is shifted to another station, then the probability of overlap is 72 percent for a 1-minute delay and 82 percent for a 2-minute delay. For rotations at 5-minute intervals, the probability of overlap is reduced to 32 percent, or to 50 percent for a 1-minute delay.
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24. The colony was the gift of J. R. Tollet of Palo Cedro, Calif., who was suggested by H. H. Laidlaw of the University of California, Davis.
25. The colony was the gift of D. A. Grigg of Harper, Ore., who was suggested by W. P. Stephen of Oregon State University.
26. The queen in each colony had been originally obtained from H. E. Park of Palo Cedro, Calif.
27. The number tags were obtained from Chr. Graze K.G., Württemburg, Germany. Each set consists of numbers running from 0 to 99 in five colors, thus of 500 unique tags. By the addition of small dots of colored paint, the number of unique tags was increased to 2200.
28. N. E. Gary, personal communication.
29. The orange oil and peppermint oil were obtained from Safeway Stores, Inc., Oakland, Calif.
30. *Local Climatological Data August 1969; Local Climatological Data September 1969* (published by the U.S. Department of Commerce and available from U.S. Department of Commerce, Federal Building, Burns, Ore.).
31. Permission to use this site was kindly provided by J. W. Riley, district manager, Bureau of Land Management, Burns, Ore.
32. This information was provided by C. Bacon of the Bureau of Land Management, Burns, Ore.
33. The research discussed was funded by U.S. Public Health Service grant FR 07003 and by a grant from the Ford Foundation through the Associated Students of the California Institute of Technology Research Center. We thank Lynda MacLeod and Paul Carpenter for technical assistance, Dennis DiBartolomeo for technical assistance and aid in developing the capturing technique, Drs. N. E. Gary and H. H. Laidlaw for valuable technical advice, Dr. Ian Phillips for thoughtful criticisms, Dr. R. L. Sinsheimer for arranging much of the financial support, and especially Dr. Seymour Benzer, without whose interest, advice, and guidance the research would not have been possible.

A Scientific Safari to Africa

Africa needs help from U.S. scientists with its problems of health, agriculture, technology, and education.

Glenn T. Seaborg

As the technicians removed the sample containers from the target holder, the laboratory director explained how the radiation-attenuated organisms of the parasitic disease leishmaniasis were being tested to determine their immunological potential. Success would offer a means to control the vicious disease leishmaniasis, which disfigures and blinds millions in the tropics.

The scene I was witnessing and the explanation I was receiving were occurring not in a highly advanced U.S. medical research laboratory but on the outskirts of Addis Ababa, in a modest building that houses the Institute of Pathobiology of the Haile Selassie I University. The explanation of the application of one of the most advanced and progressive techniques for the control of parasitic diseases was being given by Aklilu Lemma, dean of the Faculty of Sciences of the university and director of the laboratory. I was visiting Ethiopia—and five other African countries—with several other U.S. scientists and scientific administrators (*1*) to become better acquainted with African science, to establish contacts between African and U.S. scientists, and to identify ways in which closer and more effective cooperation with science in Africa might be achieved.

In almost 9 years as chairman of the Atomic Energy Commission, I had already visited over 50 countries, ranging from the technologically and scientifically advanced nations of Europe to the developing states of Asia and Latin America. Despite my long-standing interest in Africa, I had avoided a visit there because I doubted whether the state of scientific—and especially of nuclear energy—development would justify the trip. Finally, however, conversations with other government officials led to the idea that a visit to Africa by a senior U.S. government science official would be beneficial. Secretary of State William P. Rogers gave the plan his enthusiastic support.

I was to visit Africa in my capacity as a scientist, rather than specifically as chairman of the Atomic Energy Commission. My purpose was to make a broad-ranging evaluation of science on that continent and of the prospects for beneficial scientific cooperation between the United States and the countries I would visit. An itinerary was drawn up which included six countries: Morocco, Tunisia, Ethiopia, Kenya, the Congo (Kinshasa), and Ghana. Both northern and sub-Sahara Africa and both English- and French-speaking areas were represented. A small group of outstanding scientists in the fields of medicine, biology, and agriculture was selected and was supplemented by appropriate government officials who could follow up any leads for increased cooperation.

Our group departed on 3 January 1970 and returned 13 days and 21,720 miles later. My predominant reaction on this trip was surprise—surprise that Africa had come as far as it has in science, in self-government, and in eagerness to move ahead. Although some of the countries we visited had only a handful of college graduates just 10 or so years ago, I returned with the conviction that, in many respects, Africa is moving faster (although from a more elementary base) and has more unclouded prospects for technological and economic progress than many developing nations in other parts of the world.

If the progress in Africa is surprisingly impressive, the needs are even more apparent. The efforts to develop a radiation-attenuated vaccine for the leishmaniasis organism is an example. In a well-equipped laboratory, the irradiation would be conducted with a small cobalt-60 gamma source, rather than with the electron accelerator with maximum energy of 300,000 electron volts that Dr. Lemma was using, in order to ensure uniformity of dosage throughout the entire sample. Dr. Lemma was well aware of this deficiency in his procedure and was anxious to correct it.

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If we want to seize the opportunities that exist to help Africa in a number of modest but highly effective ways, much of the initiative must come (in light of current budgetary restrictions) from nongovernmental individuals, institutions, and resources in the United States. This article is one of several steps that I am taking to inform the American scientific community of the opportunities for exciting and productive cooperation with emerging Africa. If it generates even a handful of new contacts between American scientists and their African counterparts, its preparation will have been worthwhile. Throughout the article I have identified people and institutions in Africa in the hope that interested American scientists will contact them directly.

What We Saw

Throughout Africa, the scientific emphasis is on agriculture and medicine and, most importantly of all, on science education. Since science ministries generally do not exist, responsibility for scientific research is spread among the "using" ministries and the universities. The universities in particular are the focal points of scientific achievement and planning for the future. The heads of the university science faculties are often, therefore, the "de facto" senior science officials of the countries we visited. The ministers of agriculture and health are also influential in scientific affairs. I was gratified to discover that the heads of governments themselves have a lively interest in science and a sharp recognition of its importance to their national development. Emperor Haile Selassie, for example, who contributed one of his palaces with its grounds to provide the core of Ethiopia's Haile Selassie I University, told me that he believes science and technology will play a crucial role in Ethiopia's, and indeed in all Africa's, development.

Morocco

Morocco was a more traditional land than we had expected, despite its many years of close contact with European technology through association with France.

Its economy remains primarily agricultural, and King Hassan himself has directed that emphasis in the development of Morocco be placed on agriculture. Its modest scientific program is thus pointed in this direction, but public health and mineral exploitation are also important.

The Minister of Agriculture, Mohamed Benhima, explained to us that the most critical problem in conducting agricultural research programs is the shortage of personnel, including both professional scientists and skilled technicians. This refrain was heard over and over again during our African visit. Because of this shortage, there is heavy dependence on foreign scientific personnel. Local officials and foreign personnel are cooperating in strenuous efforts to train local scientists and to prepare them to assume leadership roles as expeditiously as possible.

Agricultural research work in Morocco is conducted in the National Institute of Agricultural Research (INRA), founded during the French rule, and in the biology department of the Faculty of Sciences of the Mohammed V University, both in Rabat.

Albert Sasson, chairman of the biology department of the Faculty of Sciences and a native of Morocco, is typical of the competent, highly qualified, and enthusiastic young scientists who are now making their way upward in African educational and scientific institutions. In addition to providing inspiring leadership to this department, Professor Sasson is personally engaged in research on the physiology of olive and citrus trees, a subject of immediate relevance to Moroccan agriculture. Other areas in which the department is active include the effect of calcium on nitrogen metabolism, nitrogen fixation by legumes, and the mycology and microbiology of arid soils.

Morocco has important mineral resources, principally phosphates, and reasonably good prospects for future discoveries. This fact has given rise to an interesting research project involving radioactive dating of Precambrian rocks by the argon-potassium and rubidium-strontium methods. This work is performed at the laboratory of the Ministry of Commerce, Industry, Mines, and Merchant Marine, under Minister Mohamed Jaidi.

Minister Jaidi is also responsible for an interministerial committee to explore and coordinate Moroccan programs in the peaceful uses of nuclear energy. The committee has a small full-time staff headed by Ahmed Majid. From these officials we learned that the maintenance of foreign equipment is a common problem due both to inadequately trained manpower and to frequent shortages of spare parts. On later laboratory visits, we sometimes saw equipment that was inoperable because parts as simple as transistors or vacuum tubes were unavailable.

Over the last several years, Morocco has received significant assistance in the peaceful uses of nuclear energy from the International Atomic Energy Agency (IAEA) in Vienna. This was our first direct encounter with the agency's technical assistance program in Africa. Throughout our visit, we learned that the agency's modest program of providing equipment grants, fellowships, and experts was the principal link of African scientists to the possibilities of beneficial uses of nuclear energy.

The medical uses of radiation and radioisotopes are the most intensive current use of nuclear energy in Morocco. A Soviet-built cobalt-60 teletherapy unit supplied by the IAEA is in use in Casablanca at the Radiological and Cancer Control Center of Morocco, and a small medical radioisotope clinic is functioning at the Avicenne Hospital in Rabat. Research efforts at the Rabat clinic are interesting and advanced; the work there on the use of technetium-99^m to identify tuberculous disease of the spinal cord brought us into direct contact with a problem that is commonplace in Africa. The project is now under the direction of a talented Frenchman, Robert Granier, who is scheduled to leave soon with no well-qualified Moroccan available as a replacement.

The Faculty of Sciences of Mohammed V University has an enrollment in excess of 1000, of whom about half are candidates for science degrees; the remainder are enrolled in science courses required by other faculties. Later in the tour, Dean Ben Abdeljlil pointed out that the principal function of the African university in science today is to produce science teachers. Lacking scientific and technological tradition, these countries desperately need an exponential growth in the number of students with elementary scientific knowledge, not only to provide a nucleus of future university science candidates but, perhaps even more importantly, to develop a public capable of accepting and absorbing scientific and technological innovations. This gap is one that we who come from a society oriented for centuries to the application of technology can only dimly understand.

Tunisia

Our stop in Tunisia brought us into contact with the most scientifically oriented country of our entire visit.

Tunisia has a seething fervor for education, and the greatest enthusiast and leader is President Bourguiba himself, who has assigned it the highest of national priorities and nearly a third of the national budget. Despite Tunisia's population of only 4½ million, the University of Tunis has an enrollment of 9000, of whom 2600 are studying sciences.

The university is beginning to move from its location in downtown Tunis to a strikingly handsome new campus on the outskirts of the city, built with help from several nations including the United States, which financed construction of the building that houses the law school (Fig. 1), and the Soviet Union, which financed the engineering building. The Faculty of Sciences, headed by Dean Adnan Zmerli, is awaiting completion of a magnificent building at the new campus, built with aid from Kuwait. As in Morocco, however, most of the foreign faculty members are French, many of them under French government assistance programs.

Tunisia's foreign minister, Habib Bourguiba, Jr., son of the founder and president of the nation, represents the younger generation of highly educated and informed men who are now in positions of governmental responsibility in Tunisia. Minister Bourguiba spoke to us eloquently of the role of education and science in Tunisia's effort to transform itself into a modern society.

Like Morocco, Tunisia operates a National Institute for Agricultural Research, which dates from the days of the French protectorate. There we reviewed a project, under M. B. Cheikh and F. Soria, aimed at controlling the Mediterranean fruit fly by sterilization of the male. These flies annually wreak some $3 million in direct damage to Tunisia's citrus crop and cause much higher indirect losses by inhibiting citrus culture in the areas of heaviest infestation. The technique involves release of a large population of radiation-sterilized males in a breeding area; they compete with the normal males to breed with the females and thus reduce the population of each succeeding generation.

This method has successfully eliminated the screwworm fly from large areas of the United States. However, careful and sophisticated work is required to extend the technique (if it is applicable at all) to new species.

Medical research and educational facilities in Tunis were well equipped but understaffed; obviously, outside cooperation in the form of visiting experts could be helpful. The U.S. medical research ship S.S. *Hope* was in port at Tunis at the time of our visit and was providing assistance and training to Tunisian physicians.

One well-established science in Tunisia is archeology. In modern Carthage in the suburbs of Tunis, the Bardo, an outstanding museum of Carthaginian and Roman antiquities, houses perhaps the world's largest and finest collection of Roman mosaics. Its director, Mohammed Yacoub, is a fascinating source of knowledge of ancient Carthage and its art.

Ethiopia

Ethiopia was the most atypical of the countries we visited. Never colonized and long isolated by geography and its own culture, it lacks the educational and governmental infrastructure of the former French or British colonies. Thus, Ethiopia is making the most recent entry into the world of science of any country we visited. The newness of these efforts does not, however, diminish their enthusiasm or effectiveness. Haile Selassie I University, established in 1961, already has an enrollment of 4600 students, including approximately 2700 in the Faculty of Sciences.

Like universities almost everywhere, it is experiencing student unrest and was on an extended Christmas holiday at the time of our visit because of recent troubles. This circumstance did not interfere with our meeting with university officials and members of the faculty. The university has received extensive financial assistance from the United States and has enjoyed a close cooperation with Oklahoma State University in the area of agriculture. Its academic vice president, Frank Bowles, is sponsored by the Ford Foundation.

Like new universities throughout Africa, Haile Selassie I University sees as its highest priority the creation of educators, including those needed to reduce its own still heavy dependence on outside staff. Ethiopia has one of the lowest literacy rates in Africa; however, great strides are being made in overcoming this deficiency, and the country now has 600,000 students enrolled in elementary schools out of a total population of 22 million.

The scientific emphasis in Ethiopia is appropriately on agriculture and medicine, but an interesting and important geophysical observatory is located in Addis Ababa, founded and headed by Pierre Gouin, a talented Canadian. It takes advantage of the strong seismicity associated with the nearby Rift Valley and of the close proximity of the earth's magnetic equator. Dr. Gouin's seismic and magnetic measurements are, therefore, of worldwide interest, but perhaps the most important function of this excellent small laboratory for Ethiopia is the role it plays in teaching young scientists how a small research institution can do high-quality work with a minimum of resources. In fact, this lesson is one that Dr. Gouin could teach admirably to many of our own laboratories. The observatory manages, against difficult odds, to keep its instruments in operating order. Instrument maintenance, as I have noted earlier, is an ever-present problem in Africa, and Ethiopia shares the need for more trained technicians and for more spare parts.

Ethiopia is a focal point of tropical diseases. Partly for this reason, Addis Ababa is the site of the Naval Medical Research Unit No. 3 (NAMRU 3), the U.S. Navy's principal tropical disease research facility. Under the able directorship of Jack R. Schmidt, this well-equipped and well-staffed laboratory is doing outstanding research on tropical diseases of interest both within and outside Ethiopia. Here again, a valuable by-product of the effort is the opportunities created for the training of local scientists.

The majority of Ethiopians are highland animal raisers, and animal production thus presents some of the most critical problems in Ethiopia's largely agricultural economy. Lands are overgrazed, and the underfed cattle are highly susceptible to diseases. Veterinary medicine is seriously underdeveloped, with only about a dozen Ethiopian and 50 foreign professionals working in this field. Outside assistance would obviously bring large returns in this area.

In Ethiopia, we had our first discussion of a medical problem that plagues sub-Sahara Africa and is surprisingly akin to difficulties we face ourselves. This is the problem of bringing medical care to the outlying villages and rural areas where the vast majority of Africa's population lives. As in the United States, the professionally quali-

fied physicians, native as well as foreign, congregate in the few cities. Most rural residents go through life without seeing a physician. Dr. Getachen, associate dean of the medical faculty, told us that Ethiopia is therefore actively developing programs for the training of paramedical personnel.

Fig. 1. The Law Faculty Building of the University of Tunis, built with funds provided by the United States on a new campus overlooking the city of Tunis, Tunisia.

Kenya

The attraction of Kenya for its former colonial population and for today's tourist is evident immediately upon arrival at Nairobi, where the climate is surprisingly comfortable for a city within 2 degrees of the equator.

Kenya has a close association with the neighboring republics of Uganda and Tanzania. Although the hoped-for political union of these countries as an East Africa Federation did not materialize, cooperation is still close, and many common institutions, including universities and research organizations, still exist.

The Kenyans are largely farmers and are deeply attached to the land. The British left them with an impressive scientific and educational infrastructure, which they have preserved well and built upon significantly. All of these factors, physical and human, combine to make Kenya a land of great current attractiveness and future potential.

Kenya's vice president, Daniel arap Moi, in common with many other African leaders we met, expressed a keen understanding of the role science could play in his country's development. He also pointed to the inspirational value for African scientists of contacts with scientists from abroad, as exemplified by our visit.

Few of the scientists we met on our visit matched the enthusiasm, eloquence, and ability of J. M. Mungai, dean of the Faculty of Medicine of the University College of Nairobi. Dean Mungai stressed the need for an expanded system of public health for the country. He described the modest beginning that has already been made in the form of regional clinics manned by paramedical personnel sufficiently skillful to treat common ailments and capable of referring cases to physicians in the city when necessary.

Kenya has 1200 physicians for a population of 11 million, but most of these physicians practice in the cities and only 20 percent are native Kenyans. Dean Mungai sees the current role of the physicians in countries such as Kenya as that of education, administration of a public health service, maintenance of satisfactory standards of health care, and, of course, treatment of cases beyond the capacity of paramedical personnel.

It was Dean Mungai who was most articulate in expressing to us the importance of allowing Africans to set their own development goals. Experts, he explained, will always be welcome to help in reaching those goals, but the objectives and programs themselves must be locally determined.

University College, with an enrollment of 2000, is located on an attractive campus that would do justice in natural and architectural beauty to any in the United States (Fig. 2). Its principal, A. T. Porter of Sierra Leone, described the close relationship between University College and the University of California, an arrangement that we believe can be a model for "sister university" relationships between every African university and an American counterpart.

The science and engineering faculties of University College still serve the regional grouping of Kenya, Uganda, and Tanzania. The engineering faculty is almost entirely British, but the proportion of native Kenyans in the science departments is considerably higher. The dean of the engineering faculty, W. B. Palmer, on loan from the University of Leeds, believes that upon graduation the African students are as well qualified as their European counterparts academically but that they fall short in experimental and practical skills because of the absence of a technological tradition in Africa.

Outside Nairobi is located the East Africa Agricultural and Forestry Research Organization (EAAFRO), an institute dating back to the pre-World War I German protectorate. It is extensively supported under the U.S. technical assistance program and is directed by an American, Ordway Starnes. As a regional organization for Kenya, Tanzania, and Uganda, it attempts to fill gaps in national agricultural research programs rather than conduct a comprehensive research program of its own.

An interesting sidelight is that the laboratory has a herbarium with 140,-

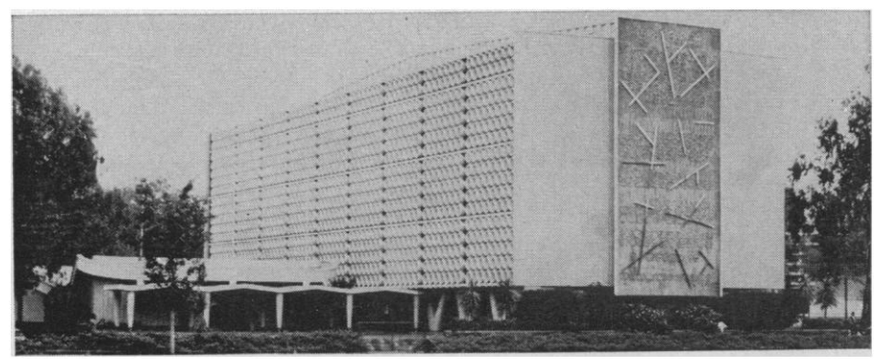

Fig. 2. One of the strikingly modern buildings of University College, Nairobi, Kenya.

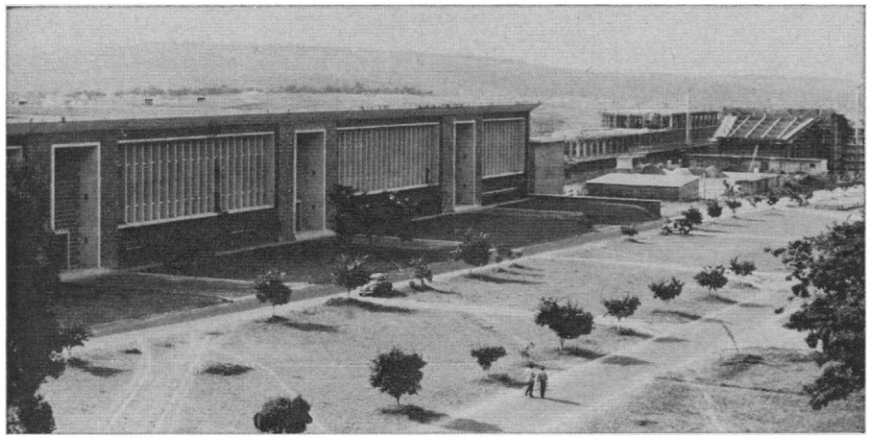

Fig. 3. The main quadrangle of the Lovanium University, on the outskirts of Kinshasa (formerly Leopoldville), in the Democratic Republic of the Congo. The campus buildings are designed, engineered, and constructed by university personnel under the supervision of Monsignor Luc Gillon.

000 species of plants which are being examined in the United States by the National Institutes of Health for anticarcinogenic properties. However, its main programs are directed toward local needs, including the improvement of livestock and the development of grains suitable for use on the marginal lands that constitute much of the three countries' land area.

The EAAFRO publishes one of the few science journals produced in Africa, the *Agriculture and Forestry Journal*. An activity related to the journal is the East African science information service, initiated in 1966. Through this service, scientists in East Africa receive copies of table of contents of journals and can subsequently obtain any desired articles upon request. The service distributes about 40,000 articles a month to about 113 locations in eastern Africa. The information service has approximately 934 journals in its library, and it calls on other libraries of universities in the area for assistance.

Aside from direction of the laboratory's research program, Dr. Starnes, like overseas experts throughout Africa, regards his principal task to be one of developing local scientists to replace himself and his expatriate colleagues. The laboratory's staff today numbers over 100 scientists and technicians.

Congo (Kinshasa)

In Kinshasa (formerly Leopoldville), we visited the impressive Lovanium University, which was created in 1954 and now has an enrollment of 3300 students (Fig. 3). The present rector is Monsignor Th. Tshibangu. Here we met Luc Gillon, a driving force in the establishment of the university, first rector of the university, and still a very active administrator there. Monsignor Gillon, a nuclear physicist from Belgium, was instrumental in the establishment of the university's Nuclear Research Center. The director of the center and the government's commissioner of nuclear science is Felix Malu.

The Nuclear Research Center has a 50-kilowatt (thermal) Mark I Triga research reactor, which was placed in operation in 1959 and is the only nuclear reactor in Africa outside of the United Arab Republic and South Africa. It is soon to be upgraded to 200 kilowatts (thermal). The center has received much assistance from the International Atomic Energy Agency and from the United States. The general research program of the center includes the areas of agronomy, medicine, biochemistry, radiochemistry, and radiological protection. It is evolving into a regional center providing training for students from member states of the Organization for African Unity.

A United Nations hospital is located at Lovanium University and is staffed and operated by Danish personnel. Although the hospital's facilities did not appear to be particularly modern, the training and enthusiasm of the staff made it an impressive operation. As in other African countries visited, infectious and nutritional diseases are the most prevalent in the Congo, and outstanding research is being conducted by Jacob Raft and his Danish colleagues at the hospital.

On the flight out of the Congo, we were able to fly over the Inga Dam site on the Congo River. Construction is underway on a dam that will provide a modest amount of electricity to meet Kinshasa's short-term requirements. If fully developed, the site could be one of the world's largest and cheapest sources of electricity.

Ghana

Ghana, with its three universities and a comparatively long history of its talented students obtaining graduate degrees from British universities, has a very strong intellectual structure. Emphasis in current programs is on encouragement of graduate training in the sciences.

In Accra, I visited with Prime Minister K. A. Busia for discussion of Ghana's needs in the education field and the value of scientific visits such as ours.

At the University of Ghana at Legon (Fig. 4), Alexander Kwapong, the exceptionally able vice chancellor, explained that the university now has a student body of 2500 and has produced 4000 graduates so far. The university has research institutes in the fields of animal science, irrigation, and forest products. Dr. Kwapong described the exchange relationships that the university has with numerous universities in the United States and the United Kingdom. He said that the exchanges of students and professors had been very beneficial but that increased numbers of American scientists, as well as up-to-date equipment, were needed for advancing education at the university. For example, the university has acquired an IBM 1620 computer and a grant to obtain a director for the operation of a computer center, but thus far it has been unable to locate a properly qualified man.

Dr. Kwapong noted that plans are being developed for a research program on environmental effects, with emphasis on the biological sciences. Also planned is a tropical biology center to be located in West Africa. American efforts have contributed already to the Volta Lake project, a scientific laboratory for the study of artificial lakes and their phenomena, which is of great importance to the future of Africa.

After discussions with Modjaben Dowuona, chairman of the Council for Scientific and Industrial Research (CSIR), we visited some of the labo-

ratories of the CSIR, which is composed of a number of institutes relating to industrial applications, aquatic biology, and agricultural research. At present, approximately 70 percent of its funds are spent on agricultural research, with cocoa receiving the most attention because it is the major cash crop. Although we were unable to visit the Cocoa Research Institute, 105 kilometers north of Accra, we were told that it has an impressive Radioisotope Research Institute, which is well equipped for up-to-date research on ways to control the diseases that now threaten the important cocoa crop of Ghana.

Another laboratory we visited was the Radioisotope Applications Center directed by B. W. Garbrah, which falls under the jurisdiction of Ghana's Atomic Energy Committee, headed by J. A. K. Quartey of the department of chemistry of the University of Ghana. Research there is devoted primarily to the use of radioisotopes in the fields of medicine and agriculture. The center has fine facilities, but its work is limited by the lack of modern equipment. The laboratory is located at the site of an uncompleted research reactor, which the Nkrumah government had acquired from the Soviet Union. The decision of the new government not to complete this costly facility and to concentrate on radioisotope applications that are more in keeping with Ghana's needs and capabilities is indicative of the responsible approach of the present government.

Particular attention at the Radioisotope Applications Center is given to film badge monitoring for hospitals in Ghana and to the study of the effects of antimalarial drugs on humans. A whole body counter is being built, and renography and thyroid studies (using iodine-131) are to be undertaken.

At the Medical School of the University at Ghana, located at the Korle Bu Hospital, we visited with Dean C. O. Easmon and Silas R. A. Dodu, head of the department of medicine. Their work includes research on malaria and development of a family planning program through establishment of community houses.

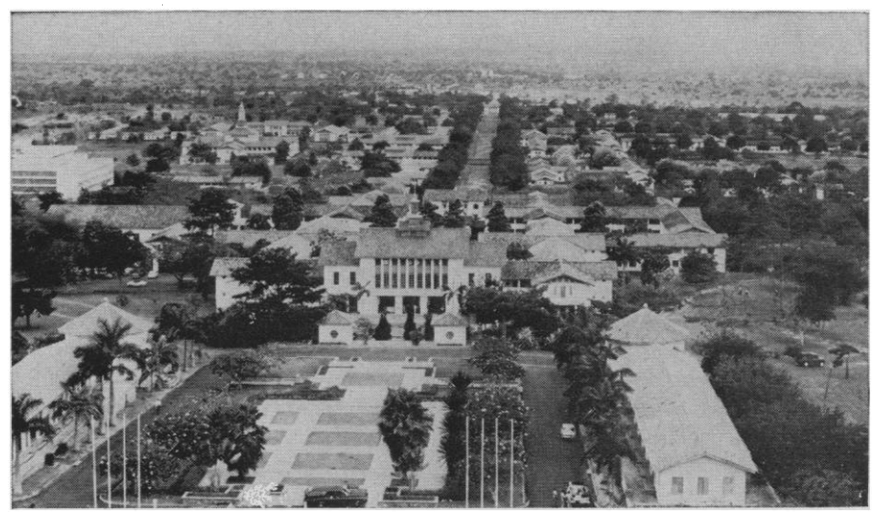

Fig. 4. The University of Ghana campus at Legon, near Accra.

Observations and Conclusions

I have already put forward the principal conclusion of our mission. Briefly, scientific talent is present in Africa and is making real and current contributions to the solution of Africa's problems, contributions that can be greatly enlarged with even modest outside support.

Despite the generally early stage of scientific and technological development in the countries visited, they are making good use of the small nucleus of the well-qualified and dedicated administrators, scientists, and doctors present, most of whom were educated in the United States or Western Europe, to help ensure the growth and independence of their respective countries.

This core of trained and enthusiastic professionals constitutes an irreplaceable asset to the African nations, which needs to be properly encouraged and supported in the development of scientific, educational, medical, and agricultural programs. The focal points for development of these programs are generally the universities, most of which have received assistance from the United States. Fortunately, government leaders usually recognize the important role to be played by these institutions and, within the limitations of available manpower and financial resources, provide support in maintaining and expanding them.

There was widespread agreement in the countries visited that improvements in agricultural techniques are imperative in order to provide more food, to cope with population increases, and to reduce the present high incidence of disease through improvement of nutritional standards. Almost equally important is the expansion of public health activities in the rural areas where most of the people live. The degree of progress to be achieved in resolving problems in these areas will depend, to a great extent, on how quickly the African nations can apply scientific techniques to these problems.

African government and university officials welcome the assistance and support that is needed from the advanced countries, but, to their credit, these leaders are anxious to proceed on their own initiative and would regard such assistance as being of an interim nature.

We found that technical assistance provided under United Nations development programs has been most valuable in meeting immediate requirements. In my own field of special knowledge, for example, in each of the countries we visited the International Atomic Energy Agency has provided equipment and experts, which are being used in the development of new techniques in such areas as agriculture, medicine, and mineral exploration.

Private foundations and universities in the United States have been particularly helpful in supporting and encouraging African education and medical research. We were often reminded of the importance of this assistance and the desire of African universities and specialized institutes for closer relationships with these American groups. We were encouraged to see that local representatives of the U.S. Agency for International Development are becoming increasingly involved with technical assistance to scientific and educational programs and are aware of the role of science and technology in the developing countries.

These are observations on the bright side. Clearly, African science is not without problems. We found that major communication gaps are present at all levels of African science. There is an inadequate and delayed flow of information between Africa and the United States and other advanced countries, among the African states themselves, and even among different institutions within each state. Members of our group repeatedly heard from members of the African scientific community that they felt cut off from their colleagues in the mainstream of scientific activities, particularly those in the advanced countries that have the most to offer. Owing to limitations in their own budgets, these African scientists are usually unable to travel abroad and to participate in international scientific meetings. Even the number of scientific journals and other publications that they receive is limited. Moreover, these journals are received many months after publication, with the result that they cannot keep current on research being conducted elsewhere.

The African states must cope with the problem of training an ever-increasing number of professionally qualified people in all fields, including the sciences. Further, there are very limited opportunities for graduate and postgraduate education at the universities today, and funds are limited for sending students abroad for advanced training.

There is a shortage of equipment in most of the universities and hospitals, as well as an acute shortage of skilled technicians to maintain the equipment that is already there.

Perhaps less demonstrable, but equally valid in our collective view, is the general conclusion that Africa has bright prospects for sound and steady development. Part of this feeling may have derived from the observation that Africa, in comparison with other developing areas visited by various members of our group, is by and large not yet overpopulated. It would be too much of a simplification to say that population problems are not present, but the crushing burden of people that is so evident already in parts of Asia and Latin America is still absent in all or most of Africa. But population growth rates are high, and a well-planned and determined effort is needed now if Africa is to avoid the morass of overpopulation.

Finally, we felt that we saw in the people a receptivity to ideas and advice, and to change itself, which should accelerate the development process.

If we are correct in these observations, Africa is deserving of all the help we can give it. Here are our views on what can be done.

Recommended Actions

The single most important step that we can take is to increase the exchange of scientists and technologists at the graduate and postgraduate levels between African nations and the United States. This exchange should take place in both directions and should cover all principal scientific fields, especially medicine, biology, and agriculture.

The current tight limitations on resources in the United States require that we devise new means by which these exchanges might be encouraged and supported. In the short term, an increase in any kind of communications between African scientists and their American counterparts could have salutary effects. Personal correspondence and newsletters from the science departments of American laboratories and universities would involve almost no funds and very little effort. Visits to Africa might be included on the itinerary of American scientists already traveling abroad, perhaps on vacation, at some cost savings in relation to trips made expressly to Africa.

In the longer run, I believe one of the most effective means for improving exchanges and communication between African and American science is by what is sometimes called the "sister laboratory" or "sister university" approach. This technique has been used to advantage in nuclear cooperation between laboratories of the U.S. Atomic Energy Commission and those in a number of developing countries and has also been used in other scientific fields. It involves the establishment of a permanent association between an overseas institution and an American one with similar interests. I believe that this arrangement develops an attitude of responsibility on the part of the "senior partner"—the American institution—for the progress of its junior partner, which brings about results that would not be possible through more casual and temporary forms of cooperation. Even where funds for salaries, equipment, and other forms of concrete assistance to implement these partnerships are severely limited, useful results can still be achieved through the continual guidance and consultation that these arrangements can provide at very little cost.

I believe the science community of the United States could set as a goal that within 3 years the science, agriculture, and medical faculties of every African university that so desires should have a "sister college" relationship with its counterpart department or college in an American university.

Another area where important help can be given at modest cost is in increasing the availability of scientific literature and documentation to African institutions. The addition of a few African institutions to the circulation list of the major American scientific journals would cost each scientific society very little. We should also try to find a way to establish one or more documentation centers in Africa through which scientific literature from abroad can be made readily available to African scientists.

We also need to increase substantially the number of scholarships available to Africans in science, medicine, and agriculture, and we need to find more Americans in these fields who can spend 1 year or more in Africa. I believe we should consider the establishment of a program by which young Americans would agree to serve a period of time abroad in exchange for government financial help in their education. We learned in Africa that such a program is pursued by France, and other countries are considering making similar arrangements. Fellowships provided by private foundations, which are already being made available to a gratifying degree, should also be increased if at all possible.

The American concept of agricultural extension services to promote the education of farmers and the practical application of existing knowledge could make a tremendous contribution in Africa. Here, too, I believe the concept of the "sister" organization relationship may be applicable. I believe African nations would be encouraged to establish extension services or to expand present ones where they exist, if they knew that their organization would be "adopted" by and have frequent access to the advice of a specific U.S. agricultural extension service.

It was heartening to find in Africa that the major share of the development burden is being carried by the

international organizations of the United Nations family. One obstacle to even more effective help from these organizations is the inexperience of many of the African nations in soliciting the advice and assistance that these bodies can provide. I would therefore suggest that each of these nations consider the establishment of an organizational unit, staffed by professionals experienced in the ways of the international organizations, to serve as a focal point for requesting technical assistance from them and from other available sources.

Beyond the ideas suggested above, there are many steps that could be taken, both by private organizations and universities and by individual scientists, to promote scientific cooperation with Africa. Our group believes that the nongovernmental role in African scientific and technological development could be greatly assisted if there were a focal point in the United States for promoting, coordinating, and following up these activities. Perhaps the most logical approach in this direction would be for a philanthropic foundation with existing ties in Africa to assume this responsibility. Another possibility is the organization envisaged by Robert E. Marshak, recently appointed president of the City College of New York, and by Roger Revelle, director of the Harvard Center for Population Studies, who have proposed establishment of an International Science Foundation that would assist scientists in the developing countries and that would not be limited to support from the United States alone. Either type of organization might well provide a timely mechanism to stimulate scientific cooperation with the African and other developing countries.

I believe there are few goals today that are more worthy of the serious support of the American scientific community.

Notes

1. Other members of the visiting team were Herman Pollack (Bureau of International Scientific and Technological Affairs, Department of State, Washington, D.C. 20520); Cyril L. Comar (New York State Veterinary College, Cornell University, Ithaca, New York 14850); William H. Taft, III (Bureau of International Scientific and Technological Affairs, Department of State, Washington, D.C. 20520); Henry N. Wagner, Jr. (Radioisotope Laboratory, School of Hygiene and Public Health, 615 North Wolfe Street, Baltimore, Maryland 21205); Norman P. Neureiter (Office of Science and Technology, The White House, Washington, D.C.); Myron B. Kratzer (U.S. Atomic Energy Commission, Washington, D.C. 20545); Justin L. Bloom (U.S. Atomic Energy Commission, Washington, D.C. 20545); John R. Totter (Division of Biology and Medicine, U.S. Atomic Energy Commission, Washington, D.C. 20545); James E. Ammons (Division of International Affairs, U.S. Atomic Energy Commission, Washington, D.C. 20545); and Charles F. Baxter (Division of Space Nuclear Systems, U.S. Atomic Energy Commission, Washington, D.C. 20545).

NEWS AND COMMENT

Stanford: Why Pitzer Resigned as President

"We have now proven beyond argument that a university community can make life unlivable for a president. We can make him the scapegoat for every failure of the institution. We can use him as the target for every hostility that is in us. We can fight so savagely among ourselves that he is clawed to ribbons in the process. We have yet to prove we can provide the kind of atmosphere in which a good man can survive."—John W. Gardner at ceremonies inaugurating Kenneth S. Pitzer as president of Stanford University on 14 June 1969.

"The prospect of a more scholarly life at a less hectic pace is most welcome. . . . While the conflicting pressures on the presidency at Stanford have not yet reached the full dimensions he [Gardner] described, nevertheless there are wounds and there is fatigue."—Pitzer, in a letter of resignation submitted a year later.

Kenneth S. Pitzer has always been something of a "golden boy" in the American scientific community. Attractive, intelligent, reputedly cool under fire and supposedly adept at reconciling conflicting interests, his career has heretofore been marked by a progression of successes. In 1950, as a young government research administrator, he was designated one of the ten outstanding young men of the year by the U.S. Junior Chamber of Commerce. As a professional scientist, he has long been considered a "chemist's chemist." The esteem of his peers was signified by his election to the prestigious National Academy of Sciences in 1949 and by his receipt of the coveted Priestley medal of the American Chemical Society in 1969. Moreover, as a rising "statesman of science," Pitzer has been appointed to a number of prominent government posts. He has served as research director for the Atomic Energy Commission (AEC), as chairman of the AEC's General Advisory Committee, and as a member of the President's Science Advisory Committee.

Pitzer has been no slouch in the world of academic administration and politics either. At Berkeley, where he taught for 24 years, he served as vice-chairman of the campus division of the Academic Senate and was chosen by the faculty to serve on its academic freedom committee after a loyalty oath controversy there. Then, in 1961, he became president of Rice University in Houston, Texas, and presided over a 7-year period of growth capped by a successful capital funds campaign. Thus, while Pitzer had no great national reputation as an educator, it was not a total surprise when Stanford, stymied in its efforts to land a more luminous figure, tapped Pitzer to become Stanford's sixth president effective 1 December 1968. "Of course," Pitzer's friends said, "he's a natural choice."

That was less than 2 years ago. Today Pitzer is on vacation, serving out the final weeks of his presidency until his resignation, which was submitted on 25 June, becomes effective 31 August. Provost Richard W. Lyman will become acting president of Stanford on 1 September, while the Stanford trustees begin the search for still another president. The whole process will necessarily have a certain treadmill quality about it. It took 17 months to find Pitzer and he didn't last much longer than that on the job.

What happened to drive Pitzer out of the hot seat at Stanford? This particular reporter has made no effort to