, necessitating, in turn, huge increases in the output of feed grains and pasturage. Furthermore, the transportation costs associated with distributing these fertilizers would be prohibitive.

The point is not that there should be no safeguards to protect the environment and human health from the possible damaging side effects of modern agricultural technology. On the contrary, governments should make every effort to protect the health and welfare of their citizens. But we must also become more knowledgeable and realistic about science and technology and their relationship to food production in our interdependent world. In our view, the antiscience and antitechnology bias so prevalent in affluent countries is both hypocritical and potentially damaging to the third world. In effect, the haves are telling the have-nots that they should stay with their pristine, rural, bucolic, miserable life-styles, since greater material well-being isn't what it's made out to be. Yet people in the developed world are healthier and have the prospect of leading longer, more productive, more comfortable lives than ever before. To trade places with peasants in the less developed world would be to cut their life spans by one half or more, see up to half of their children die before reaching the age of ten, often as a result of minor and easily curable illnesses, live in illiteracy with substandard clothing, shelter, and sanitation, and face poor prospects of improved economic well-being for themselves and their children. Unwittingly, this is the continuing fate that the affluent antitechnology groups are wishing on the third world's people.

Blainey, Geoffrey
Through three decades of readable and authoritative books, the historian Geoffrey Blainey has interpreted Australian economic and social history and anthropology. The son of a clergyman, Blainey was born March 11, 1930, in Melbourne. After graduating from Queens College of the University of Melbourne, he set out to be a free-lance writer and took a job in Tasmania on the Mt. Lyell mining field. From that experience came his first book, *The Peaks of Lyell* (1954).

WARRNAMBOOL STANDARD

His second book, *A Centenary History of the University of Melbourne* (1957), took him back to academe, and in 1961 he began his teaching career as reader in economic history at the University of Melbourne. He was made professor in 1968, and in 1977 he was given the Ernest Scott chair in history, which he continues to hold. For six years he was also dean of the faculty of arts. His lucid and imaginative writing has won him numerous awards and helped make him a television presence in explaining economic history and international affairs. He has served on many public agencies, as chairman of the Australia Council (the main patron of the arts in Australia) and chairman of the Australia-China Council. In 1982–83 he was visiting professor at Harvard University. His later books include *The Causes of War* (1973), *Triumph of the Nomads* (1975), and *A Land Half Won* (1980).

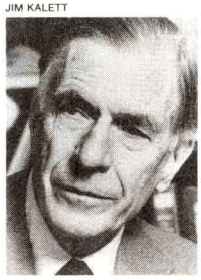
MIN ZHONGJIE—XINHUA NEWS AGENCY

Fei Xiaotong
Fighting his way back from the obscurity to which the Cultural Revolution condemned him, Fei Xiaotong (Fei Hsiao-t'ung), China's foremost social anthropologist, has revived the scientific study of village life in China.

Born Nov. 2, 1910, in Wujiang (Wu-chiang) District, Jiangsu (Kiangsu) Province, Fei was graduated in 1933 from Yanjing (Yen-ching) University in Beijing (Peking) and did graduate work at Quinghua (Chi'ing-hua) University in Beijing, the London School of Economics, and the University of London. He became professor of anthropology at Quinghua in 1945 and deputy dean there in 1949. His star appeared to be rising until he made the mistake of taking Mao Zedong's (Mao Tse-tung's) Hundred Flowers movement too literally. He rebounded from these troubles but fell victim to the Cultural Revolution in 1967. Fei reappeared, fully rehabilitated, in 1972 and is now professor and director of the Institute of Sociology of Beijing University and chairman of the Chinese Democratic League.

In addition to his writings, Fei's effectiveness in communicating knowledge in recent years has resided in his scholarly contacts with Western colleagues. Among his books originally written in English are *Peasant Life in China* (1939), *China's Gentry* (1953), *Chinese Village Close-up* (1983), and *Small Towns in China* (1986).

JIM KALETT



Galbraith, John Kenneth
Economist, diplomat, author, critic, and consummate communicator, John Kenneth Galbraith, for almost 40 years, has been an articulate and influential force in the moderate-liberal wing of the U.S. political spectrum. He was born Oct. 15, 1908, in Iona Station, Ont., earned a B.S. in economics at the University of Toronto in 1931, and then went to the University of California at Berkeley for an M.S. (1933) and Ph.D. (1934). For five years he was an instructor at Harvard, taking time for post-doctoral studies at Cambridge in 1937–38.

In 1939 he went to Princeton University as an assistant professor of economics and quickly found his way into the bureaucracy gathering in Washington as World War II approached. He held a variety of government posts in the wartime and postwar years. He was named to the board of editors of *Fortune* magazine (1943–48) and in 1948 returned to Harvard as lecturer. Professor of economics (from 1949), Paul M. Warburg professor (1959–75), and professor emeritus thereafter, he still found time to play a prominent role in public life. In 1961–63 he was U.S. ambassador to India. Upon his retirement in 1975 he was made a fellow of Trinity College, Cambridge.

His vast literary output includes titles that have passed into the language (*American Capitalism: The Concept of Countervailing Power,* 1951; *The Affluent Society,* 1958; *The New Industrial State,* 1967). His most recent books are *The Anatomy of Power* (1983) and *Economics in Perspective: A Critical History* (1987).

THOMAS STUDIOS

Jacobs, Jane
An acute observer of urban life and problems, Jane Jacobs has brought to the study of city planning a distinctive vision that made her widely celebrated even while it infuriated those whose oxen were being gored. Born Jane Butzner on May 4, 1916, in Scranton, Pa., the daughter of a physician, she got a job after high school graduation as a reporter on the *Scranton Tribune.* About a year later she went to New York City, where she built a reputation as a competent and versatile free-lance writer.

In 1944 she married Robert Hyde Jacobs, Jr., an architect. Already keenly interested in city neighbourhoods and their vitality, both as writer and—increasingly—as community activist, she explored urban design and planning at length with her husband. In 1952 she became an associate editor of *Architectural Forum,* where she worked for a decade. Near the end of her tenure there she contributed a chapter, "Downtown Is for People," to a book produced by the editors of *Fortune* magazine, *The Exploding Metropolis* (1958), and three years later published her first full-length book, *The Death and Life of Great American Cities,* a brash and passionate reinterpretation of the actual needs of modern urban places. Translated into Japanese and several European languages, it established her as a force to be reckoned with by planners and economists.

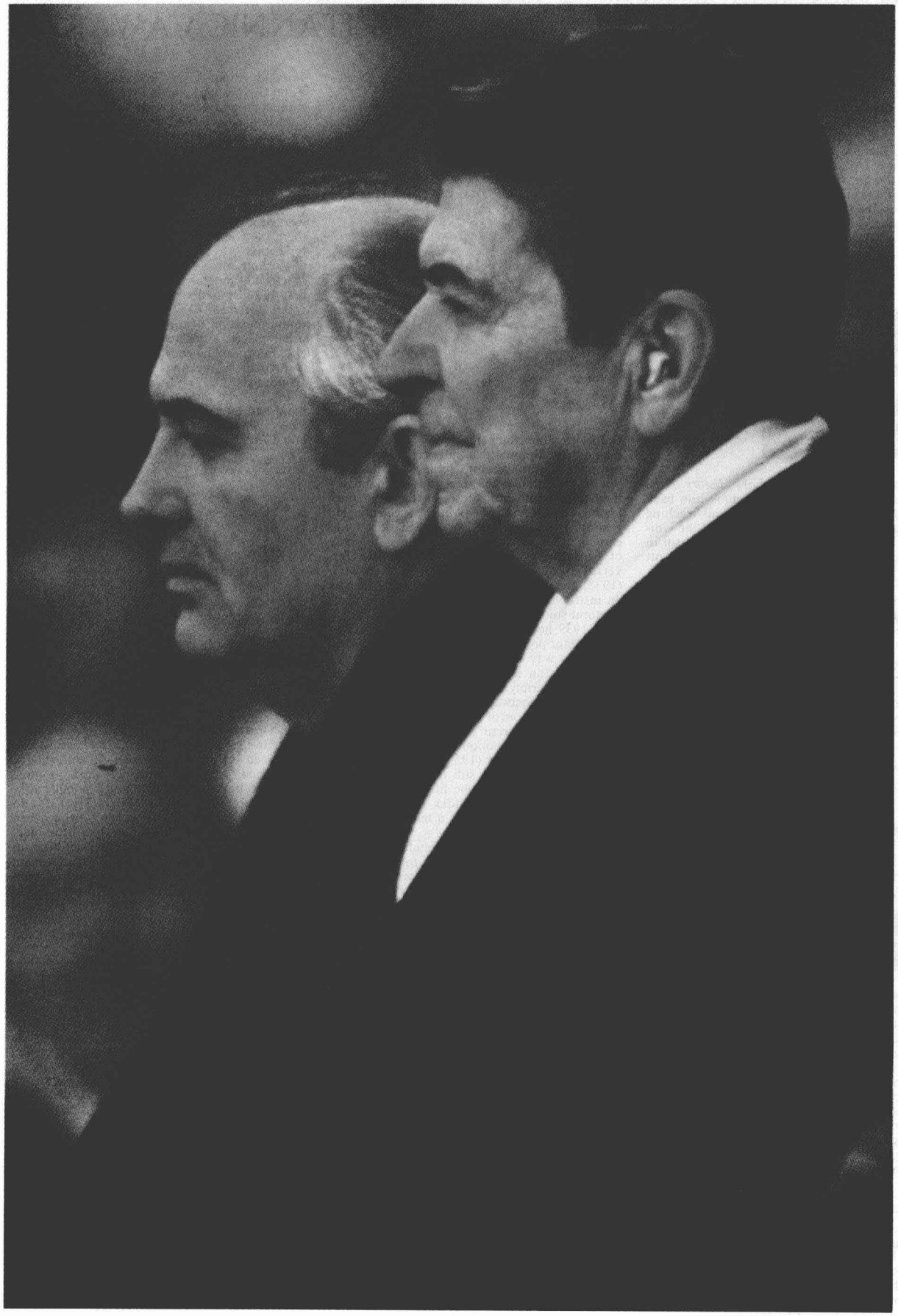
In 1969 she moved to Canada with her husband and later took Canadian citizenship. Her *The Economy of Cities* was published in 1969 and *Cities and the Wealth of Nations* in 1984.

INSTITUTO NACIONAL DE BELLAS ARTES, MEXICO

Paz, Octavio
Some indication of Octavio Paz's versatility can be gained from his many roles—poet, essayist, polemicist, diplomat, probably Mexico's most respected living intellectual, and a popular television personality. Born March 31, 1914, in Mexico City, Octavio Paz began writing when very young and helped to found "a little magazine," *Barandal.* Like most writers of his generation, he experienced a period of radicalism during the 1930s. However, the controversies of the time, particularly those pertaining to freedom in art, distanced him from his radical friends. The final breakup came with the German-Soviet nonaggression pact and Leon Trotsky's assassination.

In 1946 Paz moved to Paris, where he remained for ten years, befriending the poets and writers of the Surrealist movement. He joined the Mexican diplomatic service, but in 1968 he resigned to protest the bloody repression of student unrest in Mexico. During this time he founded and edited *Plural* magazine, published by the daily newspaper *Excelsior.* In 1975, when Pres. Luis Echeverría engineered the ouster of the paper's editor in chief and other staff members, Paz resigned and, with a group of independent writers, founded *Vuelta.* He has received a number of prizes, including the Premio Cervantes.

Among his books of poetry are (dates are for English translations) *Sun Stone* (1962), whose influence has been compared with that of T. S. Eliot's *The Waste Land; Eagle or Sun?* (1976); and *The Monkey Grammarian* (1981). Prose works include *The Labyrinth of Solitude* (1961), an influential essay about the character, history, and culture of Mexico; *Conjunctions and Disjunctions* (1976); and *One Earth, Four or Five Worlds* (1985).



FERRY—GAMMA/LIAISON