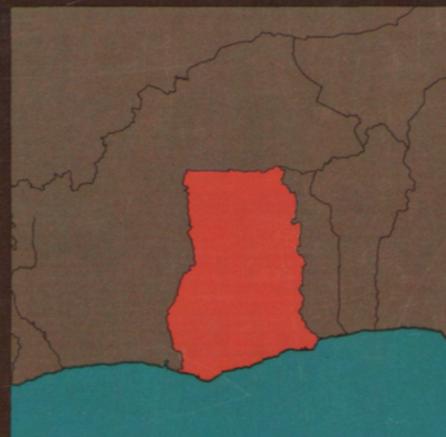
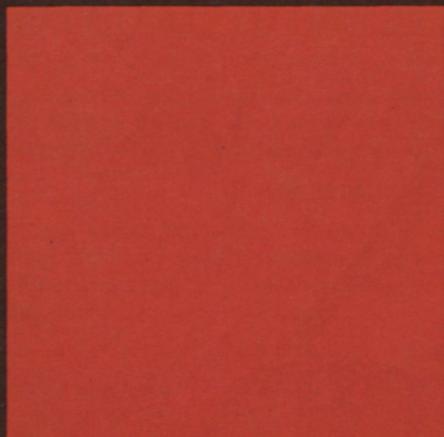


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Opposite: Potential land-use map for Limon Province, from the work of a Cornell-Costa Rica team on regional development. Areas are marked for such uses as crops, forest, and pasture. Outside: Developing countries in which Cornell groups have worked include the Philippines, Ghana, Costa Rica, and Venezuela.



ENGINEERING EDUCATION IN DEVELOPING NATIONS

A Concern of a Multidisciplinary Cornell Program

by Franklin J. Ahimaz

The economic and social progress of developing nations is greatly dependent on the kind of education its citizens receive.

Problems such as how to allocate resources for education to obtain the greatest social benefit, and how to adapt educational programs to meet national needs, must be confronted by these countries. From the standpoint of universities in more advanced nations, questions of how programs for foreign students can be made more appropriate should be considered. Especially in scientific and technological subjects, a large proportion of students from developing nations go abroad, particularly to the United States, for graduate work.

CORNELL AS A CENTER FOR INTERNATIONAL STUDIES

A center for the study of these and related problems was established at Cornell University three years ago, with the formation of the Program on Policies for Science and Technology in Developing Nations. Cornell is an especially appropriate place to establish such a center, because it educates a

large number of foreign students and has a faculty that is active in many phases of international problems and programs. With a five-year institution-building grant from the United States Agency for International Development (AID), the Program is sponsoring courses, seminars and conferences, and research. The Program is multidisciplinary, involving representatives from the University's Program on Science, Technology, and Society and the Center for International Studies, and drawing on faculty members and students from many parts of the University.

One of the special functions of the Program is to formulate policies for scientific and technological education in developing nations. I will indicate the place that research in this area has in the overall activities of the Program, and in particular consider a project in which I have been directly involved: a program of the Office of Planning of the University of Costa Rica and the Cornell Program to jointly draft plans for science and engineering in Costa Rican educational institutions.

THE AIMS AND ACTIVITIES OF THE CORNELL PROGRAM

The major objective is to build capabilities at Cornell, through teaching and research, for examining and determining the role of science and technology in developing nations. A parallel goal is to identify and evaluate alternative policies for science and technology that might be implemented at national and regional levels to promote beneficial social and economic development in these countries.

An example of the activities of the Program is a workshop that was conducted at Cornell in cooperation with the Korea Advanced Institute of Science, and attended mainly by participants from the two groups. The general subject of the workshop, held in late 1972, was Curriculum Planning, Interdisciplinary Research, and Technology Transfer. Among the topics discussed were the transfer of computer and agricultural technology to Korea; scientific and technological manpower studies and needs; academic participation in the industrial research needs of

“The potentially explosive problem of unemployment among the educated and the steadily increasing demand for higher education are features common to most developing countries.”

Korea; and opportunities for joint research. A proposed project, for example, was research on machine recognition of Korean characters.

The following spring, the Program was host to a symposium on United States Bilateral Aid Strategies in Selected Areas of Science and Technology, arranged in cooperation with the Office of Science and Technology of AID. The Program has also sponsored an extensive seminar series designed to acquaint members of the Cornell community with its purposes and activities. Outside speakers who participated in the series represented many disciplines and came from universities, foundations, corporations, and national agencies and advisory groups in the United States and other countries.

Since its formation, the Program has sponsored three new interdepartmental courses at Cornell for upperclass and graduate students: Science, Technology, and Development; Low-Cost Housing Primarily for Developing Nations; and Transportation Policies for Developing Nations (see the articles in this issue by Slate and Irwin).

The importance of formulating science and technology policies of developing nations was recognized by AID in its award of a special contract to the Program for a study of Science and Technology Policy in a Small Developing Country (Costa Rica).

PROBLEMS ENCOUNTERED IN EDUCATIONAL PLANNING

One of the greatest problems in developing nations is unemployment. Recently reported percentages of unemployed among the working populations in urban areas are, for example, 13.6 in Colombia, 11.6 in Ghana, 14.9 in Kenya, 11.6 in the Philippines, 15.0 in Sri Lanka, and 7.9 in Venezuela. More than one-half of the unemployed were under twenty-five years of age, and more than one-third were under twenty, indicating that the problem should be of immediate concern to educational institutions as well as to the governments. Moreover, high unemployment occurs among the “educated” (those who have had primary, secondary, or higher education) as well as the illiterate. For example, of the Phil-

ippine workers who were unemployed in 1965, 26 percent had a high school education and 13 percent were college educated. It appears that education at all levels should be carefully examined and restructured to foster a better employment situation. The goal would be to achieve matching of job expectations and job opportunities.

In most developing countries at the present time, there is a shortage of competent industrial and engineering researchers, technicians, teachers of technical subjects, etc., yet a minority of students are preparing for jobs in these areas. According to a 1971 World Bank sectoral working paper on education, the median percentage of students at all levels who are studying vocational courses is 11 percent, and at the university level, the median percentage of students enrolled in science, engineering, medicine, and agriculture courses is 21 percent. This enrollment pattern indicates that the educational systems are not in tune with the realities in developing nations.

Of course, problems would arise in any attempt to coordinate education

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The College of Engineering is particularly active in Cornell's interdisciplinary Program on Policies for Science and Technology in Developing Nations. Dean Edmund T. Cranch serves as director of the Program, and Franklin J. Ahimaz, assistant dean and professor of engineering, is assistant Program director. A number of engineering faculty members, including those who have written in this issue of the *Quarterly*, are actively involved in the various projects.

A new member of the environmental engineering faculty and a new Program participant is Assistant Professor Peter J. Murphy, who recently completed six years at La Universidad del Valle in Cali, Colombia, working with the Rockefeller Foundation program for university development. While at the Colombian university, Murphy set up fluid mechanics and hydraulics laboratories. He also worked with his students in the design and building of simple equipment adapted to the needs of the Colombian farmers in primitive areas. The projects included devices to generate electricity—Pelton wheels for outlying farms with usable streams, and inexpensive windmills that can be used on hill crests. While in Colombia (see picture), Murphy also did consulting work on the relocation of lumbering docks.

Murphy



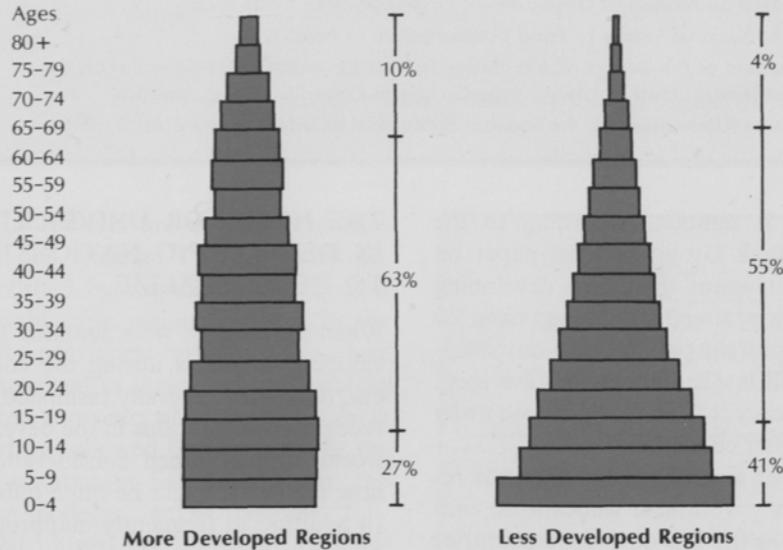
with the vocational market. Implementation of such a program at universities, for example, would require cordial working relationships among governmental agencies, the productive sector, and the educational institutions, but these are not always easy to achieve. Another requirement would be the means to accurately predict manpower needs, but in fact virtually all long-term manpower forecasts have turned out to be seriously in error. As a country moves up to higher stages of development, its manpower requirements change, and universities might do well to develop mechanisms that would enable them to continuously evaluate national programs and manpower needs, and be able to respond quickly to changing conditions.

A current trend in educational planning in developing countries is a shifting of expenditures in the direction of primary education. Part of the reason for this is that there is a high proportion of young people in these areas, as compared with the more developed regions of the world (see Figure 1). Up to age fourteen, the population distribu-

Figure 1.

THE AGE STRUCTURE OF WORLD POPULATION

The more developed regions include North America, Europe, and the U.S.S.R.
The less developed regions include South Asia, Africa, and Latin America.



tion is almost uniform for the developed regions, but shows a pyramidal shape for the less developed countries. Those in the 0-14 age group constitute 27 percent of the total population in the more developed world, and 41 percent in the less developed countries.

The emphasis on primary education in developing countries is in keeping with cost-benefit analyses which show that in developing countries, expenditures for education at the lower levels result in a higher social rate of return than expenditures for more advanced education. The high comparative cost of advanced education is shown in Table 1. Such a policy is also consistent with national goals of providing equality in educational opportunity, because the beneficiaries of higher education are normally children of the wealthier classes. In most developing countries, opportunities for employment increase rapidly from school age on, and since children of poorer families need to work and contribute to the family income, there is a built-in bias against the participation of the poorer classes in secondary and higher educa-

Table 1.

SOCIAL COSTS OF DIFFERENT LEVELS OF EDUCATION

The figures are ratios of social costs, defined as direct costs plus the earnings foregone by students of employable age. Particularly noticeable is the very high social cost of higher education as compared with primary education in the less developed nations. Data source: G. Psacharopoulos, *The Economic Returns to Education in the Process of Development: An International Comparison* (Amsterdam: Elsevier, 1972).

Degree of Development	Secondary ÷ Primary	Higher ÷ Primary
Developed (New Zealand, United Kingdom, United States)	6.6	17.6
Intermediate (Chile, Colombia, Israel, Mexico)	6.6	20.9
Less Developed (Ghana, India, Kenya, Korea, Nigeria, Uganda)	11.9	87.9

RESEARCH PROJECTS SPONSORED BY THE CORNELL PROGRAM ON SCIENCE AND TECHNOLOGY IN DEVELOPING NATIONS

Science, Technology, and Development in the Andean Nations

Technological and Economic Aspects of the Jamaican Alumina Industry—
A Case Study With Inherent Policy Implications

An Industrial Policy for an Economically Integrated Caribbean Commonwealth

An Investigation into the Nature of Basic Housing Systems in Developing
Countries Using the Case of Ghana

Research on Models of Development Organization in Costa Rica

ENCA (National Survey of Food Consumption) in Peru

Evaluation of the Impact of Alternative Forms of Economic Development on the
Nutritional Status of Low-Income Groups in Colombia, South America

Housing Alternatives for the Squatter Settlement in Limon, Costa Rica

tion. If a developing country decided to reallocate funds within the educational sector in favor of higher education, indirectly it might be furthering a policy in conflict with national goals.

THE SPECIAL PROBLEMS OF UNIVERSITIES

The potentially explosive problem of unemployment among the educated and the steadily increasing demand for higher education are features common to most developing countries. In many countries, the demand for higher education has risen to levels that are taxing the very limits of existing institutions. Enrollment figures for the University of Costa Rica and its affiliates illustrates what is happening (see Table 2).

The dilemma that the university administrations and the governments face is complex and does not yield to easy solutions. Admissions could be restricted by means of competitive examinations, but such a policy might be vulnerable to attack as unrealistic and undemocratic. Additional allocations from national funds would provide relief, but the likelihood that this will be

possible is remote. According to the World Bank Group sectoral paper on education, more than fifty developing nations are already spending over 20 percent of their public funds on education at all levels; and as we have seen, the tendency is to shift allocations away from higher education.

Without much hope for dramatic increase in government allocations, universities in the less developed countries might consider adopting structural reforms aimed at providing revenue and decreasing costs as well as improving the quality and relevance of educational programs. A particularly urgent problem is how to distribute the financial cost of a university education: how much should be assumed by the students and their families, and how scholarships and loans should be made available. One suggestion that should receive serious consideration is the levy of a tax on the incomes of university graduates to help support a scholarship program. Other areas in which reforms are needed include curriculum, course content, instructional methods, faculty development, and types of research.

THE NEED FOR UNIVERSITIES IN DEVELOPING NATIONS TO DECENTRALIZE

When universities were founded in developing countries during the colonial era, they were generally fashioned after recognized institutions in the developed world without much consideration of how the needs might be quite different. In addition to frequently inappropriate curricula and procedures, the results included inequalities in the accessibility of national universities to students from different parts of a country. The data in Table 3 provide an example. San Jose Province, where the university is situated, is represented by 64.2 percent of the enrollment, although only 35.6 percent of the nation's people live there. On the other hand, Guanacaste, Puntarenas, and Limon Provinces have 11.0, 12.2 and 5.1 percent of the national population, respectively, but only 1.9, 3.0, and 1.0 percent of the students at the university come from these provinces.

The need, therefore, is for the university to decentralize its activities so

Table 2.
ENROLLMENTS AT THE UNIVERSITY OF COSTA RICA

	1968	1969	1970	1971	1972	1973
San Jose Campus	9,189	11,000	12,528	14,606	15,724	18,257
San Ramon (Regional Center)	188	310	384	413	714	924
Turrialba (Regional Center)				117	221	355
Liberia (Regional Center)					204	255

Source: O. Torres Padilla, *Situacion Socioeconomica de los Estudiantes de la Universidad de Costa Rica. (Oficina de Planificacion, Universidad de Costa Rica, 1974.)*

that its services are equally accessible to all the citizens. This might be accomplished by expanding the practice of establishing regional centers in the various provinces. Initially, these could be organized as junior colleges offering the first two years of instruction, which would be followed by two years at the main campus in San Jose. Later, the junior colleges might become full-fledged universities linked to the University of Costa Rica in San Jose. In addition to providing more of the poorer people with access to higher education, regionalization offers several other advantages. It might help stem the "brain drain" that is now occurring in some provinces: students who move out of their home provinces to seek higher education rarely return. It would also relieve, at least temporarily, the pressure of a rapidly expanding student enrollment at the San Jose campus. And it would give the university the opportunity to plan and offer study programs and vocational training that are appropriate to the needs of particular regions.

The financing of such a system would be a major problem, of course. A solu-

Table 3.
DEMOGRAPHIC
DISTRIBUTION OF STUDENTS
AT THE UNIVERSITY OF
COSTA RICA IN 1973

Province	Percent of Total Enrollment	Percent of National Population
San Jose	64.2	35.6
Alajuela	11.6	17.7
Cartago	7.6	11.3
Heredia	7.8	6.2
Guanacaste	1.9	11.0
Puntarenas	3.0	12.2
Limon	1.0	5.1

Source: *Estadisticas universitarias y direccion general de estadistica y censos.*

tion might be to use funds now designated for graduate education to establish junior colleges. Such a reallocation of resources would be consistent with the aims I have mentioned of dispersing funds more in accordance with the age distribution of the population and with maximum rates of social return.

IMPLICATIONS FOR GRADUATE STUDY PROGRAMS

By no means does this suggestion imply that developing countries should not have graduate programs; on the contrary, they have a great need for strong and relevant graduate education. The challenge is to restructure the organization of graduate programs according to the circumstances of these nations—circumstances which are quite different from those in the industrialized world. The practice of modeling educational systems after those that proved successful in the developed world results, at the graduate level, in the establishment of graduate departments, programs, and research facilities at each university. These are very expensive and the mounting social costs of educa-

tion as it moves toward the higher levels make it difficult to justify the support of such programs in national universities.

The economically viable solution is for several countries to cooperate in creating and supporting a regional graduate studies program. This could be organized so that centers for different areas of study would be located within the various participating countries. In order for a regional graduate program to function effectively, however, it is essential that students from all the participating states have an equal opportunity to avail themselves of the resources of the center; and there cannot be equality in access unless disparities in educational levels at the national universities are evened out. This could be accomplished through the use of educational technology, including instructional video tape systems, by the regional center.

No doubt this approach is fraught with difficulties arising from existing conflicts between nations, the selection of locations for the facilities, concerns about the possible loss of individual national prestige, etc. Nevertheless, sub-

stantial savings in the cost of graduate education are possible through the creation of regional graduate studies centers, and I believe that such systems would be feasible and beneficial.

THE STATUS OF ENGINEERING EDUCATION

On the basis of experience with engineering educational programs in two developing countries, I would like to offer some observations on structural reforms that could improve this area of higher education.

The rising demand for technological education and the limited facilities that are available combine to create an increasing competition for admission to engineering programs. The trend is to use achievement tests to help in the selection process, but it is doubtful that these are good indicators of future performance. Aptitude tests might be better, but in either case, testing fails to take into account differences in the backgrounds of, say, rural and urban applicants. What is needed is a more broadly based system for judging competence and potential.

Instruction in engineering, and probably in many other areas, could be improved in a number of ways. The curricula could be made more pertinent to the technological needs of the particular country. More effective teaching methods could be used; for example, the usual comprehensive annual written examination could be replaced by more frequent tests that would encourage good study habits and could be designed to emphasize logical thought and the ability to solve problems.

A common deficiency in the engineering programs of developing nations



is the failure to compensate for a lack of exposure to engineering and of practical experience. Entering students generally have not had the opportunity to work with tools, to tinker in the basement workshop, to assist in a family house-building project, or to enter science contests at schools. It is impossible to correct for the absence of gradual engineering exposure during the formative years by a mass dose of practical training at the college level, yet some training program is necessary to provide students with an understand-

A special AID contract study conducted by Cornell in cooperation with Costa Rican experts includes a study of the natural resource potential of Limon Province for development of the region. This is conceived as a model study applicable to other small developing countries. The project, conducted by the Program on Policies for Science and Technology in Developing Nations, includes also the development of plans for scientific and technological education in Costa Rica.

1. Housing is one of the problems confronted by the Cornell-Costa Rica team. These shacks are part of a squatter settlement in Limon City.

2. Squatters acquire electricity by tapping lines near the settlement.

3. Cornell students participating in the project included these three from Costa Rica, who have since completed undergraduate degrees in agriculture. Shown at the station in Guapiles waiting for a train to another area of Limon are, left to right, Federico Vargas, Guilleirimo Ramirez, and Jose Bonilla.

4. Vargas and Ramirez inspect a cornfield in the Guacimo area with the local extension agent (at left). The corn has been bent over to prevent water from entering and rotting the ears.

ing of field experience and the dignity of manual labor. A factor that makes practical training important and difficult to provide is that industries in developing nations usually do not offer planned training programs for their employees and therefore may be reluctant to participate in such programs for engineering students. The responsibility of organizing and administering an effective program rests with the university. The Faculty of Engineering of Kabul University in Afghanistan, for instance, requires the successful com-



pletion of a six months' practical training program as a requirement for graduation.

The introduction of structural changes requires qualified and competent staff members. Unfortunately, the generally low faculty salaries and unrealistic promotion requirements make the recruitment of a competent staff difficult. Although a professor has social stature, this is not enough to offset the attractive salaries offered outside the university. Generally, a staff member at a university takes on an outside part-time job to support his family. It might be difficult to increase staff salaries, since often they are closely tied to the Civil Service salary structure of the government, but the provision of fringe benefits such as faculty housing and medical insurance would help.

It might also be feasible to offer additional remuneration to staff members for conducting applied research relevant to the needs of the country. An additional benefit of such projects would be that students could be employed to assist in the work, thus giving them research experience and some understanding of the technological problems of national significance. Unfortunately, applied research institutes affiliated with universities are not common in developing nations; the potential of such arrangements has been generally overlooked. Also, since certain kinds of developmental research call for multidisciplinary approaches, they are difficult for autonomous, discipline-oriented departments to undertake.

The kind of scientific and technological education that is available in most United States universities is highly spe-

The greatest technological need in developing countries is for innovative improvements in existing methods rather than the introduction of high technology and culturally incompatible facilities. The photographs at right were taken in Afghanistan during Professor Ahimaz' work with a United States engineering team under an AID contract.

1. This bridge was constructed in the traditional manner by local people with the help of Peace Corps volunteers. Workers with technological skills could help devise improved structures that would make use of local materials and abilities.

2. Chaff is still separated from grain by primitive means in many rural areas. Simple farm machinery would be more helpful to this farmer than sophisticated equipment developed for large-scale agriculture.

3. Housing in rural Afghanistan reflects a Moslem culture which requires privacy yet close proximity. As new households are established, additions are made to the family dwelling. Modern western-style apartment buildings are not suited to people accustomed to this style of housing; the need is for technological improvements and modifications that conform to established housing patterns.

4. This aqueduct fashioned from a log helps irrigate a rural farm. Better irrigation might be achieved through creative adaptation of technology. A large-scale electricity-powered irrigation system would be of little use to the small farmer in this area.

5. This water wheel provides irrigation without the use of unavailable energy such as electricity. A modern touch is the coca cola cans which convey water to the trough. The efficiency of such a water-powered system could be greatly improved by application of engineering knowledge. Shown in the picture is a civil engineering professor from Kabul University who accompanied Ahimaz and a group of students on a tour of rural areas. The students, mostly from urban areas, had little prior knowledge of rural conditions and needs.

“ . . . the educational systems are not in tune with the realities in developing nations.”

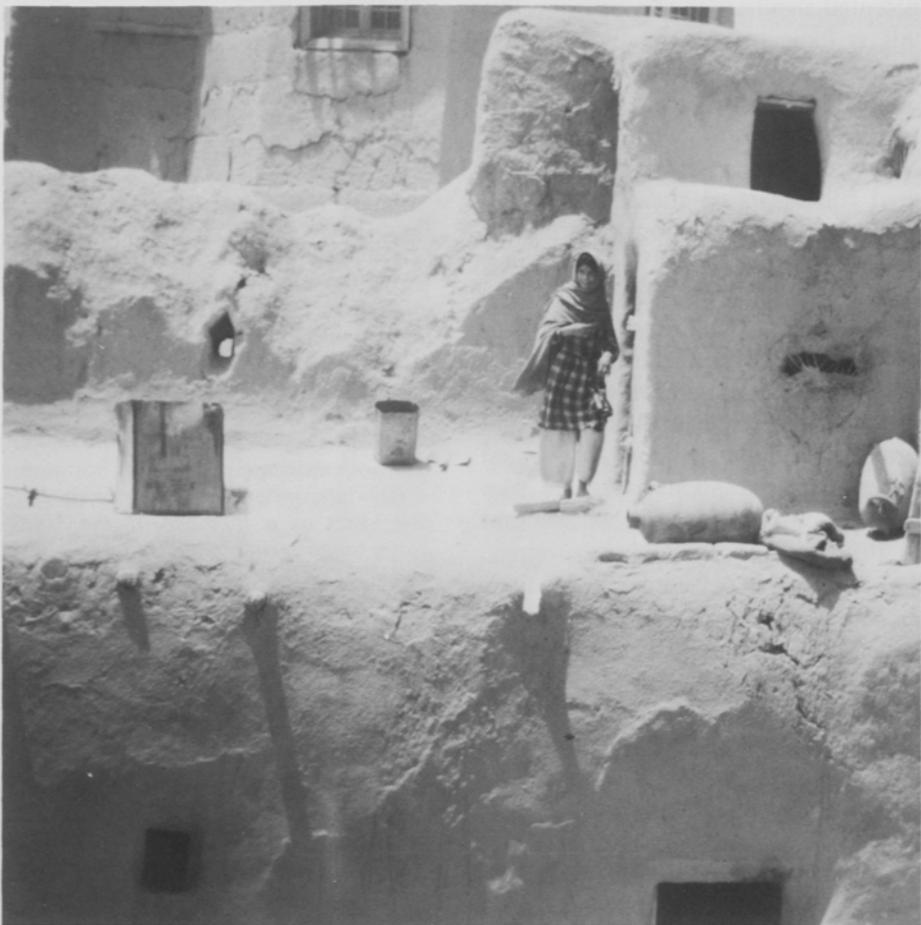
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2



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cialized and aimed at meeting the needs of the United States. An international student following such a curriculum would invariably learn skills that are marketable only in nations of the developed world. It is not surprising, therefore, that when a graduate from a university in the United States returns to his native land, he is often unable to find a job that matches his training and becomes a "brain drain" candidate, anxious to find employment in a developed country. On the other hand, specially organized degree programs for students from developing countries might be too restrictive, and might be viewed as "second class" education.

THE ROLE THAT U.S. UNIVERSITIES CAN PLAY

What does appear feasible is a supplementary program at universities in the United States that would enable international students to adapt their education to the particular needs of developing countries. Such a program would also be attractive to United States students interested in careers with international agencies or multinational corporations in developing countries. The



potential significance of a program like this is indicated by the fact that 25 percent of the gross national product of the United States is derived from industrial activities outside the country. Nearly every one of the top one hundred companies on the annual list of *Fortune* conducts a substantial part of its business outside the United States.

This kind of educational option is being developed at Cornell in the Program on Policies for Science and Technology in Developing Nations. The Program sponsors special courses and provides research support for United States and international students who wish to work on projects relevant to the needs of developing countries. The Program is developing capabilities among professors and students in particular areas where science and technology have the potential to contribute substantially to the economic and social progress of developing nations.

The foundation of the Cornell approach is a healthy interaction of physical and social technologies which can contribute to national well-being and self-sufficiency.

Franklin J. Ahimaz, professor and assistant dean at the College of Engineering, came to Cornell in 1971 to work with the Division of Basic Studies and the newly established Program on Policies for Science and Technology in Developing Nations. As assistant director of the Program, he is responsible for developing courses and research. He recently prepared a paper on science and technology education in developing nations, which was presented at a meeting of the United Nations Committee on Science and Technology held in Geneva this past October.

Ahimaz, a native of Burma, received his undergraduate education in India, earning the B.S. degree in physics at Madras Christian College in 1946 and the B.E. degree in mechanical engineering from the College of Engineering in Trivandrum in 1950. He was awarded the M.S. degree in hydraulics from Bucknell University and the Ph.D. in engineering mechanics from Cornell. He has taught in the mechanical engineering department at Bucknell and the mechanics department of the Illinois Institute of Technology in Chicago, and he has worked as a senior research engineer at the IIT Research Institute.

His international experience includes five years as a member of the United States engineering team in Afghanistan under an AID contract. In this project he offered courses, directed research, and worked with the faculty of Kabul University to improve the level of instruction, and he was responsible for initiating the Center for Engineering Consulting Services and Applied Research there. He has traveled extensively in Asia and Southeast Asia, the Near East, Africa, and Central America to explore possibilities for developing programs in engineering education and research in these areas.

He is a member of the Society for Experimental Stress Analysis and Sigma Xi.

LOW-COST HOUSING FOR DEVELOPING COUNTRIES

by Floyd O. Slate

During the last half of the twentieth century, the world *need* for construction of all kinds will exceed the total amount of building accomplished throughout all of human history. This assessment by the United Nations Center for Housing, Building and Planning demonstrates the magnitude of the need for housing, especially in the rapidly growing urban centers of developing nations.

In spite of the urgency of the situation, however, little progress has been made in effective planning or implementation of housing programs in these parts of the world. Among the various reasons for this are two important problems that are being attacked here at Cornell in the interdisciplinary Program on Policies for Science and Technology in Developing Nations.

One of these problems is that important aspects of a given housing requirement are neglected unless the project is approached from a variety of viewpoints. Yet essentially all past efforts to cope with the extremely complicated situations that are involved in low-cost housing projects have been

strongly oriented toward the approaches and procedures of a single discipline or profession. Projects have been conceived, planned, and executed primarily by architects, or engineers, or planners, or economists; as a result, they have been deficient in important ways. The other problem has been the lack of an organized literature collection to help define the complex field and to provide students and workers with information on the current status of knowledge and experience.

I would like to discuss some of the situations that are encountered in the huge area of international housing needs and programs, and how Cornell's efforts are helping to meet them.

THE MAGNITUDE OF THE WORLD HOUSING PROBLEM

The needs for even minimal housing or shelter are immense. According to a World Bank study, more than 200 million dwellings—a number almost equal to the entire world supply in 1960—will be needed between now and the end of the century simply to house the additions to urban populations in de-

veloping countries. This estimate was made in a section working paper, *Urbanization*, published in 1972. "Perhaps the most salient feature of the housing situation," the paper states, "is the stark fact that typically well over half of the urban population cannot afford minimal 'permanent construction' housing, even if financing arrangements are made available or limited subsidies given."

Squatters now make up about one-third of the population of a large part of the world's medium-sized and larger cities. Refugee squatters (see photographs) pose a particularly large and difficult problem, and one that shows no signs of being ended, for new groups fleeing from new conflicts feed the refugee total faster than earlier groups can be taken care of.

These conditions in developing countries create housing problems that are strikingly different from those of industrial nations. Just in terms of finances, the contrast is extreme. In the United States, for example, the current cost of building a "cheap but permanent" new housing unit is at least

Right: About 200,000 refugee squatters settled outside Karachi, Pakistan, in 1956 after the War of Partition. These two photographs were taken from a modern highway leading into the city. The flimsy construction of the dwellings and the open sewage ditch (visible in the top photograph) are typical of squatter colonies around the world. Such settlements become permanent homes for rural people who migrate to cities in the hope of finding employment or sustenance, and sometimes they are used for transitional housing by people displaced by war or other disaster. Most, although not all, squatters are very poor.



\$15,000; the poorer countries, even with great outside help, must limit costs to about \$600 per unit, and even then only a small fraction of those who need housing can be accommodated. The minimum standards for housing as specified by the United Nations are completely unrealistic; the cost would be so high that very few people could be helped. It is my opinion that while any level of help or improvement is worthwhile, a small increment of improvement for a very large number of people is better than a large increment for a few.

SOME MAJOR PROBLEMS IN PROVIDING HOUSING

The underlying problem in housing the people of the world is that there are simply too many of them. Even minimal solutions appear almost impossible in the face of the population levels that are projected for the future. Nevertheless, decisions must be made on what kind of housing to provide for what groups of people.

The implementation of any housing program in a developing nation in-



volves many difficulties. Problems of land tenure, for example, are encountered in many parts of the world. Economic problems include the financing of construction, from initial cost through—in most cases—at least partial repayment by tenant or owner. Frequently the housing units that are built are unsuited to the climate or poorly sited, and therefore fail to meet the needs of the intended occupants. Often problems arise because of a lack of understanding of or even concern about social aspects such as the cus-

toms of the people or their preferences about the kind of housing to be built. Many of these problems could be alleviated through integrated technological, economic, and social planning.

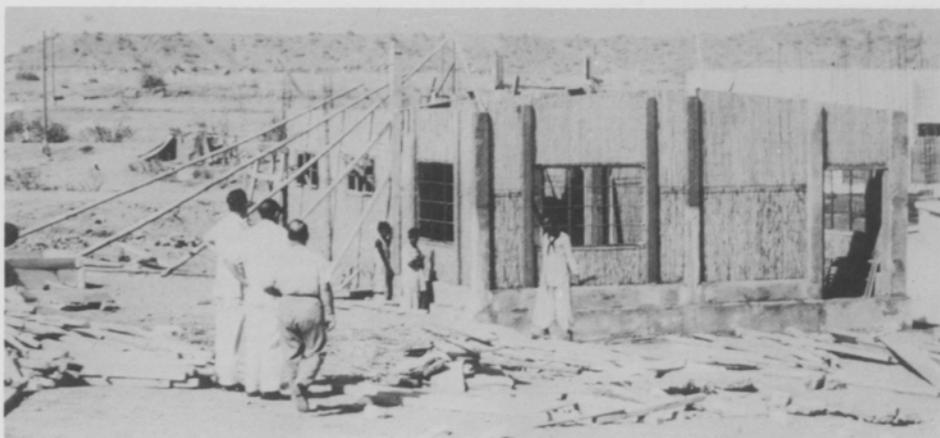
Particularly apparent to an engineer is the frequent use of imported rather than indigenous materials for construction, as shown by the ubiquitous corrugated steel roof found on the poorest housing in all parts of the world. Among the problems associated with this practice is a less favorable balance in foreign exchange. Accompanying

photos illustrate the kind of small-unit housing that can be constructed with use of local materials, and I believe that this should be encouraged where possible. It seems reasonable to predict, however, that in major urban centers, where the problem of housing is most acute, at least 90 percent of future buildings will be constructed of concrete and other masonry materials.

A related problem is the use of capital-intensive rather than labor-intensive schemes for housing construction. This also is a misguided approach, since unemployment and poor housing usually go together. In general, developing countries would serve their national purposes better by developing construction techniques adapted to local conditions and using local labor, including self-help by future occupants, than by importing unmodified or slightly modified foreign building standards and technologies.

Of course, problems and potential solutions vary greatly over the world and even within one country. For example, rural and urban problems and solutions are almost always vastly different. In rural situations it is easier to build with local materials, to use a labor-intensive approach, and to encourage self-help. On the other hand, social problems involving traditions and customs may weigh heavier in rural areas.

Among the problems that must be considered, to some extent, everywhere, is how to provide housing for low-income people without intensifying social problems. Segregation, including the identification of people as "poor" or "destitute" may lead to troublesome situations. Some recent attempts have



1

An example of housing built with indigenous materials is this construction in Karachi. Locally gathered reeds are woven into mats which are slid into vertical slots in small concrete columns, and then cement mortar is plastered over the surfaces inside and out. 1. An early stage of building. 2. A closeup showing the window construction and the wire framework of the mats. 3. A completed house, with whitewashed exterior. This construction is an example also of how modern technology can be integrated into local building techniques: the matting was done by machine and factory-built windows were used.



2



3



Left: The roof and walls of this traditional Philippine house are made of locally available thatch installed on a sturdy wooden frame. A feature is the woven split-bamboo matting, on the lower level, which can be let up or down for privacy or protection. The builder-owner of this home is probably a middle-income farmer. Such housing is generally adequate in rural areas, although in villages there would be problems of water supply, sewage disposal, and fire hazard.

Right: One of the rare successful modern housing projects in developing regions is this one in Singapore.



been made, particularly in the United States, to mix low-cost and higher-cost housing and therefore low-income and higher-income people. Some success has been indicated and some opposition has been met; more time is needed to assess the results.

Another aspect of housing programs that needs more study is how to encourage maintenance and improvement of homes by their occupants. In my opinion, ownership or some form of equity rights is an important incentive in this respect. Equity rights could be limited to prevent early sale or sub-rental, but would still offer the hope of future profit or complete ownership.

WHAT IS AND IS NOT BEING DONE

Surprisingly little has been done in the developing countries toward providing low-cost housing for low-income people, particularly the great numbers of families who do not qualify for any sort of loans because they are not land-owners or have no regular income. Most of what has been built has been subsidized housing for civil servants,

who are largely people of middle or low-middle income, and include some in the high-income levels. Most of the rest of the low-cost housing, both government and private, has gone to middle-income people who can afford to make appreciable rental or purchase payments. In general, the poorer people of the developing countries have remained outside the mainstream of developmental activity.

Those projects that are built for the very poor, such as squatters, are situated in traditionally segregated work or population areas, and usually on waste land—in a swamp, for instance, or a desert—as though the intention were to get rid of these people. In such a segregated area, perhaps a few miles out in the desert, people have little chance to work or even to beg, and though they could choose to starve to death in their new and better housing, they often abandon the subsidized or free housing to return to the city as squatters again. Abandoned, and therefore wasted, housing projects of this nature are not uncommon. In fact, in preparing to teach a course on the

subject of low-cost housing, I had no trouble finding examples of “bad” projects to analyze, but had extreme difficulty finding “good” cases.

The few successful projects include some in Hong Kong and, especially, in Singapore. The situation in Singapore is far from typical, however, because of the industry of the people and the economy of the country, which make possible the expenditure of nearly \$2,000 per living unit. Slums and squatters actually have been eliminated. We can all learn something about housing programs from Singapore, with its strange-working mixture of socialism and capitalism.

CORNELL ACTIVITIES IN THE FIELD OF LOW-COST HOUSING

The initial activity at Cornell in this area was the introduction last year of a multidisciplinary course, Low-Cost Housing Primarily for Developing Nations, which will be offered again next year. The basic idea was to present various aspects of housing problems, including engineering technology, architecture, physical planning, economics,

“In general, the poorer people of the developing countries have remained outside the mainstream of developmental activity.”

and sociology. A group of four Cornell faculty members, with assistance from other University professors and some outside specialists, collaborated to give the course, and support was provided by the Program on Policies for Science and Technology in Developing Nations. Of the class of ninety upperclass and graduate students, more than one-fourth were from developing countries.

The major topics covered in the course were: historical aspects, indigenous housing, housing problems in the developing nations, current practice and malpractice, site selection and planning, use of indigenous materials, design of housing, construction technology, housing production, case studies, and policy proposals. Aspects of economics and sociology were brought into the picture at every stage. The principal faculty members, in addition to myself from the College of Engineering, were Peter Cohen and Henry W. Richardson from the College of Architecture, Art, and Planning; and Charles B. Daniels, an economist from the College of Human Ecology.

Places in which faculty members and

outside speakers had had experience included Nigeria, Ghana, Afghanistan, Pakistan, Ceylon, Peru, Colombia, Costa Rica, and Puerto Rico. Countries represented among the students were, in addition to the United States: Pakistan, Ethiopia, Nigeria, Italy, Mexico, Rhodesia, Bangladesh, Canada, Iran, China, Peru, Sierra Leone, Greece, Ghana, Afghanistan, India, El Salvador, and Thailand. Cornell schools and colleges represented among the students were: Engineering; Arts and Sciences; Architecture, Art, and Planning; Human Ecology; Hotel Administration; Agriculture and Life Sciences; Industrial and Labor Relations; and Business and Public Administration.

To encourage people of different disciplines to actually work together, the class was divided into small teams of four to six people from different fields of study and including at least one foreign student. These teams prepared, with faculty help, joint reports on special topics. Each report followed a useful format; for example, one was written as for a minister of public works to aid him in the preparation of

a five-year plan for low-cost housing. Other reports were written as if they were intended for industrial firms, developers or builders, building research centers, or financing institutions. The faculty felt that the most successful part of the course was these team reports, many of which were of superb quality and represented major efforts on the part of the participants.

A second, more specialized course, called Workshop on Site Selection, Physical Planning, Materials, and Design of Low-Cost Housing for Developing Countries, was introduced by Cohen, Richardson, and Slate in the spring of 1974.

A simultaneous effort was to identify and catalog reports and publications relevant to low-cost housing for developing nations. This was found to be necessary for class use, since no suitable bibliography existed. An initial listing, distributed to class members, has been expanded into a comprehensive annotated bibliography of more than one thousand publications that should prove to be highly useful to workers and researchers all over the

world who are involved in various aspects of this vast and as yet ill-defined field. *Low-Cost Housing for Developing Countries—An Annotated Bibliography 1950-1972*, by Floyd O. Slate, Mary Acton, and Thandiwe Chinamora, was published last June by Cornell University.

Another Program activity in this area is an ongoing research project on basic housing systems in developing countries, using Ghana as a case study. The principal investigator for this project is Professor Richardson of the Department of Architecture, who is a Ghanian and is personally acquainted with a number of Ghanian officials in the housing field. Others involved include myself, Darrell F. Williams of the Department of Policy Planning and Regional Analysis, and a number of graduate students, including a Ph.D. candidate from Ghana. The purpose of the study is to develop guidelines that would help planners in developing countries formulate effective housing policies at the national, regional, and local levels. Although there is general agreement on the urgency of housing needs, there is considerable controversy about how to meet them. A basic area of disagreement, for example, is whether traditional designs and skills should be used, or whether highly organized methods and new building materials should be introduced. Underlying specific questions such as this are more fundamental problems involving national objectives and priorities. In the specific case of Ghana, the focus is on analysis of the overall effects of alternative strategies for technological development in the housing industry.

“ . . . the mere production of housing may fail to provide a satisfactory solution to housing problems.”

CLASS PROJECTS IN LOW-COST HOUSING PRIMARILY FOR DEVELOPING NATIONS

A Low Cost Housing Project for Lagos, Nigeria
Housing for Reconstruction of Managua
Indigenous Materials for Low Cost Housing in Arid and Semi-Arid Areas
Indigenous Materials for Low Cost Housing in the Wet Tropics
Contracting Systems
An Analysis of Uncontrolled Settlements
Low Cost Housing for the Region around Delhi, India
Structural Systems for Low Cost Housing
Site Influence
Unit Design
Suitability of Modern Technology Migrants
Impact of Urbanization on Traditional Living Patterns
Standardization and Modular Components
Environmental Systems
Planned Communities

The resettlement of squatters in the Limon area of Costa Rica is being studied in a project that is just underway. The investigators are Professor Peter S. Chi of Cornell's International Population Program, and Maryann D. Griffin of the Department of Consumer Economics and Public Policy, assisted by Williams and myself.

PLANS FOR FUTURE WORK AT CORNELL

The group of Cornell professors who are working on problems of low-cost

housing are now seeking to expand the activities in this area. A proposed University Program on Low-Cost Housing for Developing Nations would sponsor courses, seminars, workshops, study programs, and research, and would carry out studies, develop policies, and conduct actual projects in developing countries.

The Cornell group believes that the mere production of housing may fail to provide a satisfactory solution to housing problems. It favors a multi-purpose approach which links housing policies to the general economic and social concerns of a country. With an interested faculty group representing many disciplines and a large foreign student enrollment at the graduate level, Cornell has the potential to develop an excellent center for study in this area. It is hoped that the proposed Program will make a significant impact on housing problems and place Cornell in the forefront internationally in this field.

THE OUTLOOK FOR HOUSING THE WORLD'S POOR

Within the last few years there has been a great development of interest in low-cost housing. Although future trends are not yet clear, it seems likely that there will be increasing activity in this field, and perhaps real progress in meeting the problems effectively. Certainly, programs such as those being developed at Cornell will provide an improved basis for decisions on how to proceed in a very difficult and complex undertaking.

Some may conclude that housing the world's poor is a hopeless task, and others may have serious doubts



that the problem can be solved to any significant degree. Many of us, however, believe that attempts must be made and that solutions far better than those that have been tried can be found.

Floyd Slate, professor of civil and environmental engineering, coordinates and helped plan the multidisciplinary course, Low-Cost Housing Primarily for Developing Nations, which he discusses in this article. In connection with the development of the course, he spent a leave visiting every country in Central America and also the Yucatan region of Mexico to observe various aspects of low-cost housing. In 1969 he spent several months of a sabbatical leave traveling throughout the Orient and observing the use of construction materials and low-cost housing projects.

His interest in the problems of developing nations extends back for many years. He has served as a consultant in his specialty fields of concrete, masonry, and corrosion in Puerto Rico, Costa Rica, Panama, and El Salvador, and has also lectured in universities in several foreign countries. In 1956 he spent a year in Pakistan as a technical adviser under the auspices of the United States State De-

partment. In this assignment, he helped establish a national research center and also studied problems of low-cost housing.

In addition to his consulting activities abroad, Slate has served as an industrial consultant in the United States in the fields of soil stabilization, corrosion, geotechnics, resources, and the testing of materials. He has been awarded the Wason Medal for Materials Research by the American Concrete Institute three times, most recently last spring. The 1974 medal was in recognition of joint research on concrete by Slate, Cornell structural engineering professor Arthur H. Nilson, and Tony C. Y. Liu of the Gulf General Atomic Company.

Slate received his university education at Purdue, which awarded him the degrees of Bachelor of Science, Master of Science, and Doctor of Philosophy in chemistry. After two years at Columbia University as a chemical supervisor for the Manhattan Project and three years of teaching and research at Purdue, he came to Cornell in 1949 as an associate professor of engineering materials. He is now a member of the Department of Structural Engineering.

He is a member of the American Chemical Society, the American Institute of Chemists, the American Concrete Institute, the American Society for Testing and Materials, and the American Society of Civil Engineers.

TRANSPORTATION AND NATIONAL DEVELOPMENT

by *Lynne H. Irwin*

The economic development of nations or regions is tied to the availability of transportation facilities. This is a fact that has been demonstrated over many centuries, extending back to the history of the Roman Empire and beyond, and it is still true today. The developing countries of the world can benefit from a knowledge of the stimulus that can be given by a good transportation system.

The pertinent question is how they can profit from the transportation experience of more advanced regions. No country today is exempt from transportation problems. The United States certainly has its share: failing railroads, an ancient merchant marine, crowded freeways, and underutilized airlines. There are no highly successful models to follow, and in any case, the developing countries have different problems, needs, and priorities.

One advantage that they have is the opportunity to "leapfrog" over some of the intermediate stages of transportation evolution. It is not necessary for Tanzania or Costa Rica to build a stagecoach system, for example; they

know in advance that buses will provide more efficient transportation. Yet it is not always easy to anticipate whether or not a developing nation can benefit from the adoption of transportation policies and practices of more economically advanced countries.

The current problems of United States railroads illustrate why an underdeveloped country should be cautious. In the late 1800s and early 1900s, many towns were clamoring for rail service, and the companies made investment decisions which in later years proved to be in error. Clearly, too many miles of railroad were built. The growth of highway transportation made it easier to move goods from farm to market and over short hauling distances by truck, and this made railroad feeder routes unprofitable. The automobile and the airplane became more popular than railroads for passenger movement. And the failure of the government to allow the railroads to adjust their routings and rates has resulted, over the years, in the bankruptcy of several major railroad companies.

TRANSPORTATION PROBLEMS IN DEVELOPING NATIONS

Whether or not a country may be considered to be developed or underdeveloped is more a matter of scale than of categorical differences. Many of the countries that are considered advanced have relatively underdeveloped regions; the Yukon and Northwest Territories of Canada, Western and Northern Australia, and the Appalachian region of the United States are examples. Nevertheless, there are conditions that are characteristic of the so-called developing nations of the world: low per capita income, small gross national product, high unemployment, and an inequitable income distribution. Frequently their economies are based on the export of agricultural or natural resource products. Socially, they are characterized by rapidly increasing populations, poor housing, widespread illiteracy, and inadequate nutrition.

In these countries, most of the problems faced in transportation planning are centered in one or more of the following needs:



Modest improvements in highway construction techniques can mean the difference between satisfactory and unusable roads in rural areas of developing countries. The unpaved road at left, which is a typical connecting road in rural Iran, is frequently difficult and dangerous to travel on, and is impassible during wet weather. The all-weather road at right is a national arterial highway in Belize (formerly British Honduras). These photographs were taken by Professor Gerald W. Olson of the Cornell Department of Agronomy. The picture at left was taken while Olson's four-wheel-drive vehicle was stuck in deep ruts.



- to provide for economic advancement through an integrated plan that encompasses agricultural, transportation, and industrial development and takes into consideration national needs and priorities
- to provide a sufficiently extensive multimodal network of transportation to encourage economic development without incurring economic waste through overinvestment in transportation
- to provide enough governmental regulation of transportation to encourage

planned development, but to avoid excessive regulation, which results in inefficient operation of the system

- to avoid undesirable social and environmental impacts of overall development and of the transportation system in particular
- to identify and adopt technologies of civil construction which will maximize in-country benefits during the process of building the transportation system
- to attract sufficient risk capital to finance development at a reasonable rate

In attempting to meet these needs, the developing countries encounter difficult and sometimes unanticipated problems. Some mistakes have been made and some insights have been gained.

THE PLANNING OF TRANSPORT SYSTEMS

Although the availability of a viable transportation network is a necessary factor in economic development, it is not sufficient in itself. The existence of marketable goods or the potential

for trade is also necessary. This was illustrated recently by the failure of the Transamazon Highway to stimulate development of the western interior of Brazil. The development plan called for more than 3,300 miles of arterial highway to be pushed into the Amazon jungle. It was expected that up to ten million people would move into the region to produce farm products and raise beef cattle, but after four years of road construction, fewer than 5,000 families have established homesteads and no products have been exported from the region. Evidently the provision of transportation means was not enough to overcome other environmental difficulties.

An important requirement is to achieve a balanced transportation network. In addition to an optimum distribution among transportation modes, there should be a workable balance between arterial and feeder roads, for neither is sufficient without the other. A country that concentrates on building feeder routes may find that its development is stifled without arterials to facilitate the movement of people and goods to terminal points in the cities. For example, if fish or produce cannot be moved to market before it spoils, it ceases to be an economic good. Conversely, a country with a network of arterials but an inadequate feeder system may find that it cannot develop interior regions and is limited to strip development along the arterials. Sometimes, however, there are circumstances which make the linking of certain cities undesirable. Studies now being made by Cornell researchers in Colombia show that when one city is economically and socially stronger

than another, an improved transportation linkage between them would promote the development of the stronger one at the expense of the weaker.

The selection of transportation modes is an important decision for a developing country. It has been shown that for haul distances greater than about two hundred miles, railroads provide cheaper transportation than trucks do. On the other hand, trucks are highly efficient for pickup and delivery of goods. Water transport, if it is available to a given country, frequently offers economic advantages over both these modes. If more than one kind of transportation is used, the integration of facilities is an important aspect of the planning; for example, containerization can reduce handling costs at terminals.

The energy cost of transportation is an especially important consideration of developing nations. With today's high cost of fuel, the energy demand of the transportation sector can have significant impact on a nation's balance of payments. The data in Table 1 compare the energy demands of several transportation systems.

The decisions that are made in determining what form of transportation to develop seem to be influenced sometimes by the desire for international prestige. Expenditures for transportation facilities can be a very expensive way to express national vanity, however. A pitfall that developing nations sometimes fall into is to establish an international airline, frequently jet powered, and usually operated at a loss. This is often justified on the grounds that it will encourage tourism, but in fact it may be a liability.

“ . . . the developing countries have different problems, needs, and priorities.”

Table 1.
ENERGY COSTS OF TRANSPORTATION

Mode of Passenger Movement	Energy Used per Passenger Mile (BTU)	Passenger Miles per U.S. Gallon
Bus	1,090	125
Railroad	1,700	80
Automobile	4,250	32
Airplane	9,200	14

Mode of Freight Movement	Energy Used per Ton-Mile	Ton-Miles per U.S. Gallon
Pipeline	450	300
Water	540	250
Railroad	680	200
Truck	2,340	58
Airplane	37,000	3.7

Another frequent mistake is the construction of multilane arterial highways in rural regions. Often a developing country's best highway runs from the airport to the capital. This may be impressive for ceremonial occasions, but many miles of feeder road could be built for the cost of a single mile of expressway.

A third pitfall is a way of modernizing that may be impractical for developing nations: conversion to diesel locomotives on railroad systems. Diesel locomotion can offer economies if trains can be made longer and the

load per car increased. But if the rolling stock cannot be adapted to greater loads, if bridges must be reconstructed to support heavier engines, or if sidings must be lengthened, the potential economies may fail to materialize.

GOVERNMENT REGULATION AS AN ECONOMIC FACTOR

Regulatory policies on the part of a government may facilitate transportation development, but they can also hamper the effectiveness of the transportation system. It is common in most developing countries for the railroads

and airlines to be owned by the government, but the trucking industry is usually privately owned. If the railroads or the airlines, or both, operate at a loss, there is a natural tendency for the government to try to control the competition from the trucking industry through taxation, licensing, and tariff structures.

An example is a situation that exists in India, where there is an extensive railroad system. Trucks and drivers are licensed to operate in only one state and a duty must be paid if goods are transported into another state. This has led the trucking industry to build transfer facilities at the state lines so that freight can be reloaded on trucks that are licensed in the adjoining states. While such practices help boost the demand for railroad transportation by increasing the cost of truck transportation, their overall effect is to generate economic waste by reducing the efficiency of the trucking industry.

Proposed regulatory policies should be carefully examined to ensure that they will not work to the detriment of development.

*“ . . . many miles of feeder road
could be built for the cost
of a single mile of expressway.”*

THE CORNELL PROGRAM ON TRANSPORTATION POLICIES

Interest at Cornell in these problems led to the recent formation of a program in Transportation Policies for Developing Nations, under the auspices of the Program on Policies for Science and Technology in Developing Nations. It is intended primarily for the sizeable number of upperclass and graduate students from foreign countries, and its objective is to provide exposure to the process of policy making in the area of transportation as this relates to technological, social, economic, energy, and other factors.

The multidisciplinary approach to the program is reflected in the interests and experience of the professors who form the core faculty. Gordon J. Cummings, of the Department of Rural Sociology, is interested primarily in problem-oriented approaches to community and regional development. He has been involved recently in studies of health and social service delivery systems in Colombia, England, Ireland, Scotland, and the United States. Dar-

rell F. Williams, of the Department of Policy Planning and Regional Analysis, is a specialist in development planning, especially in the areas of policy formation, analysis and evaluation of policy outcomes, resource allocation strategies, and service delivery systems in the public sector. His most recent international experience includes a study of the delivery systems for basic urban housing services in Ghana and in Limon Province, Costa Rica. In Limon Province he was also involved in research related to small-scale industrial development. The third core faculty member is myself, representing the Department of Agricultural Engineering. My specialty field is the design and engineering of highways, particularly secondary roads, and my recent research has focused on the strengthening of marginal materials for road building in rural areas.

Planning for the program was begun in March of 1973, and the first of three initial activities was implemented in the spring term of 1974. This was a seminar series offered by Cornell faculty members from various depart-

ments and several specialists from outside the University.

The preparation of an extensive annotated bibliography was begun last March. Nearly eight hundred references have been obtained from the Cornell libraries, and a search of holdings of the United Nations, the World Bank, and similar organizations is planned for the period between semesters. Publication of the bibliography is expected in the late spring of 1975.

The third part of the initial program is a course, Transportation Policies for Developing Nations, that is being given during the fall term this year. The main topics considered are models and techniques of the policy making process, economic concepts and techniques for transportation, policy choices in transportation modes and construction methods, sociological analysis of transportation, and the technology of road building. These subjects are treated in talks by Cornell faculty members and visiting experts in a variety of fields.

Many of the speakers are presenting case studies based on their experi-

ences in foreign countries, including Nepal, Colombia, Venezuela, India, and Belize. These case studies illustrate various aspects of transportation development, including the effects of changing technology on transportation and agriculture, the influence of soils on transportation and development, and labor-intensive as compared with capital-intensive methods of construction.

An important part of the course is the preparation of term project studies of individual countries by teams of two or three students. Since the class members represent a variety of backgrounds, these studies promise to be unusually interesting and worthwhile. Two of the students, natives of Pakistan and Nepal, have worked as engineers in the planning ministries of these countries and are studying for advanced degrees in policy planning and regional analysis. Two American students, one in agricultural economics and the other in civil engineering, have had the experience of working with the Peace Corps in Nepal. Two French students with undergraduate degrees in civil engineering from a French uni-



Roads in developing regions often must be built in difficult terrain. These roads are in Afghanistan.



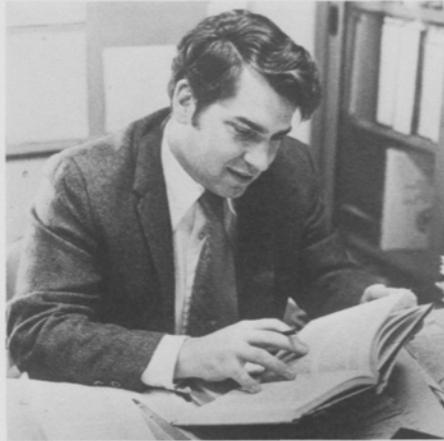
versity are planning to work in West Africa on development projects; one is specializing in civil engineering and the other in policy planning and regional analysis. A student from Ethiopia was employed for several years by an architectural firm in his native country; he has an undergraduate degree in city and regional planning and is working toward an advanced degree in the same field. Three Americans who have not yet had foreign experience round out the class: one is enrolled in agricultural engineering and is specializing in com-

munity development, one is a business and public administration student specializing in international development, and one is majoring in urban planning.

FUTURE DIRECTIONS AND PROJECTS OF THE PROGRAM

The program on Transportation Policies for Developing Nations has made a good beginning, and plans for further development are being considered. Much depends, of course, on the availability of support and the continued interest of faculty and students.

A particularly valuable extension would be to set up a program of graduate student and faculty research within developing nations. The primary purpose would be to find ways of adapting present technology to meet the transportation needs of particular areas, and to develop new methods when they are needed. For example, since unemployment is a major problem in the developing nations, the use of labor-intensive construction methods could be explored. Comparisons would be made of labor-intensive and capital-intensive technologies in terms of con-



struction costs, the design standards that could be achieved, and the durability and serviceability of the roads.

Of course, the technology needed to implement a program of labor-intensive road building would have to be developed beyond the present state of the art. There is a need for an intermediate level of construction equipment, somewhere between hand tools and the heavy machinery used in large-scale highway projects. The aim would be to develop equipment that would increase labor productivity and improve construction standards rather than replace labor with machines. If such equipment proved capable of improving the quality of construction that is now accomplished by hand methods, it might also be useful for building local roads in the United States.

Further curriculum development is another area in which the Cornell program would expand its activities. The fact is that education in the universities of the United States does not always serve the needs of students from the developing nations. In courses on highway engineering, for example, the

emphasis is often on freeways and the problems of the major urban regions in the United States, and while many of the transportation problems of developing nations are similar to those of the United States, building freeways is not likely to offer the best solution. Much of the present technology, though, is potentially very useful; examples are soil stabilization techniques and design criteria for low-volume roads. Similarly, the studies being conducted at Cornell on the environmental, social, and economic impacts of transportation can be helpful to foreign students.

To be of greatest value to developing nations, a graduate program in transportation must be "packaged" to include a preponderance of information that can be put to use in underdeveloped regions. This is the intent of the Cornell program on Transportation Policies for Developing Nations.

Lynne H. Irwin, assistant professor of agricultural engineering, began his activities in the program on Transportation

Policies for Developing Nations during his first semester at Cornell in the spring of 1973. His research and teaching interests—highway design and engineering with emphasis on secondary roads—are particularly applicable to problems of road building in developing regions of the world.

His recent research has focused on the strengthening of marginal materials for town and county road construction in New York State. It has also included work on highway drainage problems resulting from tropical storm Agnes in 1972.

Irwin holds the B.S. and M.S. degrees in civil engineering from the University of California at Berkeley and the Ph.D., also in civil engineering, from Texas A & M University. He taught for three years at California State University at Chico, and has had summer experience in engineering design and construction. He is licensed as a professional engineer in Texas.

Irwin is a member of the American Society of Civil Engineers, the American Society of Agricultural Engineers, the American Society for Engineering Education, the American Society for Testing and Materials, the Highway Research Board, the Association of Asphalt Paving Technologists, the International Society for Soil Mechanics and Foundation Engineering, the American Road Builders Association, and the honorary society Sigma Xi.

AIRPHOTO INTERPRETATION AND REMOTE SENSING

International Aids in Land and Resource Planning

by Donald J. Belcher and Ta Liang

Cornell's College of Engineering has the most extensive program of training and research in airphoto interpretation available in the United States and possibly in the world. Interest in this work has increased internationally as many countries have sought to improve the utilization of their land and resources, and Cornell has played a major role in helping them formulate plans to accomplish these goals.

The Cornell program was organized in 1950 as the Center for Aerial Photographic Studies, and since then has broadened to include interdisciplinary work involving additional remote sensing techniques and satellite imagery. A wide-ranging program of instruction, research, and project participation has developed over the years.

The interpretation of aerial photographs or other sensor images is a tool—a means to an end, and not the end itself. It is a skill that is useful to anyone who works with problems involving the earth sciences, because it enables one to gather detailed information about a wide spectrum of conditions at any given site, area, or

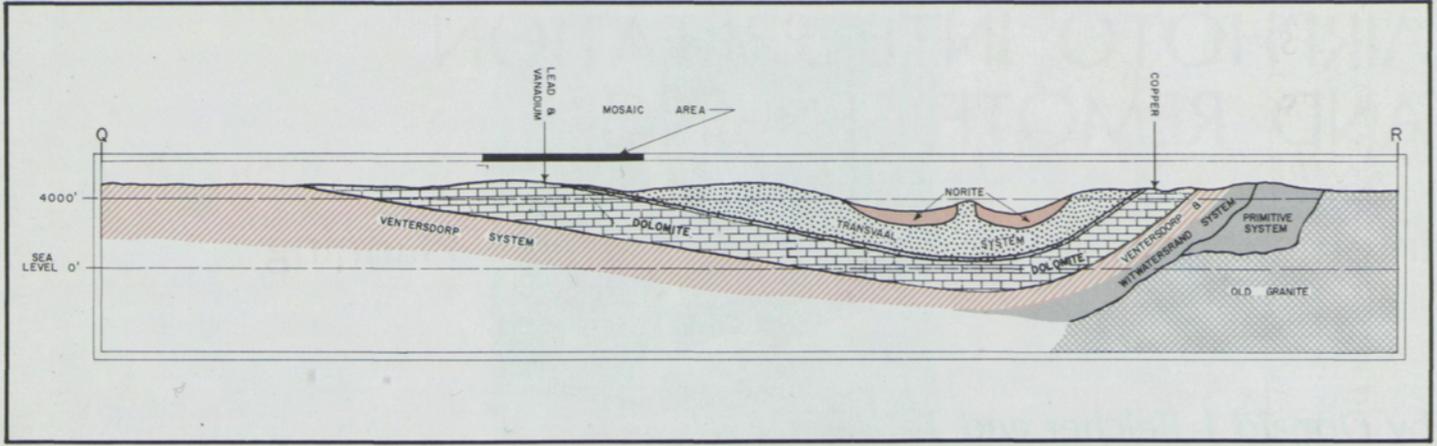


Professors who direct the Program in Measurement and Remote Sensing meet regularly with staff members. Left to right are Warren Philipson, graduate student; Gail Santner, programmer; William Teng, graduate student; Professors Donald J. Belcher, Arthur J. McNair, and Ta Liang; and research assistant Thomas Erb.

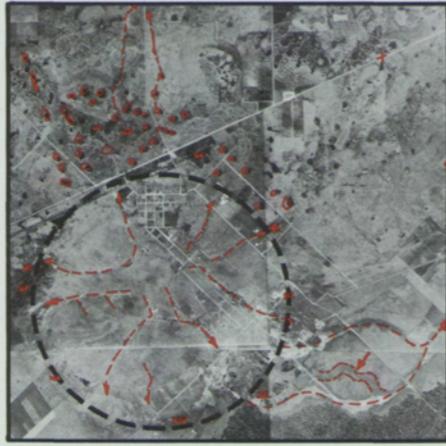
region. It is a versatile device, applicable to many uses, for the images obtained range from the level of reconnaissance photos to increasingly higher levels of complexity and detail. It is

also an efficient and convenient technique: one person can do the work of many field parties in much less time and, of course, at less cost. The ease of data-gathering is especially appreciated in areas that are remote or where transport is difficult.

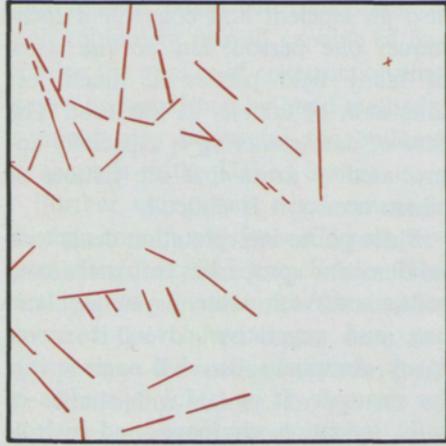
Since photo interpretation deals with fundamental properties of rocks and soils, and with water systems, land use, and vegetative cover, it serves many disciplines. In civil engineering, for example, it is useful in studies of soils, irrigation, drainage, and hydrol-



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“ . . . systems for the inventory of land and resources . . . have attracted international attention because of the growing need for land-use planning in all countries.”

One of three new geological exploration techniques developed by the Cornell aerial photography staff is illustrated at left.

1. A geological map of an area in southwestern Africa shows rock layers at and near the surface, and the location of known deposits. Mineral-containing fluid from the Ventersdorp layer rises under pressure through fissures and solidifies in pockets.

2. Airphotos are analyzed to locate special fissure patterns (defined here in colored lines) that are indicative of probable concentrations of minerals. The circular area indicated by the dotted line exhibits an unusual water runoff pattern due to a slight doming caused by pressures from beneath.

3. The detected fissures indicate the probable location of veins of mineralization. The area shown here exactly corresponds to the area in Figure 2.

4. The information derived from aerial photographs is used to locate areas where mineralization is likely to be concentrated. In the African study, research showed that existing mines (solid circles) occur at intersections of fractures, and therefore detected fissure lines were extrapolated to reveal major intersections. Drilling in some of these locations (striped colored areas) has confirmed the presence of usable ore deposits. Professor Belcher developed the new technique as a consultant in the African study.

ogy; in the location and development of ground water resources; in transport route location and maintenance; and in regional and site planning.

In the many-faceted field of geology, sensor imagery is used in a great many well known ways, and yet recently the Cornell staff in aerial photographic and remote sensing developed three additional major exploration techniques. One is a method for detecting deposits of petroleum, gas, sulfur, and salt in coastal areas around the world; another is useful in locating base metal ores in areas such as central Africa and central South America; and the third identifies certain formations that may yield resources ranging from diamonds to copper.

Students and staff members in the agronomy and natural resources departments of the University have been active participants in cooperative projects involving remote sensing and measurement, and this work has contributed to the adoption of aerial photographs as an accepted technique in soil survey work. At the time the Cornell program was begun, the use

of airphotos in soil survey was regarded with almost complete antagonism in some federal quarters; now they have become an integral part of every survey and publication.

PIONEER INTERNATIONAL WORK BY CORNELL PERSONNEL

Worldwide programs in field research and in instruction began in 1948 with the initiation of a five-year project of field studies that ultimately developed into the present system of instruction. The basic accomplishment of that project was the assembly of a six-volume encyclopedia, known as the *Landform Series*, which related airphoto images of the world's landforms to their soils, vegetation, moisture conditions, and adaptability to engineering, agriculture, and other developmental uses. With this basic reference work, a student can acquire in the classroom and laboratory the ability to recognize landforms, and their surface and subsurface significance, in airphotos from all regions of the world.

The first major effort in a specific country was the establishment in 1954

of an eighteen-month program in Rangoon to provide on-site training of Burmese officials drawn from the areas of forestry, town planning, engineering, geology, and agriculture. In connection with this project, several instruction manuals containing material similar to that in the original *Landform Series* were prepared. The unique *Landforms of Burma* continues in use at the University of Rangoon and for on-job training within the government. It is satisfying to see now a third generation of Burmese students coming to Cornell for graduate study in such fields as photogeology and remote sensing. A similar pattern of initial and continuing instruction has developed, in modified form, in cooperative work with several other countries.

Many of the nations that are engaged in major development programs are located in the tropics. These countries have an especially great need for airphoto techniques because of the scarcity or lack of existing information and because of the difficulty of ground transportation. Since soils and ground conditions in the tropics are significantly different from those of other climatic regions, an extensive research project to study systematically the airphoto patterns of the tropics was carried out by the Cornell staff (see an article by Ta Liang in the Summer 1969 issue of this magazine). Information gathered in field investigations in Central and South America, Southeast Asia, the Pacific regions, Australia, and tropical Africa was used to compile a manual of tropical soils which has been used for training and for many engineering and planning projects throughout the tropics.



1

The location of roads in difficult terrain is facilitated by airphoto reconnaissance. 1. This road in Colombia was annually cut off to significant traffic by landslides. With the help of airphotos, such a road can be relocated to avoid slides or minimize damage. 2. A railroad is to be built near an existing vehicular road in this coastal area of Taiwan. Reconnaissance was begun in the 1960s and continues during initial construction. 3. Location of a new road near an existing railroad called for airphoto reconnaissance in this area of Chile. Professor Liang served as consultant for these projects in Taiwan and Chile.



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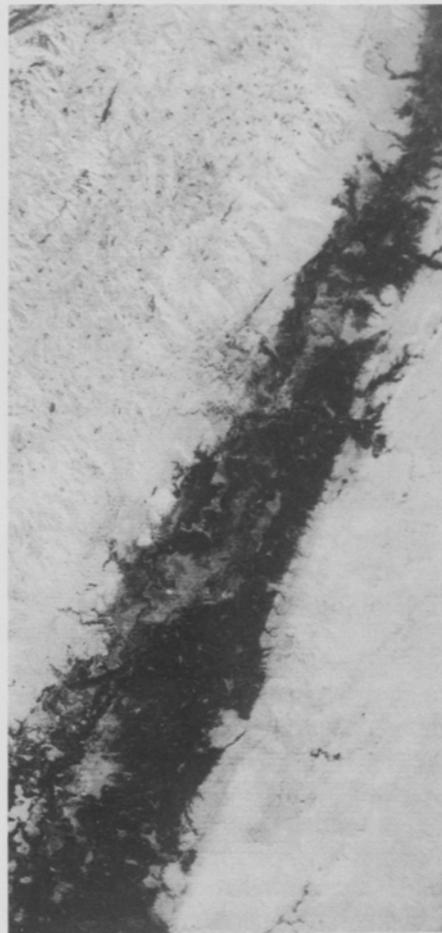
ADOPTION OF LAND USE INVENTORY METHODS

The continuing development at Cornell of remote sensing methods and applications has resulted in systems for the inventory of land and resources that have attracted international attention because of the growing need for land-use planning in all countries. With the use of advanced techniques, even the most remote areas of the world can be inventoried to determine the natural resources available for expanding populations and economies. The basis of these land use inventory systems is a collection of aerial photographs, augmented by imagery from the Earth Resources Technology Satellite (ERTS) program and radar maps. The inventory systems provide the means for interpreting combinations of these data in terms of local geography, kinds of crops, and similar ground-based general information.

Work on the development of inventory systems was begun in 1969, when the Cornell staff was asked to design a rapid, efficient, and econom-



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Aerial photography, the basic tool for gathering data on land use and resources, is supplemented by other remote sensing techniques.

1. Radar images can be used instead of optical photographs when there are problem conditions such as a cloud cover or fog. This is a mosaic map of an area in Brazil (provided by the Brazilian Ministry of Mines and Energy).

2. Infrared photography is especially useful for the study of vegetative cover. This technique is of interest in underdeveloped areas where little information is available on the distribution, types, and yields of cultivated crops.

3. ERTS satellite imagery covers wider areas with less detail than airphotos, and may reveal features discernible because of the larger scale. This picture shows an area of Burma which is underlain by a plate boundary. This is a geological feature of great importance in many areas of the world, for plate tectonics accounts for major mineral concentrations and a plate boundary is a likely location of mineral deposits. A graduate student from Burma, Soe Nyunt Swe, is now working with Professor Belcher on photogeology as related to mineralization. She has been sent to Cornell by the Burmese Geological Survey.



to chart water resources in Spain, Turkey, and parts of the Middle East. Land development studies were conducted in the Philippines, Malaysia, and Liberia. Cornell was represented on the United Nations Ground Water mission to Iran, and a Cornell staff member served as technical adviser to the Ministry of Public Works in Colombia. Cornell staff conducted the studies resulting in the selection of the site for the capital city of Brazil, and in the location of town sites in Venezuela and India.

Academically, the College not only offers courses and research opportunities on campus, but sets up training programs in foreign countries when it appears that this is the most effective way to provide instruction. Special courses ranging from several weeks to several months in length have been introduced in Venezuela, Colombia, Brazil, and Taiwan. Professionals trained at Cornell or by College of Engineering faculty members are now at work in many countries around the world.

Field studies are combined with airphoto reconnaissance in land-use and resources inventory and planning.

1. Venezuelan government officials in such fields as geology, planning, civil engineering, and forestry recently attended a class on the use of aerial photography in natural resource planning taught by Professor Belcher. Equipment for instant translation was provided.

2. Students in this special class augmented their classroom work with studies of soils, flooding, and landslide problems in field study areas such as this. During his stay in Venezuela, Belcher helped establish a project to inventory mineral and agricultural resources in that country.

3. Any available transportation is used for field reconnaissance in underdeveloped regions. Here in the Philippines Professor Liang photographed a missionary plane which carried him and his assistant to remote areas. A local guide (at left), the pilot, and two curious children are in the picture.

Especially in developing countries, major contributions to national progress and improvement in the quality of life are being made though Cornell's efforts in the area of airphoto and remote sensing interpretation.

Donald J. Belcher and Ta Liang have been working at Cornell and around the world in the area of airphoto and other remote sensing imagery interpretation for many years, and have established international reputations in this field. They are professors in the School of Civil and Environmental Engineering and members of that school's Program in Measurement and Remote Sensing.

Both Belcher and Liang have been active in projects that make use of remote sensing data for the planning of engineering and natural resources development in areas throughout the world, and they were responsible for many of the projects described in their article. Both were involved, for example, in the recent project in Puerto Rico in which workers were taught to interpret remote sensing data for the purpose of planning the island's development for maximum environmental and economic benefit.

A pioneering accomplishment in this field was the inventory of natural resources and land use of New York State, which Belcher supervised and which is also described in this article. Belcher's international consulting experience includes work in the Middle East, Far East, Europe, Africa, and Latin America. He has worked, for example, on a United Nations mission to study ground water supplies in Iran, as a consultant for town siting and water supply planning in India, with the Spanish government in the cataloging of water resources of the Pyrenees, in Brazil as the principal consultant in the siting of Brasilia, the capital city, and, most recently, with the Republic of South Africa in planning surveys of natural resources.

Liang has applied remote sensing imagery interpretation to facilities siting, resources location, soils and foundation engineering, and agricultural development and other land use applications in the United States, Canada, the Arctic, Central and South America, the Middle East, Tropical Africa, Southeast Asia and Australia. During the 1960s he supervised field studies in tropical areas around



Belcher Liang

the world as director of Cornell's Tropical Soils Airphoto Research Project. Recently he helped plan a technically feasible and ecologically acceptable route for a gas pipeline from Alaska to the border of midwestern United States. He is currently responsible for the NASA-sponsored Remote Sensing Program at the College of Engineering.

Belcher holds four degrees—the Bachelor of Science in civil engineering, the Master of Engineering, the Master of Science, and the professional degree of Civil Engineer—from Purdue University. He has been a member of the Cornell faculty since 1947, and served as the director of the University's Center for Aerial Photo-

graphic Studies for many years. He is registered as a professional engineer in Indiana and Alaska and is a member of several professional societies.

Liang received the Bachelor of Engineering degree from Tsing Hua University in China and the Master of Civil Engineering and Doctor of Philosophy degrees from Cornell. During World War II he served as a senior engineer with the United States armed forces in the China-Burma-India theater, and later worked as a soils and foundation engineer for a consulting firm. He joined the Cornell faculty in 1957. He is a member of the American Society of Photogrammetry, the Transportation Research Board, and Sigma Xi.

CORNELL'S ACTIVITY IN TROPICAL WATER MANAGEMENT

by Gilbert Levine

The Malthusian prediction of famine as the inevitable consequence of a gap between our ability to produce food and our propensity to populate has once again come to the fore. The tragic example of the Sahel of Africa appears to be only the forerunner of more widespread disasters. Famine is forecast for South Asia, as well as for large parts of Africa, in the near future; for Southeast Asia, famine is predicted in the longer run, with continued large-scale poverty in the short run.

These stark predictions, and the evidence to support them, are in sharp contrast to the optimism of only a few years ago, when the new agricultural technologies appeared capable of providing the opportunity for a dynamic agriculture in the developing countries, and for a solution to the food versus population problem.

WATER: CRUCIAL IN AREAS OF POTENTIAL FAMINE

At least partially responsible for the recent pessimism is the variability in water supply for crop and animal production in the tropical areas of the

world. The new wheat and rice varieties, symbolic of the agricultural technologic breakthroughs, were introduced in situations in which water control was possible or at a time when weather conditions were favorable. In the past few years, however, drought, sometimes followed by floods, has plagued large areas of the developing countries. This year this combination has had severe impact in major portions of India and Bangladesh. In the Sahel, years of severe rainfall deficits have devastated large areas of six countries. Last year alone, an estimated 25 percent of the cattle population was wiped out, with the death toll reaching 80 percent in some districts. Less critical, perhaps, but of major longer-range importance are the even more widespread, though shorter, droughts which reduce the effectiveness of the new agricultural technologies and inhibit investment even in those that can be effective.

The effect that variability in the water environment has on food production is illustrated in Figure 1. Average annual per capita food production since 1955 is shown for developing

countries as a group and for various regions. These data show that average per capita production in the less developed countries has increased only 0.4 percent per year. None of these regions has increased production by as much as 10 percent of the 1961-64 base; Africa has shown a declining per capita production since 1961. The sharp valleys in production are generally associated with poor climatic years.

Though some believe in the inevitability of the Malthusian prediction and some in the ultimate triumph of technology, there is general agreement that water is the key to significant increases in production potential. That this is recognized in the developing countries is evidenced by the major investments in irrigation projects that have already been made and the very large additional investments being planned. The Aswan Project in the United Arab Republic has been well publicized. The Muda Project in Malaysia, and the Upper Pampanga Project in the Philippines are less widely known, but each is in the 100-million-dollar category, and

Asia, although some research has been conducted in other problem areas. The major research emphasis has been on the irrigation requirements for regions in which small farmers predominate. A special concern has been the problems of farmer-system interaction that I have mentioned.

Typical of the Cornell research efforts is a series of projects, which have just been completed under my supervision, in the Philippines. These efforts had the active cooperation of the University of the Philippines, the International Rice Research Institute (IRRI) and the National Irrigation Administration (NIA), which is the Philippine governmental agency with responsibility for public irrigation systems. The studies were conducted in national gravity systems in central Luzon and the province of Laguna, in an effort to identify and understand the basic causes of the water use pattern typical of the regions, and to relate these to system design and operation. The research has required input from specialists in engineering, economics, agriculture, and sociology, and results have been obtained in all these areas.

EARLY IMPLEMENTATION OF RESEARCH FINDINGS

While the usual form of research reporting (thesis and technical publication) has been followed, there has been an additional effort to get the research results directly into the hands of policy makers and technical personnel. Periodic direct reports to NIA administrators have been effective in reducing the time lag between research findings and utilization. Participation of the researchers in training seminars designed for system personnel has also been



helpful. The rapidity with which research findings can be utilized, as well as the importance of irrigation problems, is demonstrated by an example from our experience: a major parameter in the design for the Upper Pampanga River Project was changed within three months of the time our research results were reported.

These field-based studies are complemented by a related research effort which utilizes data from the ERTS-1 satellite. In this cooperative project, which involves Cornell, the University of the Philippines, IRRI, and the General Electric Company, attempts are being made to determine radiation signatures for rice under different water conditions. The measurements being made as part of the field studies are utilized as the "ground truth" to verify the remotely sensed data. Very significant progress has been made, and the potential usefulness of being able to "view from above" with feet on the ground is exciting.

In addition to working in the Philippines, Cornell faculty and graduate students have participated in research in

Cornell participants in a cooperative project to correlate field studies with satellite imagery are (left to right) remote sensing expert Arthur J. McNair, professor of civil and environmental engineering; Meg Layese, Ph.D. candidate in agronomy; Professor Levine; and Senen Miranda, who recently completed Ph.D. studies in agricultural engineering. The project is supported by the National Aeronautics and Space Administration (NASA). Both Meg Layese and Senen Miranda hold faculty positions at the University of the Philippines at Los Baños. Miranda was recently named director for soil and water resources research of the Philippine Council on Agricultural Research.

Iran on major system design assumptions, in Taiwan on system water delivery scheduling, and in Brazil on soil-water relationships. The aim of all the projects is to increase understanding of the complexities involved in managing water for agricultural production in the tropics.

THE COOPERATIVE NATURE OF THE RESEARCH PROGRAMS

These research projects have been characterized by a variety of participants and a diversity of funding sources. In addition to Cornell faculty members, participants have included Philippine, Chinese, Iranian, and Dutch graduate students at Cornell, and Philippine and Chinese engineers. The Ford Foundation, through the University of the Philippines-Cornell Graduate Education Program, has been the major source of support for the research, though the United States Agency for International Development, the National Aeronautics and Space Administration (NASA), the Republic of China, and the government of Iran have all provided support for specific projects.

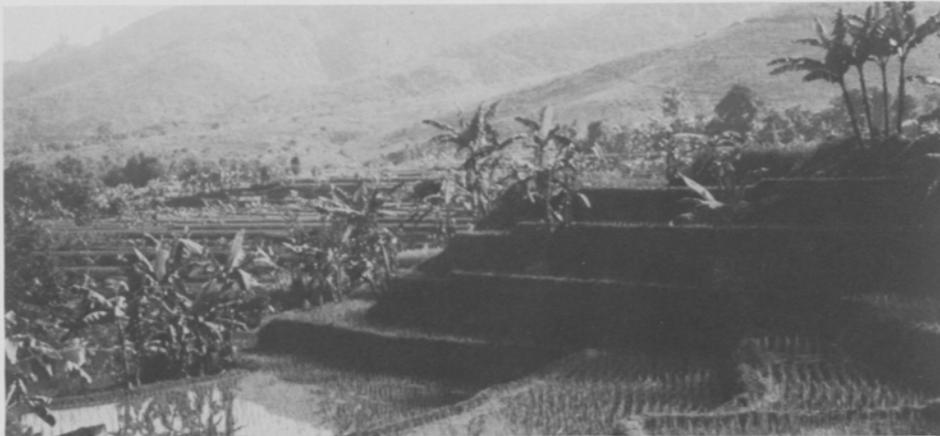
Recognition of the importance of the problem is widespread.

The availability of this external support, and the cooperative relationships with the overseas institutions and agencies, make possible a unique and valuable research opportunity for Cornell graduate students. They gain the experience of working with colleagues from developing nations under the conditions that exist in those regions. They develop the ability to improvise and acquire skill in interpersonal relations. They have the opportunity to exert a significant influence on major policy decisions. All these circumstances combine to produce a graduate experience whose value is gaining increased recognition.

CLASS WORK IN TROPICAL WATER MANAGEMENT

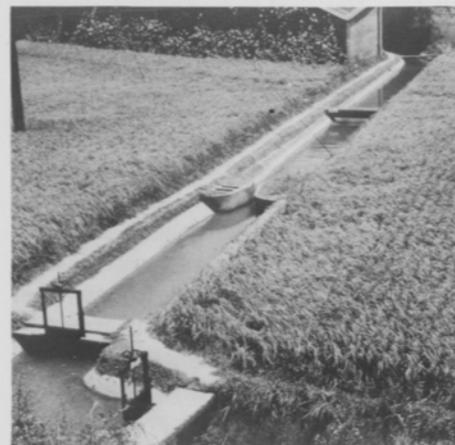
In addition to field research, the Cornell graduate program in tropical water management includes complementary investigation in the classroom. The basic course offering is a graduate seminar offered by the Department of Agricultural Engineering each spring, with different aspects of the tropical water management problem receiving special attention each year.

A new course in which the interaction of social, cultural, and technical factors was explored was offered this past spring term by an interdepartmental group of professors: Milton L. Barnett, an anthropologist from Asian Studies and Rural Sociology; E. Walter Coward, a sociologist from Rural Sociology; and myself from Agricultural Engineering. Twenty-six graduate students, representing sixteen countries and eight disciplines, participated in



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In rural areas of the tropics, traditional systems of irrigation have evolved within constraints of local physical, social, and economic environments. The Philippine and Indonesian systems (1 and 3, respectively), show adaptations to topographic differences that permit uniform water depths within paddies and water distribution by gravity, without excessive velocities. Where water is a critical resource, however, dependence upon traditional technology and social control may be inadequate. The simple, yet sophisticated, physical facilities found in many Taiwan systems (2), combined with discipline in water use, result in efficient and effective service to small-holders.



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“ . . . irrigation technology and management that has proved suitable in the developed countries (is) inappropriate under the conditions frequently encountered in developing regions.”



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Irrigation systems in the Philippines are studied by Levine and his graduate students. 1. Dutch student Jacob Kampen (right), now a water management engineer with the International Crops Research Institute for the Semiarid Tropics, studied rice field irrigation with Levine (center) and a Philippine assistant. Although such controlled studies provide valuable information, field investigations are essential for real understanding of the complexity of tropical water management. Research conditions are frequently nonideal (2), with problems of curious local residents, especially children (3), and with uncontrolled variables, such as illegal dams in irrigation channels (4).



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evening sessions that were difficult to close, even at 11 p.m. The effects that specific irrigation technologies might have on social systems, and the potential influence that cultural and social characteristics might exert on the effectiveness of these technologies, were both explored. Illuminating the discussions were illustrations provided by faculty members from the wide range of their combined experience; examples ranged from Navaho systems in the United States to communal systems in the Philippines to computer-based systems in Malaysia.

The graduate program is enriched by a series of special seminars, which this year included discussions by Canute Vandemeer of the University of Vermont and Edward J. Vandervelde of the State University of New York at Binghamton. These men are both geographers who have been studying the interrelationships of irrigation programs and social institutions—Vandemeer in Taiwan and Vandervelde in India.

The program to explore the complexities of tropical water management also includes courses at the under-

graduate level. The emphasis here is on the development of a better understanding of how technological decisions affect the lives of the people in developing nations. For example, an interdisciplinary course called Peasants, Power, and Productivity used irrigation as a major illustration of the interacting relationships of people, government, and technology. This course was taught jointly by Professors Norman T. Uphoff of the Department of Government, Davydd J. Greenwood of the Department of Anthropology, and myself from the Department of Agricultural Engineering. In a more technical vein, the agricultural engineering course Soil and Water Conservation draws upon the water management problems of developing countries to illuminate the contextual importance of technological practices.

Cornell's interest in this major area of international concern is expressed in its teaching, its research, and its involvement with the agencies and institutions directly concerned with improving the lives of the poor in developing countries.

Gilbert Levine, newly appointed director of the Water Resources and Marine Sciences Center at Cornell, has been teaching and working in the area of soil and water problems since he joined the Cornell agricultural engineering faculty in 1952. During the past ten years, he has focused on tropical problems. He holds a joint appointment with the College of Agriculture and Life Sciences and the College of Engineering.

His interest in the implications of technology around the world is reflected in his work on campus in the Program on Policies for Science and Technology in Developing Nations and in the Center for International Studies. He was associate director of the latter organization in 1970-71 and is currently serving on two of its working groups, the Rural Development Committee and the Cornell-Philippines Program.

Levine has conducted and directed research programs in the Philippines, in Brazil, and in Southeast Asia and Taiwan. Much of this has been concerned with tropical irrigation problems, the area he mainly considers in his article here. He has also worked on tropical soils problems in collaboration with members of the Cornell Department of Agronomy. Last May he participated in a joint United States-Philippines panel on environmental education, sponsored by the National Academy of Science.

Levine received both undergraduate and doctoral degrees from Cornell. He is a member of American Society of Civil Engineers, the American Society of Agricultural Engineers, and the United States Committee on Irrigation, Drainage, and Flood Control of the International Commission on Irrigation and Drainage.

COMMENTARY

American Universities and Developing Countries

Problems and possibilities associated with participation by American universities in technological education in underdeveloped parts of the world are discussed by William McGuire, professor of structural engineering, who writes from the vantage of two years' experience in teaching in Southeast Asia.

This is perhaps the worst of times to write about the role of American universities in the engineering programs of developing countries. The outlook is discouraging.

Financial support for foreign education comes chiefly from the federal government. Private foundations are interested and active, but their funds are limited. Right now, Washington is preoccupied with internal affairs. The external questions that are addressed are those of immediate military or economic concern. Long-range development, of which engineering education is a part, is receiving little attention.



Only part of this neglect can be laid to the disillusioning Viet Nam experience, Watergate, and the economic crisis. There are a number of other reasons. The United States has had a long involvement in international education, but only since World War II has the commitment been great enough to attract public scrutiny. All too often, those who proposed the post-war programs and those who approved them were both taken in by the proposer's rhetoric. The slogans of national interest, combating communism,

and eradicating poverty were flaunted and accepted. Expectations were too high.

India is the prime case in point. Twenty-five years ago we had high hopes of being able to help India. It needed outside assistance badly. It had a sophisticated, intelligent leading class which seemed fully capable of utilizing the teachings of countries which happened to have a more highly developed technology. Today, after a massive effort, the future of India is more than ever in doubt. There is little evidence that modern technology is being used effectively to combat its problems. Some of the best young engineers practicing in the United States and the United Kingdom are Indians educated in the West as part of this program. They are making outstanding contributions to society but, unfortunately, not to the relief of suffering in India. The Indian government's decision to use scarce technological resources for development of an atomic bomb makes one question its wisdom. Something has gone wrong. Without trying to analyze what it was, one

must still acknowledge the question: If India, perhaps the most needy and promising recipient of technological assistance, can't use it, who can?

THE LACK OF PROGRESS IN UNDERDEVELOPED COUNTRIES

We are coming to realize that underdeveloped countries are all, to different degrees, what Gunnar Myrdal calls "soft states." In *The Challenge of World Poverty*, he defines the term to "comprise all the various types of social indiscipline which manifest themselves by deficiencies in legislation and in particular law observance and enforcement, a widespread disobedience on various levels to rules and directives handed down to them Within the concept of the soft state belongs also corruption. . . ." The term has little to do with communism, democracy, or any other ideology or form of government. Softness pervades the whole underdeveloped world. As Myrdal also points out, the laxity and arbitrariness of a soft state is generally exploited for personal gain by people who have economic, social, and political power. Real concern for development which will change the lot of the poor can be almost absent. These are facts of life which thwart the good intentions of countries offering help, but they are facts over which they have no control.

Even such a strong advocate of foreign aid as Senator Fulbright seems to have become disillusioned by the lack of progress. So that we don't get the mistaken impression that he and people of like mind have abandoned their belief in the efficacy of aid, we should look at his writings. His objections are directed mainly to the perversion of

the aims of assistance programs and the way they have been run. Although he has said in *The Arrogance of Power* that he "can no longer actively support an aid program that is primarily bilateral," he follows with the statement, "I would, however, support and do all within my power to secure an expanded program of economic aid—a greatly expanded program of economic aid—provided that it were conducted as a community enterprise, that is, through such international channels as the United Nations, the International Development Association of the World Bank, and the Regional Development Banks." He has also endorsed cultural and educational exchanges as "to my mind . . . probably the most rewarding of all forms of international cooperation." With the passing of Senator Fulbright from Congress, it is difficult to see anyone who will pick up the fight for constructive foreign educational programs.

It is also an inescapable fact that a developed technology is not an unmixed blessing. The Western world is just beginning its effort to tame technology—to make use of its undoubted benefits while at the same time finding ways to avoid its evils. The outcome is very much in doubt. Of immediate significance is the fact that engineers have become more modest in their beliefs as to what technology can accomplish and less evangelistic in their desire to convert underdeveloped countries to an unquestioning state of high technology.

A further influence is the attitude of Western universities. In the United Kingdom, some prestige seems to attach to engineering schools in far-

off lands. Perhaps it is a legacy of the colonial tradition in which many talented Britons made their careers abroad. Or perhaps it is just an oversupply of talent coupled with an outmoded hierarchical system that compels many of their academics to seek jobs elsewhere.

Things are different in the United States. Some scholars, such as many anthropologists, have specialties which draw them abroad. For engineering professors, brief trips on professional or academic consulting, or as recipients of major fellowships, are exciting and prestigious. But for most, there is little incentive to teach abroad for the time necessary to become effective in a different culture. America is where the action is. Further, with few exceptions, American universities do not encourage their faculty to teach abroad. At the great majority, including, in my opinion, Cornell, recognition and advancement policies are such that any faculty member not having a foreign research specialty would be most sensible to stay home and cultivate his projects.

For all these reasons: lack of gov-

“American support of programs in developing countries can be justified solely in moral terms; not as condescending charity, but as simple, respectful humanitarianism.”

ernment encouragement, failure of promising programs, doubt as to the benefits of advanced technology, and the lukewarm attitude of universities; these are not good times for the promotion of foreign engineering education, and any review of the subject must recognize this.

REASONS FOR CONTINUING TO TRY TO HELP

In view of this, should American universities even bother any more with engineering programs in developing nations? Hasn't the record been one of failure more than success? Isn't the task at best an unrewarding one and at worst hopeless? Shouldn't we cut our losses now? The reasons for continuing to try are few. If one still has some faith in the possibility of improving the lot of mankind, they are compelling. If one doesn't have such faith, they probably sound like addle-brained do-goodism.

The kind of faith one needs has been described by René Dubos in his book *A God Within*. After noting, “one of the most hopeful preoccupa-

tions of the modern world—the feeling that technological societies are engaged on a suicidal road but have a second chance to discover the good life if they are willing to retrace their steps,” he observes: “The general awareness of the defects in our present ways of life is creating throughout the western world a social climate favorable to change. Change does not imply that the [recent] past should be forgotten or rejected. In fact, the new road to progress will certainly take advantage of the most advanced technological culture.”

With the possible exception of a few truly backward regions, all countries are twentieth century technological societies. They have passed the point of technological no-return. It makes no sense to say that this or that country is so many years behind the times. One hundred years ago, no one could really foresee modern technology. Now everybody—the people of the undeveloped as well as of the developed nations—knows what it is. All know the real blessings of modern medicine and the mixed blessings of the

Honda and the transistor radio. In many places, technology is embedded in a primitive and almost stifling social matrix, but it is everywhere evident and will be increasingly so.

THE ROLE OF WESTERN ENGINEERING EDUCATORS

Given these beliefs: that technological development is underway all over the world, that it is irreversible, and that, if wisely directed, it will lead to a better life, the role of engineering education follows directly and obviously. Very simply, Western engineering teachers have one of the things the developing countries need badly: the ability to teach others to understand, to use, and to develop modern engineering technology. Some of this can be accomplished through attendance of foreign scholars at Western universities, but it is generally more effective when done where the problems are—where they are obvious to student and teacher alike.

When Western governments, universities, and individuals take up this cause, what can they expect in return?

The individual can of course make money and have an exciting experience. These are fair aims and should not be denigrated. But the question really demands a more substantial answer. If one considers political, military, or business interests, the answer is now quite clear: not much. In analyzing a broader, associated question, Myrdal states in *The Challenge of World Poverty* that for his country, Sweden, "there cannot be any other reason for giving aid than the simple humanitarian impulse to feel solidarity with those who are poor, hungry, diseased, and illiterate, and who meet difficulties in their efforts to rise out of poverty." He argues that this is really the only valid reason in any country and that, particularly in America, there is a strong moral imperative which, if appealed to in these simple terms, will not permit us to deny this need.

It boils down to this: Engineering education is part of the larger task of technological development which, in turn, is part of the goal of trying to improve the human condition. American support of programs in de-

veloping countries can be justified solely in moral terms; not as condescending charity, but as simple, respectful humanitarianism. Any American who has traveled in underdeveloped countries has seen the signs of Yankee go home and has felt the resentment of the disadvantaged. It is natural this will always be. But unless he is totally blind, he will have experienced much more often the amazing affection, belief, and respect that people all over the world have for America. It is hard to believe that this country would elicit such a response if it had not shown some streak of humanitarianism.

If it is agreed that American participation in foreign engineering education is justifiable and desirable, then it will probably be accepted that it is needed at all levels, from the purely vocational and subprofessional to the most advanced. Once one embarks on technological development, whether one is in Cambridge or Chiangmai, the full spectrum of educational needs asserts itself. One needs welders, computer technologists, hydraulic engineers, and applied mathematicians. Of course, the

proportions vary from place to place. And no institution has the competence to meet all the needs. If a university undertakes programs abroad, it should recognize that it can do best what it does at home and that it should leave other activities to other types of institutions. Universities like Cornell have one place and technical institutes and vocational schools have other, equally important, places.

WHAT A WESTERN UNIVERSITY CAN DO

From 1968 to 1970 I was a professor of structural engineering at the Asian Institute of Technology in Bangkok. Since it does some of the same things Cornell's engineering college does, and does them rather well, it may merit description as an example of the kind of foreign activity a university such as Cornell could engage in.

AIT is a graduate school founded by SEATO in 1959, but now operating as an independent regional institution. Financial support comes from the governments of the United States, the United Kingdom, Japan, several other countries—including the host country, Thailand—and private organizations. Instruction is in English. At the present time, AIT has more than three hundred students drawn from most parts of Asia. They are good—the best are as good as one finds anywhere. When they graduate, the great majority of them remains within Asia, usually within their home countries. They are rising to positions of influence all over the region.

Among the most important reasons for the considerable status that AIT has achieved in South and Southeast Asia are the good facilities and the

quality of the faculty. The staff is well paid, and the institution has been able to attract highly competent and sometimes outstanding professors from all over the world. Visiting professors stay for at least two years, and sometimes considerably longer.

In class and in research there is some stress on problems of the region: low-cost housing, development of rivers such as the Mekong, local soils, tropical waste water treatment, local transportation and urban problems, etc. But there is not much difference between the approach of this particular institution in a developing region and that of a first-rate graduate school in a fully developed environment. At the level at which AIT is operating, the technological problems are the same world-wide. Bangkok's traffic problem is as bad as Boston's and calls for equally sophisticated engineering. A dam in Pakistan deserves the same modern design as one in Colorado.

The level of competence in engineering design in Southwest Asia is close, if not equal, to that of the Western world. Where there are lags, they are in such things as the regulation of design through codes, quality control, construction techniques, and construction management. AIT has done more than its share to maintain and to improve the standards of design capability. To my knowledge, it has not attempted to do much in the other areas, which can be lumped under the loose heading of the business of engineering. If one ventures into that part of technology, one must recognize and be prepared to deal with the problems of the soft state in their endlessly fascinating and frustrating variety. These problems

are enormous and enormously important, for if there is ever to be real development, they have to be overcome. It is not clear whether any academic institution could have any success in this arena, but it would make an interesting experiment.

AIT has shortcomings and problems, but they are insignificant compared to its accomplishments. I feel that it should be an obligatory case study for any American university planning a program at the same level.

I believe that such programs should be as academically free as those of good American universities and, in particular, they should be protected from government interference. The faculty should be well paid and well selected; misfits in American universities will be misfits no matter where they go. The facilities—the library, the computer, and the laboratories—should be as good as those expected back home. Given this environment, and the encouragement to stay abroad long enough to be effective, cadres of staff from American universities could have a marked impact on the science and technology of developing regions. They could not solve the world's problems, but they just might contribute to making it a little better place.

William McGuire is a specialist in structural engineering and has worked, written, taught, and consulted in this field for the past twenty-seven years.

He received his undergraduate degree in civil engineering from Bucknell University in 1942, and subsequently served for three years as a United States Navy officer in the area of aircraft maintenance. After receiving the degree of Master of Civil Engineering from Cornell in 1947, he worked for two years as a structural

designer and then returned to Cornell as a member of the faculty.

*Among McGuire's writings in his specialty field is a text, *Steel Structures*, published by Prentice-Hall in 1967. In 1962 he was the cowinner, with his Cornell colleague, Professor Gordon Fisher, of the Norman Medal of the American Society of Civil Engineers for a paper on containment structures for nuclear reactors.*

As an independent consultant, he has worked on the design of a wide variety of structures, including buildings, bridges, supersonic wind tunnels, a solar furnace, grain storage facilities, nuclear reactor containment structures and guyed towers. Specific projects on which he has worked include the Buckminster Fuller exhibit at the Museum of Modern Art in New York City, and the world's largest radar astronomy facility, built by Cornell in Arecibo, Puerto Rico.

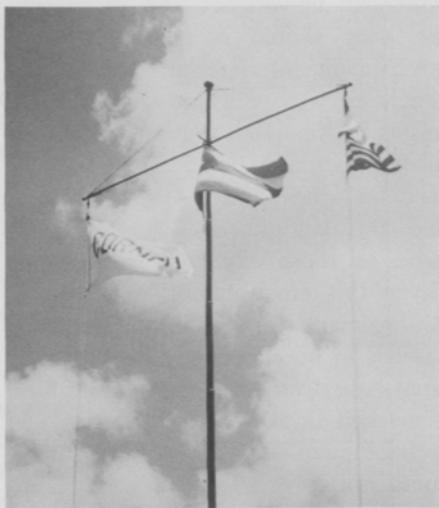
In 1972-73 he spent part of a sabbatic leave doing research at the National Bureau of Standards on the progressive collapse of buildings. During the remainder of the leave, he served as a Gladden senior fellow at the University of Western Australia and lectured at the University of Canterbury in New Zealand.

McGuire is a member of the American Society of Civil Engineers, the American Concrete Institute, the International Association for Bridge and Structural Engineering, Chi Epsilon, and Sigma Xi.

Upgrading the Arecibo Observatory

The dedication of the world's largest radio-radar telescope, held in Puerto Rico in November, was an event of particular interest to Cornell engineers. The idea of constructing the giant facility was conceived by a College of Engineering professor more than fifteen years ago, and from the beginnings Cornell engineers have helped plan, staff, and make use of the observatory.

The facility near Arecibo, now called the National Astronomy and Ionosphere Center, is operated by Cornell under contract with the National Science Foundation. The dedication, attended by some 250 representatives of government, universities, and the scientific community, was occasioned by recent multimillion dollar improvements that have increased the radar sensitivity of the instrument by a factor of 300. A major part of the project was a resurfacing of the dish-shaped, 1,000-foot-diameter reflector. Also, new equipment, including a high-frequency transmitter that has increased power to 450,000 watts, was installed, and the superstructure was stiffened to achieve the greater stability required by the



Flags of Cornell University, Puerto Rico, and the United States fly near the entrance to the Arecibo observatory.

higher operating frequencies. One of two carriage houses on the feed arm was rebuilt to accommodate the new transmitter.

The history of the Arecibo observatory began with an idea of William E. Gordon, a Cornell Ph.D. in electrical engineering, who was then a professor of engineering at Cornell and since

1966 has been dean of engineering and science at Rice University. Gordon was interested in atmospheric radio research and needed an instrument capable of quantitative measurements of wave scattering by free electrons. He established the requirements for the large reflector and consulted with colleagues to determine the feasibility of constructing it and where it might be located. These consultants included structural engineering professors George Winter and William McGuire; electrical engineering professor Benjamin Nichols; and civil engineering professor Donald J. Belcher, who was principally responsible for selecting the Puerto Rico site. Henry Booker, who was then at Cornell as head of the electrical engineering school, was instrumental in implementing the project. Merle LaLonde, B.E.E. '59, now a senior research associate, has been active in the Arecibo work from the beginning, when he was a student of Gordon's.

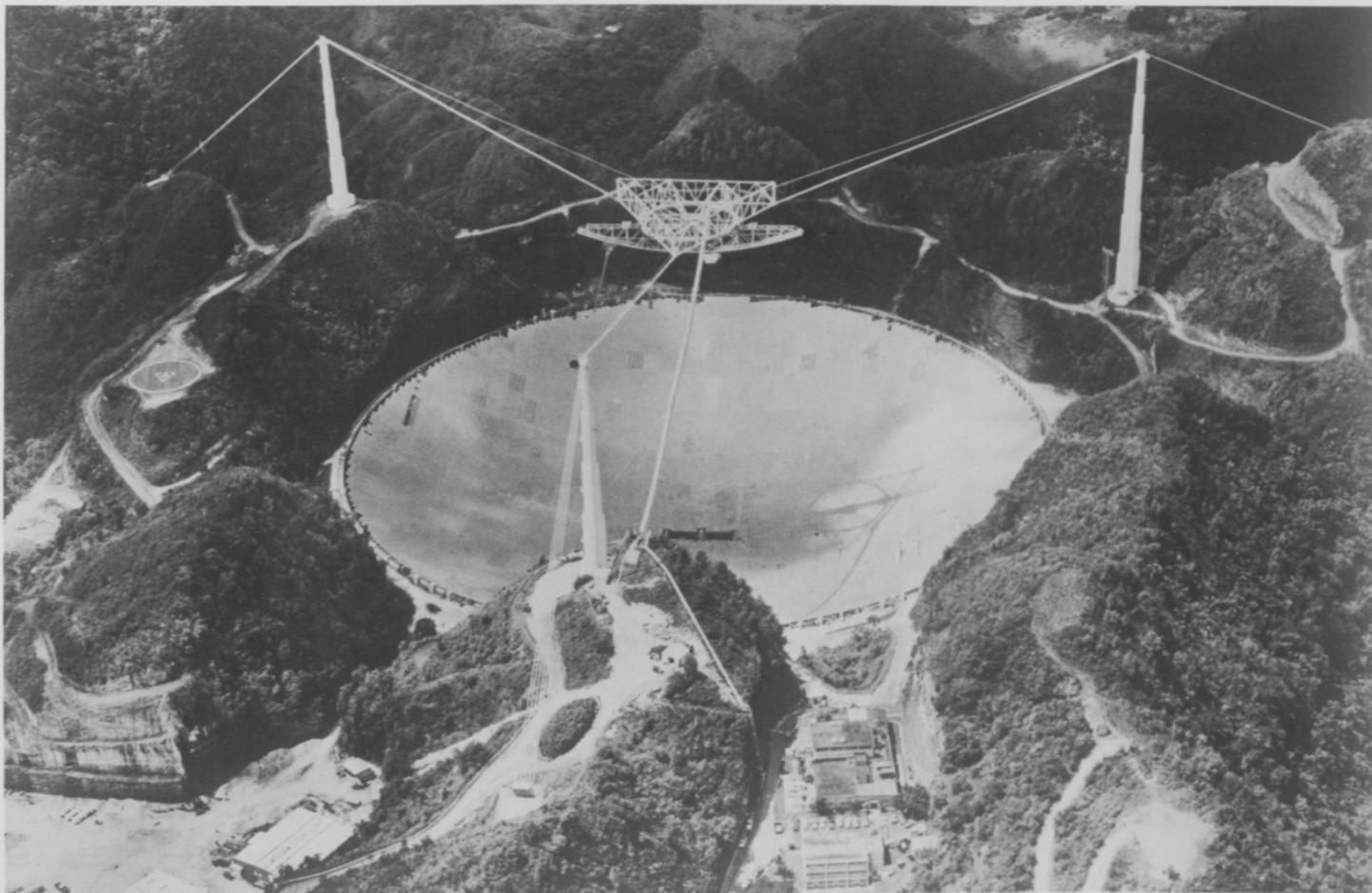
With support from the Advanced Research Projects Agency of the Department of Defense, construction of

A recently released photograph of the Arecibo observatory shows the 1,000-foot-diameter dish-shaped reflector surface and the 600-ton triangular feed support structure suspended overhead from three towers. The huge instrument is used both as a receiver to detect radio energy and as a radar telescope to transmit radar pulses and receive reflected signals.

Also visible in the photograph are the control room complex and office buildings (lower center), factory and service

buildings (lower left), and a helicopter landing pad (far left, center). The 118-acre site is located eleven miles southwest of the coastal city of Arecibo, in a natural bowl formed as a sinkhole. The location has the advantages of being near the equator, having moderate temperatures and minimal sources of electrical interference, and being protected by surrounding hills.

The original cost of the facility was \$9.3 million, and the cost of the recent upgrading was \$8.8 million.



1. Senior staff members of the Arecibo observatory include (left to right): Harold D. Craft, Jr., director of observatory operations; Frank D. Drake, director of the National Astronomy and Ionosphere Center, which administers the observatory; and Rolf B. Dyce, associate director of the observatory.

Craft studied at Cornell for an undergraduate degree in electrical engineering, awarded in 1961. Drake also attended the Cornell College of Engineering as an undergraduate; he received a bachelor's degree in engineering physics in 1952. Dyce holds a Cornell baccalaureate degree, awarded in 1951, and also a Ph.D., awarded in 1955.



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the observatory was begun in 1960, and it opened in 1963 with Gordon as the first director. Today several of the senior staff members are Cornell engineering graduates (see picture).

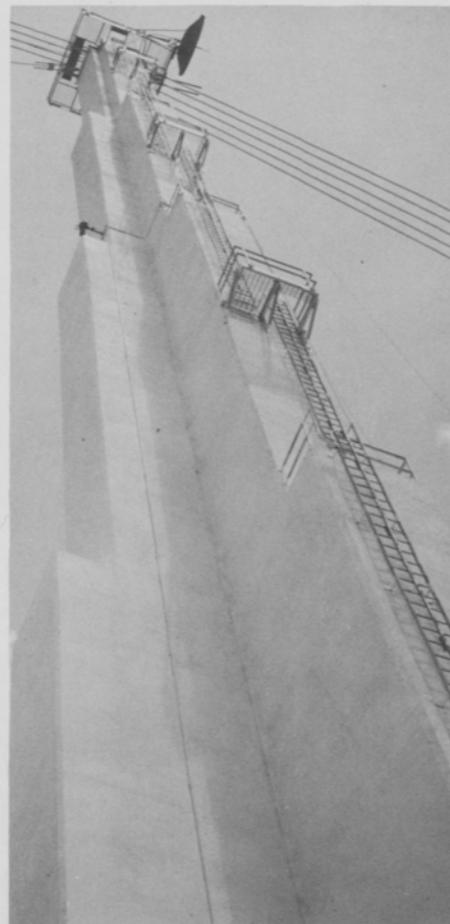
College research projects that have made use of the Arecibo facilities include ionospheric studies directed by electrical engineering professor Donald Farley and by his former colleague, the late Neil M. Brice. The observatory is available to all scientists on a competitive basis; about eight projects are in operation at a time.

Several College faculty members served as consultants in the recent upgrading. Members of a technical committee that evaluated proposals for the resurfacing included McGuire, the chairman, and Belcher. McGuire also served as a consultant to the Cornell Department of Construction in assessing required structural changes of the total installation. A computerized structural analysis of the superstructure was worked out by McGuire, Peter Gergely of the structural engineering department, and several graduate students. Farley and some of his students de-

signed and installed new digital processing equipment in 1971-72.

With the new surface and the new transmitter, the radar will be about one hundred times more powerful than any other comparable instrument. During the 1975 conjunction of Venus and Earth, for example, it will provide surface images of Venus that are expected to be comparable in quality to recent optical photographs of the moon. The radar telescope will be able to obtain reflections from the moons of Jupiter.

The Arecibo observatory facilitates research in radio and radar astronomy and ionospheric physics that cannot be conducted anywhere else. It is used for studies of the earth's atmosphere, the moon, the planets, and radio sources deep in space. Research at Arecibo increases knowledge and understanding of our planet's near and far environment; perhaps the radio telescope there will receive Earth's first evidence of intelligent life in extraterrestrial space. The Arecibo telescope is a unique scientific instrument made possible by technological skills, and it is a source of satisfaction to Cornell engineers.



2. Three towers of varying height up to 365 feet are used to suspend the feed support platform over the reflector.

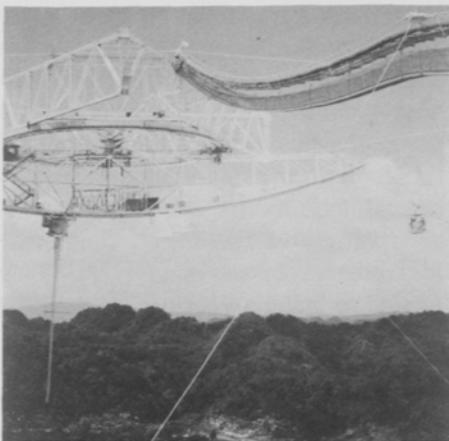
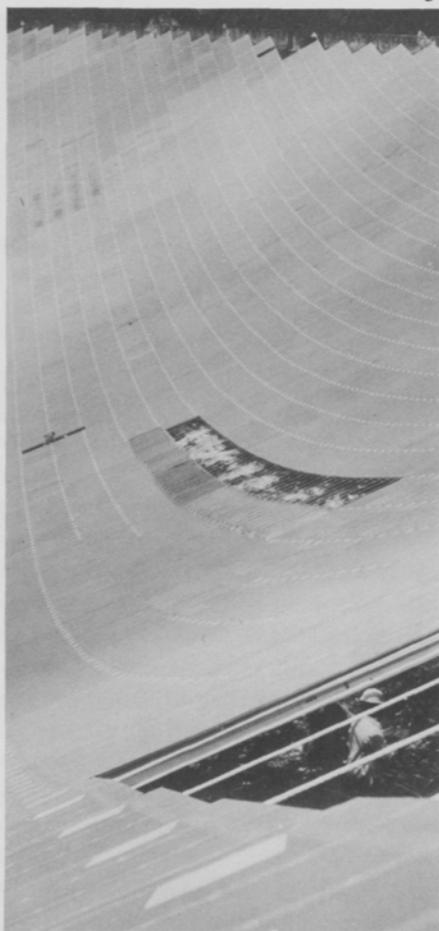
3. Access to the platform is by a 700-foot catwalk (upper right) and a cable car (middle right), which extend to the rim of the bowl. The observatory's largest feed (96 feet long) hangs from the triangular platform.

4. The support structure is suspended some 500 feet above the ground over the reflector bowl. The feed arm, attached to the triangular platform, is 304 feet long, 12 feet wide, and 33.5 feet high, and rotates around a circular track 130 feet in diameter. Two carriage houses, carrying transmitter equipment and feed lines, travel on a lower track.

5. Workers are installing one of the new aluminum panels in the 19.8 acre reflector surface in this photograph taken last spring.

6. The original steel mesh surface has been replaced with 38,778 of the perforated aluminum panels, which are attached by steel fittings to a network of steel cables. The new surface has a contour that is more nearly spherical to permit a minimum operating wavelength of 4.2 centimeters, as compared with 54 centimeters originally.

7. Workers wear special footpads to distribute their weight when walking on the reflector surface.



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REGISTER

A number of College of Engineering faculty members assumed new responsibilities with the opening of the 1974-75 academic year. Appointed were a dean, directors of University programs and centers, and heads of academic units. Also announced this fall was the retirement of Donald B. Gordon as director of industrial liaison at the College.

■ *Richard H. Lance* was named an associate dean of the College with responsibilities for programs involving outreach beyond the campus. The appointment will permit the coordination within one administrative unit of various activities in this area. Included will be the continuing education program, instructional television services, and the Cornell Consortium and other industrial liaison activities. Contact will be maintained with the undergraduate Engineering Cooperative Program, which will remain under the direction of Professor *Robert N. Allen*.

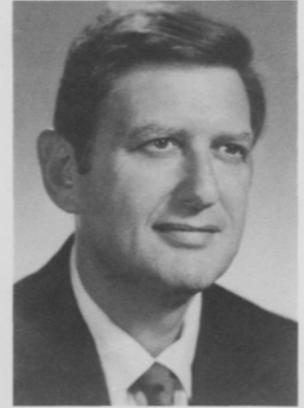
Lance has been a professor of theoretical and applied mechanics at Cornell since 1962, and last year served as acting chairman of the department.



Lance



Johnson



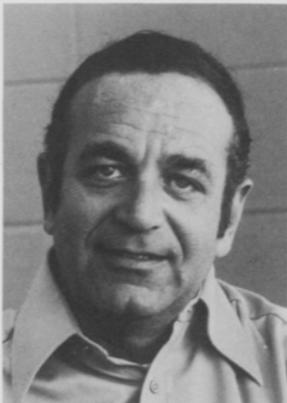
Levine

He came to Cornell after completing doctoral studies in engineering mechanics at Brown University. He began his university education at the University of Illinois, which granted him the B.S. degree in mechanical engineering, and he earned an M.S. degree, also in mechanical engineering, at the Illinois Institute of Technology. He is a specialist in engineering plasticity and the inelastic behavior of solids.

■ *Herbert H. Johnson*, professor of materials science and engineering, be-

gan a five-year term as director of the Materials Science Center, an interdisciplinary organization which facilitates graduate research supervised by some fifty-five faculty members from six departments. The center operates several laboratories which provide a wide variety of specialized equipment for research in the many disciplines related to materials science.

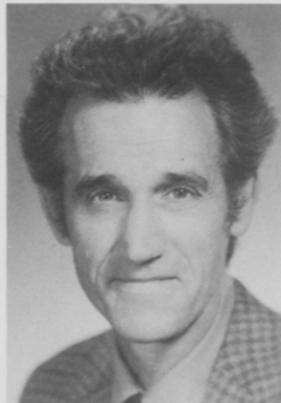
Johnson is a specialist in the mechanical behavior of solids, and in recent years has concentrated his research efforts on a study of the dif-



Auer



Batterman



Balluffi

fusivity, solubility, and distribution of hydrogen in irons and steels, and the association between dissolved hydrogen and structural defects in these materials.

He received three degrees, including a doctorate in metallurgy, from Case Institute of Technology, and joined the Cornell faculty in 1960 after teaching for several years at Lehigh University. He has served as Graduate Field Representative and, most recently, as director of the Department of Materials Science and Engineering.

■ *Gilbert Levine*, professor of agricultural engineering, is the new director of Cornell's Water Resources and Marine Sciences Center. He succeeds *Leonard B. Dworsky*, who had served as director of the center since its formation ten years ago and has now returned to full-time teaching and research in the School of Civil and Environmental Engineering.

The center has been associated with both regional and federal water resource programs, and is the designated water resource institute for New York

State. Involved in the activities of the center are Cornell personnel from many departments and disciplines.

Levine holds both B.S. and Ph.D. degrees from Cornell, and has been a member of the faculty since 1952. His research interests include irrigation system design, tropical irrigation, water resources management, and soil-water-plant relationships.

■ *Peter L. Auer*, professor of aerospace engineering, has assumed leadership in the organization of a new program at the College in the area of energy studies. He will be responsible for coordinating existing activities in this field, and developing a coherent academic and research program. The appointment is for a three-year period.

Auer, a specialist in plasma physics, has been director of the University's Laboratory of Plasma Studies for the past six years. *Simpson Linke*, professor of electrical engineering, has agreed to serve as acting director of that laboratory.

Auer joined the Cornell faculty in 1966 after fifteen years in industrial re-

search and governmental research administration. He holds the A.B. degree in chemistry from Cornell and the Ph.D. in chemistry and physics from the California Institute of Technology.

■ *Boris W. Batterman* succeeds *John Silcox* as director of the School of Applied and Engineering Physics for a five-year term. Silcox will return to full-time teaching after a sabbatic leave.

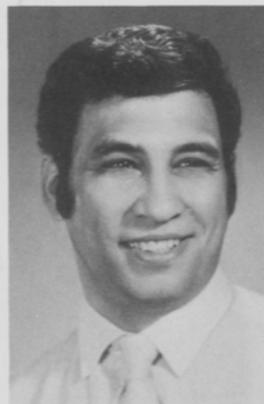
Batterman came to Cornell in 1965 after nine years with the Bell Telephone Laboratories. He holds a joint appointment in materials science and engineering and in applied physics. His baccalaureate and doctoral degrees in physics are from the Massachusetts Institute of Technology.

A specialist in x-ray and neutron diffraction and solid state physics, he recently spent a year's leave working in the Euratom Laboratories in Ispra, Italy, as a recipient of Guggenheim and Fulbright fellowships.

■ *Robert W. Balluffi*, the Francis Norwood Bard Professor of Materials Science and Engineering, began a five-year



Pao



Levin



Gordon

term as director of that department this fall. He joined the Cornell faculty in 1964 after nine years at the University of Illinois at Urbana.

Balluffi began his engineering education at the Massachusetts Institute of Technology in 1941 and was awarded the Sc.B. degree in metallurgy in 1947 after serving in the Army for three years during World War II. He continued at MIT in graduate studies and received the Sc.D. degree, also in metallurgy, in 1950. Before joining the Illinois faculty, he worked for four years at the Sylvania Electric Company and spent a year as a research associate at the Columbia University School of Mines.

His research interests center on the study of crystal defects. His work has included electron microscopic and x-ray diffraction studies of defects in metals.

■ *Yih-Hsing Pao*, professor of theoretical and applied mechanics, assumed the chairmanship of that department for a five-year term beginning last July.

Pao received his undergraduate education in civil engineering at National

Taiwan University, and then came to the United States for graduate study. He holds the M.S. degree in mechanics from Rensselaer Polytechnic Institute, and the Ph.D. in applied mechanics from Columbia University. He joined the Cornell faculty in 1958.

His specialty fields include wave propagation in solids, magnetoelasticity, and vibrations.

■ *Simon A. Levin*, associate professor of theoretical and applied mechanics and of ecology, has been named chairman of the Section of Ecology and Systematics in the Division of Biological Sciences for a five-year term.

Levin came to Cornell in 1965 as a member of the faculty of the College of Arts and Sciences, and joined the College of Engineering faculty in 1972. His main area of research interest is the application of mathematics to various fields, including ecological and evolutionary studies, and the mechanics of biological systems. He holds the B.A. degree from Johns Hopkins University and the Ph.D. in mathematics from the University of Maryland.

■ *Donald B. Gordon* is retiring as director of industrial liaison after nearly eight years of service in that office.

Gordon came to Cornell after a twenty-eight-year career in the United States Army that began during World War II and included active duty with the field artillery in Europe, participation in the occupation of Japan, combat and intelligence commands in Korea and Laos, assignment as a professor of military science at the University of Missouri, and supervisory work in civil affairs for the Continental Army Command. Injuries sustained in a parachute accident while he was training Special Forces personnel led to his retirement from active duty in 1967 at the rank of colonel.

Gordon is a 1938 Cornell graduate in civil engineering, and holds an advanced degree in personnel and business administration from George Washington University. Before beginning his military service, he had industrial engineering experience in building dams, powerhouses, and power distribution lines, and in the design and production of quonset huts for the Navy.

FACULTY PUBLICATIONS

The following publications and conference papers by faculty members and graduate students of the Cornell College of Engineering were published or presented during the period February through April 1974. Earlier publications inadvertently omitted from previous listings are included here with the date in parentheses. The names of Cornell personnel are in italics.

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Irwin, L. H., and Dunlap, W. A. 1974. *Properties of composite materials for use in expedient paving systems.* Report no. AFWL-TR-73-49 of the Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico.

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Schulte, D. D.; Loehr, R. C.; Haith, D. A.; and Bouldin, D. R. 1974. Effectiveness of Nitrogen Control in Poultry Waste Man-

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Bereano, P. L. 1974. Courts as institutions for assessing technology. In *Scientists in the legal system*, ed. W. Thomas, pp. 73-96. Ann Arbor: Ann Arbor Science Publishers.

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