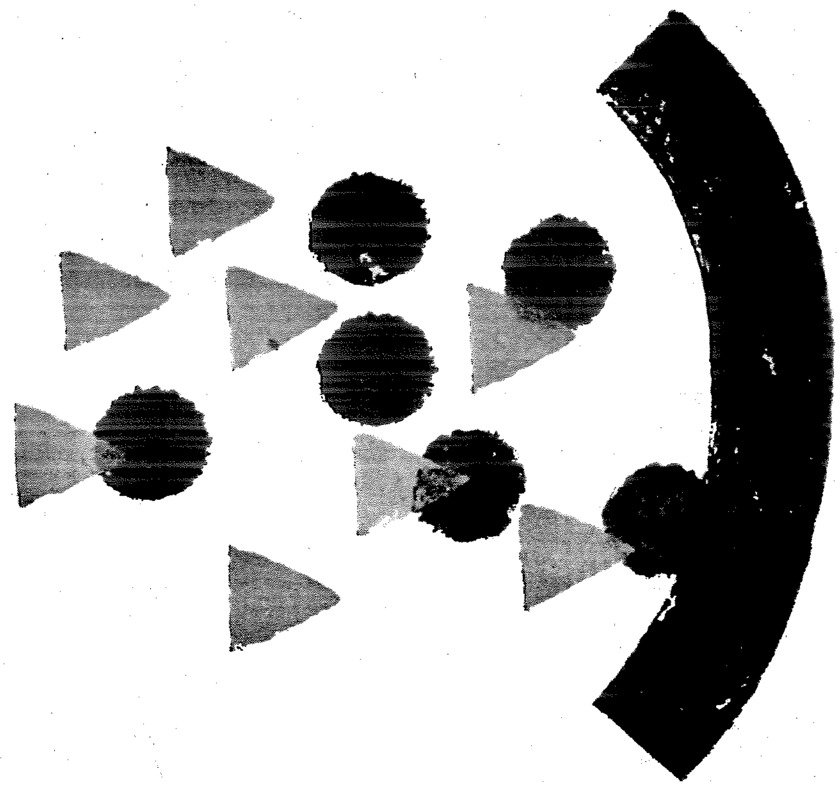
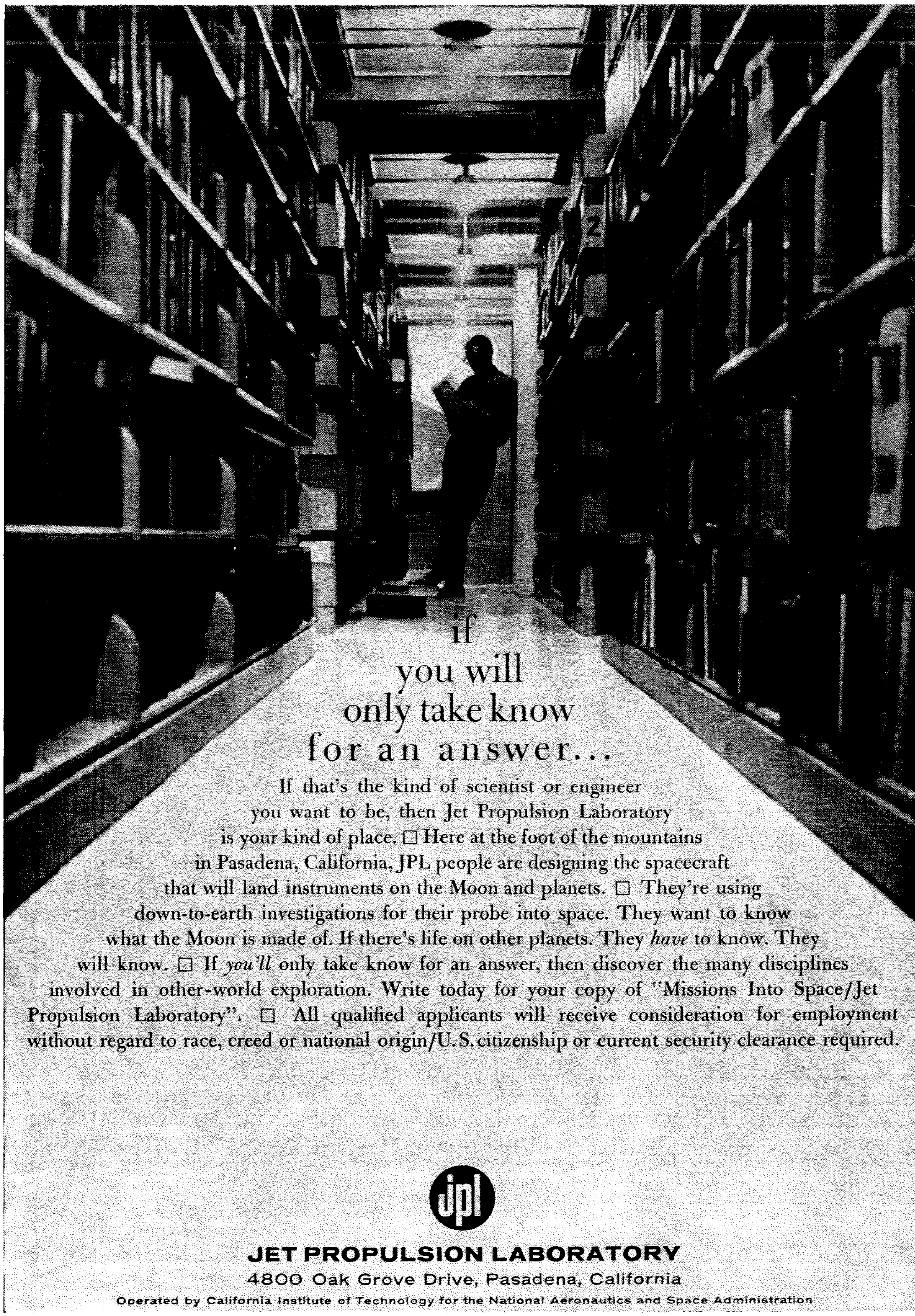
# ENGINEERING | AND | SCIENCE

*June 1962*


*Student Center . . . page 3*

*Published at the California Institute of Technology*

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# ENGINEERING | AND | SCIENCE

*JUNE 1962* *VOLUME XXV* *NUMBER 9*

*On Our Cover*

Caltech undergraduates on an inspection tour of the Institute's new $600,000 Winnett Student Center, which was dedicated on Commencement Day, June 8.

The south wall of the new Center, shown on the cover, has a brick facing which includes the bricks from the fireplace in the old Throop Club. These bricks were contributed by students almost 40 years ago and each one is carved with the initials and class year of its donor.

With the dedication of the Center, Caltech undergraduates, for the first time, have a center for extracurricular activities. The two-story-and-basement building has a total floor space of 19,000 square feet. On the ground floor is a new and greatly enlarged self-service bookstore, offices for the *California Tech* and the *Big T*, a darkroom, the campus barber shop, and a lounge which will be available for student dances, teas, and lectures.

The second floor has two meeting rooms for campus clubs, the ASCIT office, a student radio club room, and the YMCA offices.

In the basement are a recreation room for ping-pong, pool or billiards, and card-playing, and a student shop.

The Center is the 16th of 18 buildings to be completed under Caltech's current development program. For more on the Center, see page 16.

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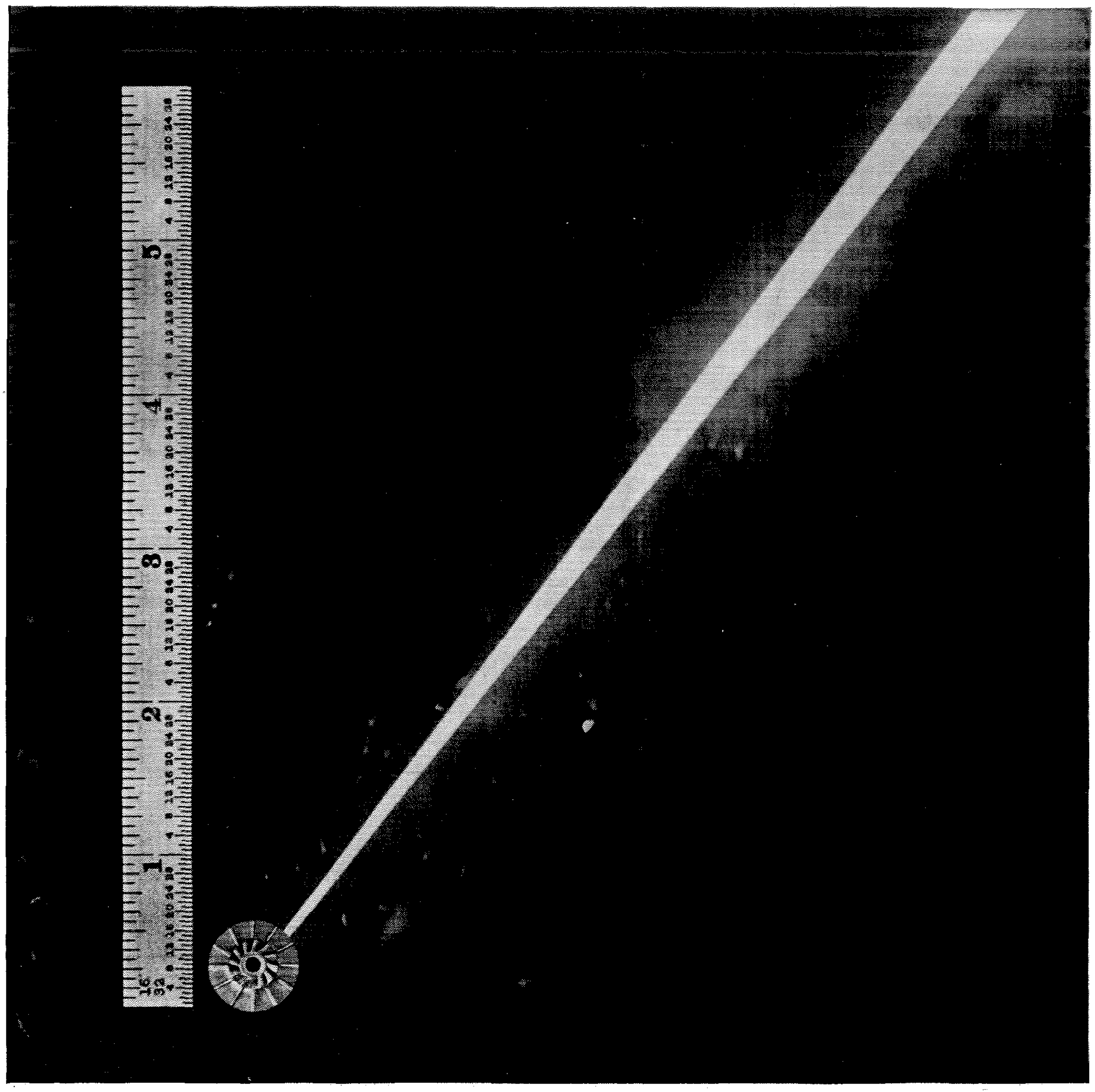
Published monthly, October through June, at the California Institute of Technology, 1201 East California St., Pasadena, Calif. Annual subscription $4.50 domestic, $5.50 foreign, single copies 50 cents. Second class postage paid at Pasadena, California.  Manuscripts and all other editorial correspondence should be addressed to: The Editor, *Engineering and Science*, California Institute of Technology. 



ENGINEERING AND SCIENCE
June 1962, Volume XXV, No. 9

# TECHNICAL COOPERATION —

## The Role of Science and Engineering in Promoting Economic Development

*by Robert W. Oliver*

*Since the start of this academic year, the Institute has been investigating the problems of technical cooperation between the more and the less developed nations of the world. This is a continuation and an expansion of the more general study of Science and Public Affairs inaugurated in 1960-61 and made possible by a grant to Caltech from the Carnegie Corporation.*

*Guest lecturers, throughout the year, have included leading experts from various countries — engineers and scientists, economists, and administrators of various national and international agencies. Herewith, some lecture highlights.*

The prescription for economic development, in a nutshell, is to increase the quantity and quality of capital. Development occurs (i.e. the average standard of living rises) because capital (man-made instruments of production) increases faster than the population. People can produce, and therefore consume, more when they have more and better tools and resources to work with.

Some economists spend a great deal of time belaboring this point. They may assume, for example, that, for every $5 spent by a nation on new capital equipment, there is a corresponding increase of $1 in the nation's annual output. Given a capital-output ratio of 5 to 1, one may compute the annual expenditure on capital needed to induce a desired increase in annual output. But calculations like these obscure the really interesting and significant problems of development: Which additions to the productive capacity of an economy ought to be undertaken first? To what extent can the output of a country be increased by applying modern technology and otherwise stimulating scientific innovations?

Very early in any study of underdeveloped countries one becomes aware of vicious circles. The people of India are poor because they have so little capital relative to their labor force, but they cannot add a great deal to their stock of capital because too large a fraction of their output must be consumed.

The people of Egypt remain poor in part because the population expands so rapidly, but birth rates remain high because many individuals can see no relation between birth control and a higher standard of living. An improvement in techniques is subverted by tradition, but tradition is reinforced by the lack of knowledge of modern techniques. Any given project is unproductive because so many other projects need to be completed first, but this is true regardless of which project is considered first.

Paul Rosenstein-Rodan, professor of economics at MIT, illustrated this last dilemma in his description of the trials and tribulations of a button manufacturer who had been successful in northern Italy and had then attempted to establish a plant in southern Italy. In southern Italy there were no real estate brokers who could supply him with information about industrial sites. There were no established utilities which could provide him with inexpensive water and power. There were no industrial designers or building contractors familiar with the type of plant he wanted to construct. There were no financial institutions to provide the funds he needed to supplement his own resources. There was no pool of skilled labor upon which he could draw to staff his enterprise once it had begun operations. In short, there were none of the local resources which could provide him with the external economies any businessman would expect.

Professor Rosenstein-Rodan also pointed out that resources may be uneconomically allocated if development planners fail to consider the equilibrium prices, interest, and foreign exchange rates which would exist in a completely free market. A public power installation which appears desirable when capitalized at an interest rate of 3 percent (the artificial rate at which a government may be able to borrow money) might be undesirable when capitalized at 8 percent (the real cost of capital).

But while this consideration may be important in a complex, developing country like India, it may be unnecessarily academic in a country like Tunisia, where so much needs to be done that it does not really matter what is done first. As Albert Waterston of the World Bank indicated, investments in transportation, communication, and power are almost certain to be worthwhile. According to Andrew Kamarck, also of the World Bank, the problem may only be that the rate of return is too low to justify the investment of loanable funds in anything!

## *The Sociology of Development*

It is all very well for economists to argue that development requires the accumulation of capital; such a generalization tells us nothing about the human processes involved. In the United States we are so accustomed to economic progress that we take for granted the culture patterns and the patterns of personal behavior that are the prerequisites of continuing, useful, capital accumulation.

How can people be induced to undertake business enterprise if the ownership of land is the highest evidence of social status? How can peasants be persuaded to improve the quality of their livestock if the quantity of cattle is a sign of wealth? How can people be induced to do anything in a new way if obedience to the traditions of the family and the tribe is regarded as the highest morality?

How can a modern, political, civil service be developed if nepotism is a time-honored practice? How can science flourish in a country where natural phenomena are explained by reference to astrology or witchcraft? How can farmers be persuaded to employ modern technology if they believe that any modification of traditional farming methods may reduce their already meager output?

How can the relatively few wealthy citizens of a country be induced to make their wealth available for productive enterprise if profits are regarded as unjust and interest immoral, and if the confiscation of property by newly successful political forces is likely? How can evolutionary political change and rule by law be obtained in a country having a long tradition of totalitarian government and of change by coup d'état or bloody revolution?

One of the most significant problems of underdeveloped areas — particularly the countries of Latin America — is that of political instability and the absence of democratic traditions. Kal Silvert and Frank Bonilla of the American Universities Field Staff believe that modern political systems will not evolve in Latin America until such time as individuals develop a sense of loyalty to the nation or state. Of significance is their conclusion, based upon an extensive survey, that the highly educated, as well as the uneducated, in such countries as Argentina, Brazil, and Mexico regard loyalty to their class, whether economic or social, as more important than loyalty to the nation.

The Technical Cooperation lectures have been liberally sprinkled with illustrations of the problem of inducing change in underdeveloped countries. A technical assistance team in Burma was unable to persuade peasants to use rice seed which would increase output per acre by 25 percent. Finally they won over a local Buddhist priest who announced to the people that he wanted to bless the seed before it was planted. While behind a screen, the priest then substituted the new seed for the old.

Recently, in Nairobi, Kenya, the officials of a government agency complained that native businessmen were using funds provided by the government to buy wives rather than to improve their stores. The retort was that the wives could produce female children who could subsequently be sold — providing a fine financial return.

Among the more interesting discussions of the year were two dealing with entrepreneurs. In the widest sense, an entrepreneur is anyone who induces change; he is a creator. In the economic sense, an entrepreneur is one who induces change resulting in economic gain; he may develop a new product, a new production method, or a new form of economic organization. He may be, though he is distinct from, a manager. He can operate either in the private or the government sector of the economy. He is the motivating force behind development, and there is a sense in which it may be said that the problem of economic development is the problem of developing entrepreneurs.

Gus Papenek, professor of economics at Harvard University, recently completed an interesting study of entrepreneurs in Pakistan. He found that new entrepreneurs did emerge, after the flight from Pakistan of Hindu entrepreneurs, and in a situation where there was a domestic market protected by tariff and other trade barriers, an import-control system which enabled a few fortunate importers to obtain foreign technical help, and a rate of return on new investment which in general exceeded 50 percent.

The new entrepreneurs behaved very much like those of the early industrial revolution in England. They seemed not to be hampered by religious or cultural traditions and were perfectly willing to reinvest their earnings in their expanding enterprises. Their investments have resulted in a substantial increase in the total production of Pakistan. The standard of living of the entire population is increasing, and the rate of new investment continues high, even though the rate of return is no longer as high as it was immediately following the birth of Pakistan as an independent nation.

But the pattern in Pakistan is not being repeated in other underdeveloped countries.

Everett Hagen, professor of economics at MIT, discussed his theory – based on research into the relevant histories of such diverse countries as Japan, Colombia, Burma, pre-revolutionary Russia, and England – that entrepreneurs are most likely to come from a certain class of people. This class, Hagen feels, must evolve over several generations from an initially aristocratic group which, for one reason or another, has become disenchanted with the established, majority, ruling group. Eventually, finding it necessary to demonstrate to themselves that they are really as good as everybody else, they become deviants who seek in some new way to reestablish their social positions. They break with tradition, though not in a revolutionary way. They induce social and cultural change. When they devote their attention to economic matters, they become entrepreneurs.

While this summary cannot do justice to Hagen's work, it can, perhaps, illustrate the importance of sociological research if we are to understand the processes by which individuals and institutions can be modified so that economic development may occur. It may also help us to understand a point emphasized by Albert Waterston: Economic development will not occur unless a society really wants it to occur – unless a society is willing to break with its own traditions in the interests of modernization.

### *The Technology of Development*

Gladwin Young, deputy director of the Soil Conservation Service of the U.S. Department of Agriculture, estimated that the agricultural output of underdeveloped countries could be increased as much as tenfold through the application of modern agricultural techniques.

At the same time, many visitors warned against the too-easy assumption that production techniques can be transferred intact from the United States to underdeveloped countries. Some modification of technology is almost always required; in some cases the modifications are so great that they may almost be classed as new discoveries. Certainly scientific research of an applied, if not a fundamental, nature is a requirement of economic development.

Montague Yudelman, professor of economics at Harvard, made this point particularly well when he compared the agricultural improvement program successfully carried out by the Rockefeller Foundation in Mexico and the infamous ground-nuts scheme in Tanganyika, Africa.

## CARNEGIE PROGRAM: Technical Cooperation

### *Lecturers, 1961-1962*

Benjamin Spiro, Inter-American Bank – *The Alliance for Progress*

Paul Rosenstein-Rodan, Center for International Studies, MIT – *Shadow Prices and Economic Planning*

J. Burke Knapp, International Bank for Reconstruction and Development – *The World Bank and Project Lending.*

Montague Yudelman, Harvard University – *Agricultural Experiments in Tanganyika and Mexico.*

Djanaghir Boushehri, International Monetary Fund – *Price Stability and Economic Development.*

Lyman Wilbur, Morrison-Knudson, Inc. – *Practical Engineering Overseas*

Max Millikan, Center for International Studies, MIT – *Foreign Aid: Lessons and Prospects*

Gustav Papanek, Harvard University – *Private Domestic Investment in Pakistan*

Albert Waterston, International Bank for Reconstruction and Development – *The Need for Micro-economic Planning.*

Laurence Taylor, University of California – *The Significance of Agriculture*

Everett Hagen, Center for International Studies, MIT – *The Non-Economic Origins of Economic Development*

Julius Kiano, former Minister of Finance, Kenya – *The Future of Kenya*

Walsh McDermott, Cornell University Medical College – *The Role of Science in Development Assistance*

Maurice Albertson, Colorado State University Research Foundation – *American Universities and Education in the Underdeveloped Countries*

Egon T. Degens, Caltech – *Water Problems in the Western Egyptian Desert*

Gen. Sir Geoffrey Bourne, Aluminium Development Association – *Combating Communist Subversion in Underdeveloped Countries*

Gladwin Young, U.S. Dept. of Agriculture – *Water Resource Development in Underdeveloped Countries*

Andrew Kamarck, International Bank for Reconstruction and Development – *Development Projects in Africa*

Frank van Hoek, The Organization for Economic Cooperation and Development – *The Technical Assistance Program of the Organization for Economic Cooperation and Development*

C. R. DeKiewiet – *American Policy in Sub-Saharan Africa*

Gilbert White, University of Chicago – *The Mekong Valley*

Hon. Loyd V. Steere, former U.S. Minister to Rhodesia and Nyasaland – *Rhodesian Political Leaders*

Charles Nixon, UCLA – *Political Process and Parties in Rhodesia*

Taylor Ostrander, American Metals Climax – *American Metals Climax in Rhodesia*

Richard Logan, UCLA – *Natural Resources and their Uses in S.W. Africa*

R. J. Hammond, Stanford Food Research Institute – *Economic History of Angola and Mozambique*

Hilda Kuper, University of Natal – *Economic Attitudes of the Swazis*

In the first case, operating on a small, pilot project, an outstanding American biochemist discovered a seed which, together with the complementary fertilizer, irrigation, and treatment for pests and insects, could substantially increase the output of corn in Mexico.

In Africa, following an inadequate survey, the British Government undertook a large-scale agricultural project. Three years and 70 million dollars later, it was abandoned as a total failure. The farm machinery was ill-suited to African soils, as were the plowing and irrigation techniques. The difficulties of dealing with tropical vegetation were grossly underestimated. The project demonstrated that money is an inadequate substitute for time, knowledge, and research.

The extent to which modern technology may contribute to an evaluation of a development plan was beautifully illustrated by two lecturers who discussed "Project New Valley," (*E&S* – November 1961), a scheme for irrigating the Western Egyptian Desert. Egon Degens, assistant professor of geology at Caltech, presented geologic evidence that the underground water in this desert is fossil water; it is not being replenished. Thus, it would be folly to carry out the Egyptian Government's plan for resettling 10 to 15 million people in this arid area.

Paul Keim, professor of civil engineering at the University of California, suggested that, by using modern reclamation techniques, the land area of Egypt which could be irrigated by the Nile even without the high Aswan dam might be increased by as much as 30 percent.

The need for high-level scientific and technical assistance to underdeveloped countries is great. This is true, for example, in the fields of nutrition and public health. Henry Borsook, Caltech professor of biochemistry, believes that the present output of potential food is adequate even in the most poverty-stricken areas of the world; the problem is that available plants and grasses are not being wisely used.

Harrison Brown, Caltech professor of geochemistry, suggested that the development of a primitive pump for rural areas in India, even if it were only 5 percent efficient, might obviate the need to use cattle to produce energy. Small devices to produce energy at the village level might be enormously useful.

Research into the problems of technical education is also necessary. As recently as 10 years ago, the Belgian government thought in terms of independence for the Belgian Congo by the year 2000. When independence was suddenly granted, the native Africans were sadly lacking in secondary and higher education. The Congo tragedy could be repeated in such other countries as Angola, Mozambique, Nyasaland, and Northern Rhodesia. C. R. DeKiewiet, formerly president of the University of Rochester, and Maurice Albertson, director of the Colorado State University Research Foundation, raised some interesting questions concerning education. Are the techniques of London University or Oxford or Harvard suited to the requirements of Nigeria or Kenya or Tanganyika? Is it more efficient to bring students from Africa or Asia to study in Europe or the United States, or to send European and American professors to teach and conduct research on the spot in underdeveloped countries? In the case of foreign students who are trained in the United States, are present educational techniques appropriate? Why is it that so many foreign students who study in the United States prefer not to return to their native countries? Why is it that the students who do return find it difficult to obtain positions commensurate with their training? It has been observed by many visitors to Caltech that well-educated people in underdeveloped countries regard it as beneath their dignity to work with their hands. Can such attitudes be overcome through education?

## *Foreign Aid*

As the British forces under Gen. Sir Geoffrey Bourne discovered in Malaya, Western nations cannot expect to win the battle for men's minds until native peoples become convinced that the Western nations share their aspirations for a better life, both politically and economically. But Americans are learning that economic development requires more than money and that a nation cannot be made to develop solely as a consequence of external, foreign assistance.

Max Millikan, director of the Center for International Studies at MIT, analyzed the weaknesses of the American foreign aid program and presented suggestions for improvement. Until recently, the aid program paid too little attention to long-range planning and to the development of human resources. Countries receiving American economic assistance must be induced to prepare long-term development programs. We must insist upon honesty in government, tax and land reform, political and fiscal stability, and, above all, a demonstrated willingness on the part of recipient nations to help themselves. While it may be necessary to give some assistance for purely political reasons, a part of our foreign-aid budget should be allocated for strictly economic development, and economic development should be financed once the criteria have been met, regardless of international political considerations.

Edward Fei, director of the Research and Evaluation Staff of the Agency for International Development, pointed out that there is a pressing need for qualified advisers to the governments of underdeveloped countries. He also discussed a new facet of the AID program: the sponsorship of research. AID is prepared to finance studies of such matters as the role of technical education in promoting development, the impact of urbanization on local customs, and the importance of wage incentives in fostering labor mobility. AID is anxious to receive research proposals concerning specific, substantive questions. It is also anxious to learn which institutions in the United States are capable of supplying teams of high-level advisers to underdeveloped countries.

### *Technical Cooperation in Southern Africa*

The Technical Cooperation Seminar was inaugurated at Caltech in September 1961. Following weekly public lectures, members of both scientific and humanities faculties met with the guest speakers in seminars. An innovation of the Technical Cooperation Seminar has been the preparation of research papers by a select group of graduate students who have studied the relation between their particular scientific disciplines and the problems of underdeveloped countries.

By the end of 1961 it was apparent that the Seminar was a useful addition to the educational curriculum and was compatible with the philosophy of the Carnegie program: scientists, engineers and social scientists could explore together the relations between science and some aspects of public affairs.

But the Seminar was primarily educational, and some members of the faculty began to wonder if the program could not be expanded to encompass research as well. Within the Humanities Division a proposal was prepared that research be undertaken concerning the problems of economic development in southern Africa. This request was granted by the Division chairmen and the Board of Trustees in January 1962, and preparations for launching the project are now well underway.

A long-range social science objective will be to analyze (perhaps even to prepare) projections of the future economic development of the nations of southern Africa. Included in such an analysis will be research into the history and contemporary politics of the area, its international relations, its present and projected resources, its patterns of foreign trade, its technological and educational facilities, and the culture patterns of the people. This research will be useful in itself; it will also be useful for coordinating investigations in such specific scientific areas as food (including agriculture and nutrition), water, energy, housing, public health, and technical education.

The problems of economic development and of technical cooperation between the more and the less developed countries of the world are not confined to any particular area of the world. The broad problems of development are the same in Brazil, Nigeria, India, and Indonesia. Thus, since the Technical Cooperation research group is interested in general principles, it does not intend to confine its attention wholly to any single part of the world. Nevertheless, research of this type can be conducted more systematically if it is focused, at least initially, upon a particular area.

During the summer of 1962 a field team will visit southern Africa to obtain an overall impression of the area. In addition, Harold Wayland, professor of applied mechanics, and Alan Sweezy, professor of economics, will be attending economic development conferences in France and Austria, and James Davies, professor of political science, will be analyzing political conditions in Portugal.

Robert Huttenback will combine his visit to Africa with an expedition to India where, among other things, he will be the first member of the Caltech faculty to participate on the spot in organizing the new technical institute at Kanpur. From Caltech's side, this important project is under the general direction of Professors Donald Hudson, George Housner, and Norman Brooks.

Caltech is, and intends to remain, devoted to high-level research and education in engineering and basic science. Nevertheless, the program of the Institute may be strengthened by this expansion of the work of the Humanities Division. As scientists are drawn increasingly into public affairs, they find it useful to collaborate with social scientists in systematic studies of the problems which confront mankind. Under the Carnegie program, such collaboration has been possible in the areas of Arms Control and Technical Cooperation. It is hoped that this work will continue, for it is clear that modern engineering and science, when harnessed for peaceful purposes, can do much to increase the material well being of people everywhere.

## Graduate Student Papers

### *Technical Cooperation Seminar*

C. R. Haden –
*Technical Assistance on a Smaller Scale*

G. Gutner –
*Aspects of Water Resources Development in Mexico.*

S. F. Masri –
*Education and the Economic Development of the United Arab Republic*

A. Abu-Shumays –
*Economical and Technical Aspects of Egypt's Aswan High Dam Project*

H. A. Thiessen –
*The Rehabilitation of the Pacific Railway and the Development of Northwestern Mexico*

P. W. Purdom –
*The Program of the Institute of Public Administration of the University of the Philippines*

R. F. Gebhardt –
*Mineral Development*

S. R. Harrison –
*The Importance of Agricultural Exports to the Mexican Economy*

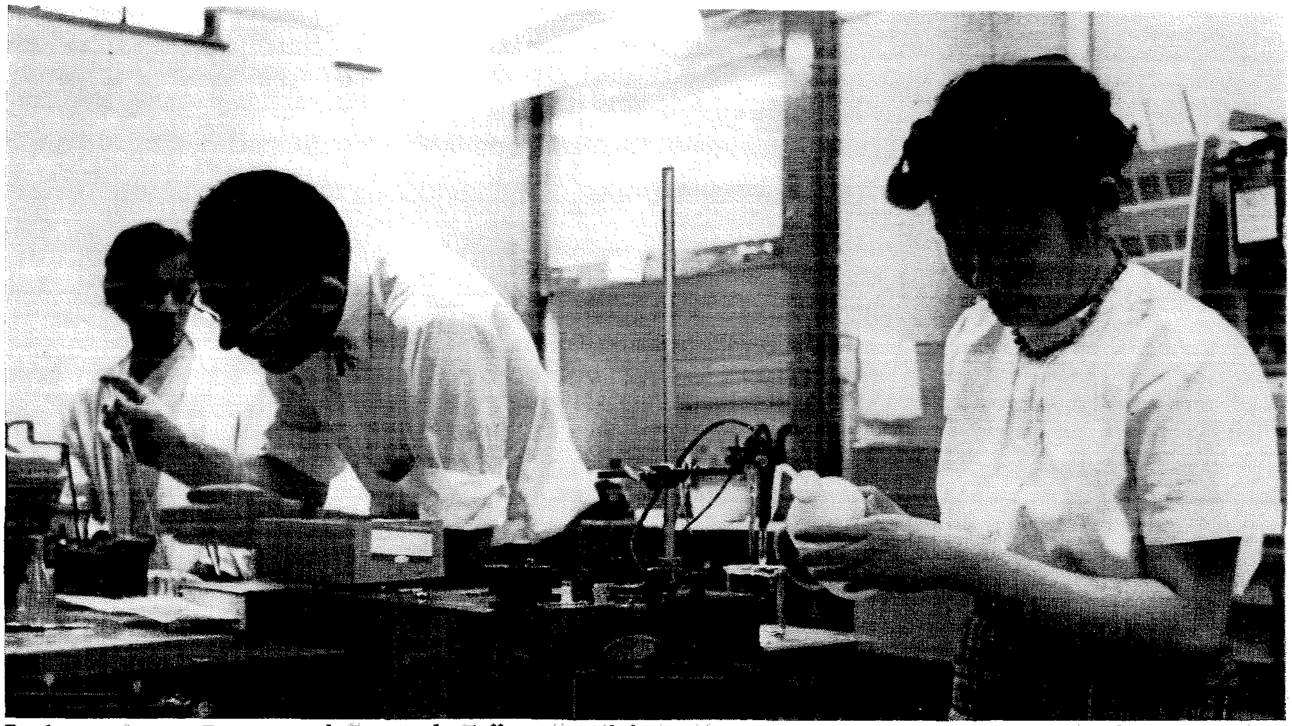
R. A. Svenson –
*Use of Microwave Systems in Communications Networks of Underdeveloped Countries*

J. J. Kennedy –
*Protein Malnutrition in Sub-Saharan Africa*

D. B. Forrest –
*The Entrepreneurial Function in the Context of the Developmental Process*

O. C. Meirelles –
*Electric Power in the Centro-Southern Region of Brazil*

S. C. Choy –
*The Education of Foreign Students in the United States*



*Professor James Bonner and Research Fellow Ru-Chih C. Huang prepare genetic material for histone studies.*

# Histone — A Protein Key?

*by Graham Berry*

Caltech biologists have discovered what may be the "protein key" that locks and unlocks the activity of the genes which regulate the processes of life.

The discovery provides a tool for the study of the basic life process by which two cells in the same organism are able to specialize — one, for instance, becoming a heart-muscle cell and the other a bit of eye retina. This tool or key is a simple protein called histone.

Dr. James Bonner, professor of biology, and Dr. Ru-Chih C. Huang, research fellow in biology, have succeeded in showing in research with fast-growing pea embryo cells that when histone "sits" on genes, it inactivates them — presumably turning off their particular protein-making activities — and that when the histone is removed, genetic activity is turned on again.

Genes carry the blueprints that enable nature to duplicate new generations of animals and plants. Every one of the millions of cells that make up a human being contains a complete blueprint of that individual, consisting of perhaps one hundred thousand genes, grouped in chains called chromosomes. A portion of the blueprint is for making the protein structures found in every cell and another portion is for making specialized proteins such as hemoglobin, brain, and skin.

It is the activity of these particular parts of the blueprint, and the way in which their genes transmit instructions to the cell's microscopic chemical factories, that are intriguing to Drs. Bonner and Huang. Their research is supported by the U.S. Public Health Service.

Is every gene in every cell active all the time? If this were true, then all the cells would try to produce hemoglobin, fingernail, and the scores of other kinds of proteins that the body manufactures. They couldn't do it, of course, and there would be no such complex organism as a human being — which, because of its many specialized cells, is capable of doing a great variety of complex things, like thinking.

Presumably only a few selected genes are turned on in any one cell, depending upon its specialized task; the rest of its genes must be turned off, according to Dr. Bonner. It may be that during the life of a particular cell, certain of its genes may be turned on and off several times.

Bonner and his group have evidence that histone is the key that turns the genes off, and that the absence of histone means that they are turned on. It has been known for some time that histone is associated with the genes in humans, animals, and plants, but its significance has been a mystery.

Histone is a small, simple protein molecule composed of about 150 amino acid building blocks. There are 20 different kinds of these blocks and they are assembled into proteins by being strung together in chains. Histone is said to be simple because it is composed principally of only two of the 20 amino acids, lysine and alanine. Indications are that 80 percent of the genes in pea cell embryos are covered with histone and only 20 percent are not.

Dr. Bonner and his group selected pea embryo cells as research aids because they are very active, multiply rapidly, and are easily obtainable. Since the basic processes of living cells – whether in peas or people – are similar, and since human cells as well as pea cells contain histone, it is most likely that histone's role is general among living cells.

To obtain quantities of the genetic material, the Bonner group has developed a clever "pea-popping" technique that chops embryo pea stems and slits open the walls of their cells to yield quantities of intact cell nuclei containing the genes linked in chromosome chains. The chains are made of DNA (deoxyribose nucleic acid), which comes in long, fibrous strands coiled in a helix. Parts of the DNA strands of the chromosome are covered with histone.

Indications are that the DNA chains transmit their instructions in these three steps: 1. Those genes sending out instructions synthesize bits of another kind of nucleic acid, RNA (ribose nucleic acid). 2. The strips of RNA are complementary copies of the DNA genes. Probably for structural strength, each RNA strip is placed on a strip of nucleoprotein, the RNA-protein combination being called a ribosome. 3. The ribosome moves out of the cell's nucleus into the main body, or cytoplasm, of the cell. Here the ribosome assembles amino acids into an enzyme which, in turn, participates in the conversion of the cell's food into building blocks for making more cells.

The Bonner group is concerned with the first step in this process – the transfer of a coded message from DNA to RNA. Obtaining their raw DNA material from the "pea popper" machine, they tested the ability of this material to synthesize RNA. In precise laboratory experiments, they found that some factor in the new DNA was suppressing this synthesis. Considering the possibility that the factor might be histone, they chemically removed the histone from the DNA. Then found that the RNA-synthesizing ability of the DNA had increased five-fold.

Dr. Bonner interpreted the five-fold increase in activity to indicate that the presence of histone had inactivated four of five genes, and that when the histone was removed, the four inactivated genes became active and synthesized RNA copies of themselves, just as the fifth gene had been doing all the time.

Next, the researchers mixed active DNA with histone and the DNA stopped making RNA. When they separated histone from the DNA, the DNA activity was restored.

"In the laboratory we have separated DNA and histone and thereby increased the synthesis of messenger RNA," Dr. Bonner explains. "We have added histone and observed the drop in RNA synthesis as histone and DNA unite. And we have separated the two again and noted the increase in RNA synthesis. This last procedure is evidence that the histone does not harm the DNA and that possibly some genes may be turned on and off more than once during the cell's life."

Binding histone to DNA stabilizes the DNA structure, the researchers discovered. This was shown by the fact that the melting temperature of histone-DNA is several degrees higher than that of pure DNA. Microphotographs show that when histone becomes fastened to the DNA, the DNA strands get twice as wide. It has been suggested by others that the two strands of DNA may become harder to separate if histone is present.

"We know qualitatively that there are a dozen or more different kinds of histone," Dr. Bonner says. "We are sure that nature has had good reasons to use these different kinds and we are studying this now."

The findings shed light on the question as to why some cells have a lot of histone and some have only a little. For example, the unfertilized egg of an animal has a great deal of histone. This suggests that the genes of the unfertilized eggs are "turned off," as might be expected. Human cancer cells have less than the normal amount of histone. This could mean that too many of its genes are "turned on," which could account for a distinguishing feature of cancer cells – the apparent loss of their ability to specialize.

The discovery raises a host of interesting questions: What is it that tells the histone which genes to inactivate? How does the mechanism, whatever it is, know when to do this? What mechanism removes histone from a gene – if this happens? Does a specific kind of histone bind with a specific kind of DNA?

The Bonner group is investigating these questions. Also, they want to know which way the histone-inactivation system goes – if it goes in one direction. They want to know whether the embryo starts out with most of the genes in its cells turned off and histone somehow is selectively removed from the genes as the organism grows older. Or are most of the genes turned on in the embryo's cells in the early stages and then selectively turned off as time goes on?

In looking for answers to questions such as these, the biologists are moving into the field of cell differentiation, and a consideration of how cells begin to become specialized cells.

# METAL FATIGUE

*A new theory makes it possible to predict the life span of any structural component in aircraft or missiles*

A new theory which makes it possible to predict the life span of any structural component in aircraft or missiles has been developed at Caltech by Sitaram R. Valluri, senior research fellow in aeronautics.

Metal fatigue is one of the most serious problems in the aircraft industry. The failure of structural components such as landing gear, or the sudden disintegration in midair of certain types of aircraft, has, in the past, been attributed to a variety of reasons. It has been found, however, that in many cases such failures have been due entirely to metal fatigue.

Dr. Valluri's theory is concerned primarily with an estimation of the residual strength of a component and an analysis of the factors affecting it. According to the theory, imperfections inherent in the material are the starting points of fatigue damage. The damage usually begins near the surface of the metal, due to the applications of such stresses as air loads, temperature changes, impact on landing of the aircraft, and noise. Acoustical damage from jet engines, for instance, is a major fatigue problem.

Metals generally consist of layers of atoms arranged in precise and regular rows, forming a lattice structure. Under the present methods of producing metals, the lattice is not perfect. The inherent dislocations or imperfections in metals are submicroscopic, and are caused by dislocations of the metal structure. In one cubic inch of metal, there are millions of dislocations.

Under certain stresses, the movement and interaction of these dislocations cause submicroscopic cracks to start – probably on the order of one millionth of an inch long. These submicroscopic cracks tend to join together like the tributaries of a river, to lead gradually to a larger and damaging crack. This is one of the important postulates of Valluri's theory. The result of such a growth pattern shows up in the form of rings, much like the growth rings in a tree.

While the theory has certain limitations, as all theories do, this method has proved amenable to a successful treatment of failure problems in complicated structures such as aircraft and missiles. It has been confirmed to a considerable extent by tests performed in industrial and governmental laboratories. Results have been predicted with a much greater accuracy than ever before.

The fatigue damage to which an aircraft is subjected is a continuous process which begins when a plane is built, and continues on as the plane flies through fair weather and foul. To successfully apply Valluri's theory, two factors must be known – the extent and kinds of stresses to which the structure is subjected, and the basic behavior of the metal during fatiguing. A piece of the same metal used in the component is tested under different kinds of stress in the laboratory, and, from mathematical calculations, the life and behavior of the component can be determined quite accurately, even as the plane is flying.

This research has been primarily concentrated on the slow progress of the cracks. Now, engineers are preparing an attack on the reaction of the metal when it gets to the point where the fracture failure can be catastrophic. Using a high-speed camera which can photograph up to 200,000 frames a second, the actual movement in a large fracture will be studied.

All metals in usable quantities now have these inherent weaknesses, but it should be possible in the future to produce the same metals with much more

*Sitaram Valluri, senior research fellow in aeronautics, in a practical demonstration of his new theory, studies the aluminum alloy hub of a large propeller blade that failed because of metal fatigue. The blade ripped loose from the hub several years ago at Caltech's Cooperative Wind Tunnel, causing great damage. A small dent at the edge of the hub caused submicroscopic cracks to start, leading gradually to a larger crack.*

strength. Physical metallurgists have been able to produce "whiskers" of metal crystals in the laboratory, each of which has only one dislocation. Unfortunately, they have been able to produce only small quantities so far.

These whiskers are frequently from 10 to 100 times stronger than similar metals produced in the usual way. While ordinary metal might have a strength of less than 100,000 pounds per square inch, the whiskers can stand stresses up to a million pounds per square inch or more. Aircraft made of the new metals would thus have a safer structure and a prolonged life.

Dr. Valluri's research is supported by the U.S. Air Force. At present, such firms as the Douglas Aircraft Company and the Northrop Corporation are actively pursuing the theory to establish its regions of validity and to develop it further.



# The Month at Caltech


*Commencement 1962*

At Caltech's 68th annual commencement on June 8, a total of 381 students received degrees – 168 Bachelors of Science, 119 Masters of Science, 84 Doctors of Philosophy and 10 Engineers. Of the 56 men who graduated with honors, 6 received both academic honor and Student Body Honor Keys: John Arndt, Jr., Peter Ford, Porter Dean Gerber, David Kauffman, Roger Noll, and Julian Prince. Student Body Honor Keys were also received by 9 other students: Bruce Abell, Kerry Donovan, William Farrell, John Golden, Robert Koh, Thomas Litle, Peter Metcalf, David Pritchard, and Charles Radoy.

The Frederic W. Hinrichs, Jr., Memorial Award for the year's outstanding senior went to Porter Dean Gerber.

This year's commencement address was delivered by Charles H. Percy, chairman of the board of trustees of the Bell and Howell Company, and member of the Caltech national board of trustees.

*Professors Emeritus*

A geneticist, two physicists, and a civil engineer are being awarded the title of Professor Emeritus this month. The four men are A. H. Sturtevant, Thomas Hunt Morgan professor of genetics; Charles C. Lauritsen, professor of physics; Earnest C. Watson, professor of physics; and Frederick J. Converse, professor of soil mechanics.

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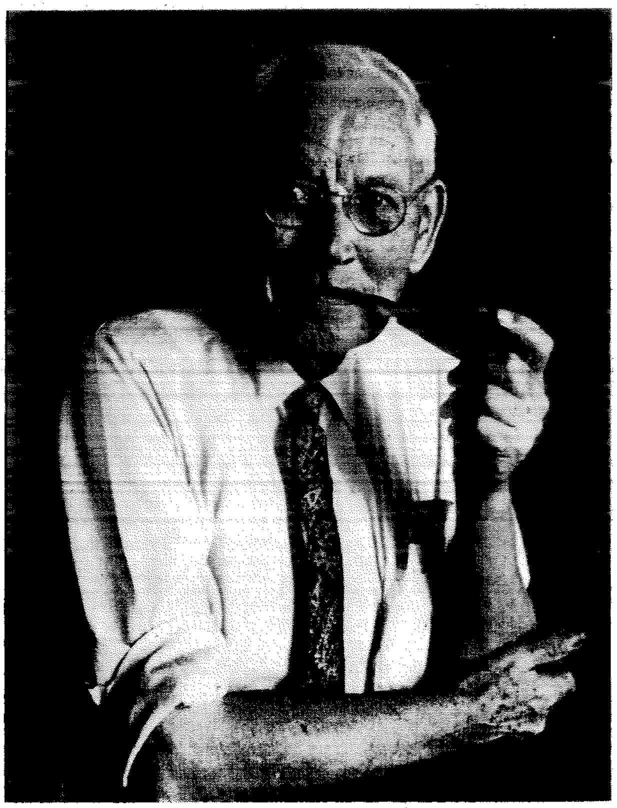
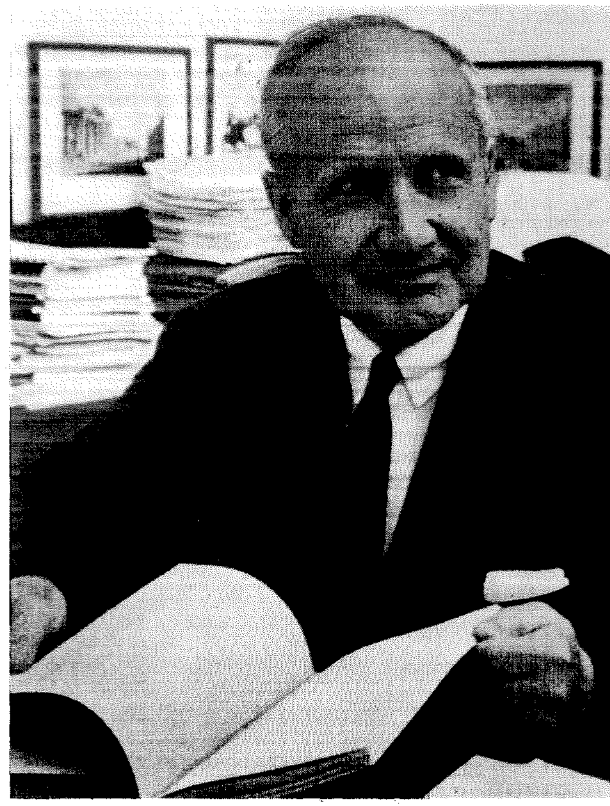
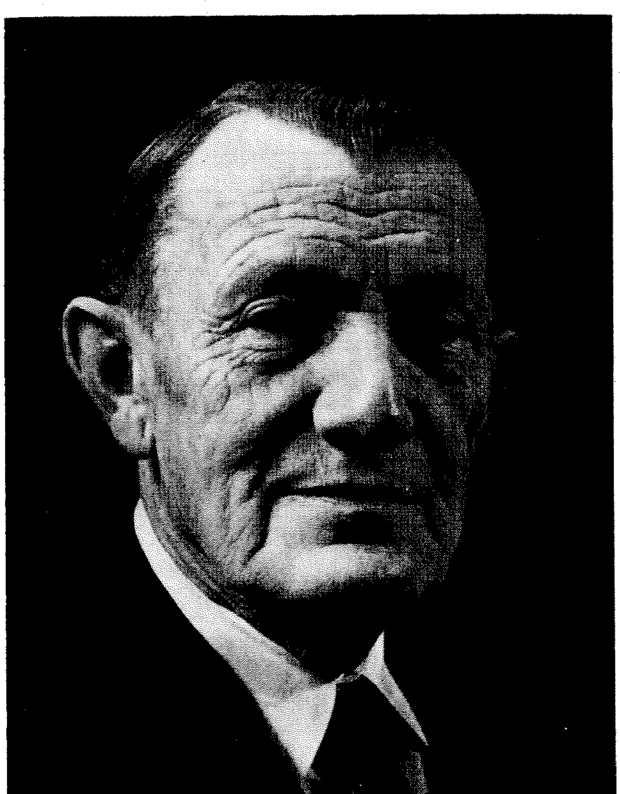


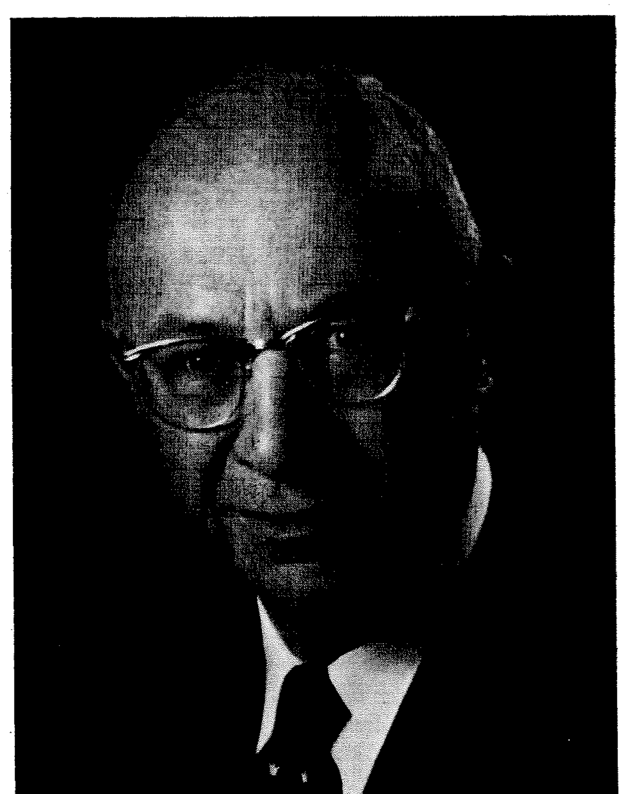
*A. H. Sturtevant, Thomas Hunt Morgan professor of genetics, emeritus.*



*Earnest C. Watson, professor of physics, emeritus.*



*Charles C. Lauritsen, professor of physics, emeritus.*



*F. J. Converse, professor of soil mechanics, emeritus.*

## The Month . . . *continued*

"It is with regret," said President DuBridge, "that we approach the end of active service for four distinguished members of the Institute faculty who have rendered distinguished service for many years.

"Professor Alfred H. Sturtevant is one of the nation's outstanding geneticists who has been at the California Institute ever since the founding of the biology division in 1928. He has played a key role in the building up of that outstanding group of scholars to its present position of leadership, and has brilliantly continued his own scholarly studies for 35 years.

"Professor C. C. Lauritsen has been on the faculty of the Institute ever since he received his PhD degree here in 1929. He was one of the pioneers in research in the field of nuclear physics, and under his leadership the Kellogg Radiation Laboratory has, for over two decades, been one of the world's leading centers of nuclear studies. Dr. Lauritsen also was scientific director of a very large and active rocket-development group at Caltech during World War II, and in subsequent years became one of the leading advisers to the government on military and scientific matters. His versatile, imaginative, and analytical mind has won respect throughout the world in both government and scientific circles, and he has brought distinction to Caltech.

"Professor Earnest C. Watson has served Caltech in a distinguished capacity for 43 years. He played a key role, in association with the late Robert A. Millikan, in building the Caltech physics department to a position of leadership in the nation. He gave skilled management and direction to Caltech's vast wartime research undertakings, and during his fifteen years service as dean of the faculty, was the Institute's key leader in faculty and curriculum matters. Under his leadership, policies were developed which gave the Institute faculty the scholarly qualities, the coherence, and the *esprit de corps* which are unmatched in the academic community of the nation.

"Professor Frederick Converse has been a pioneer in the field of civil engineering, an adviser to builders, architects, and contractors throughout the area, and a valuable member of the Institute faculty for 40 years."

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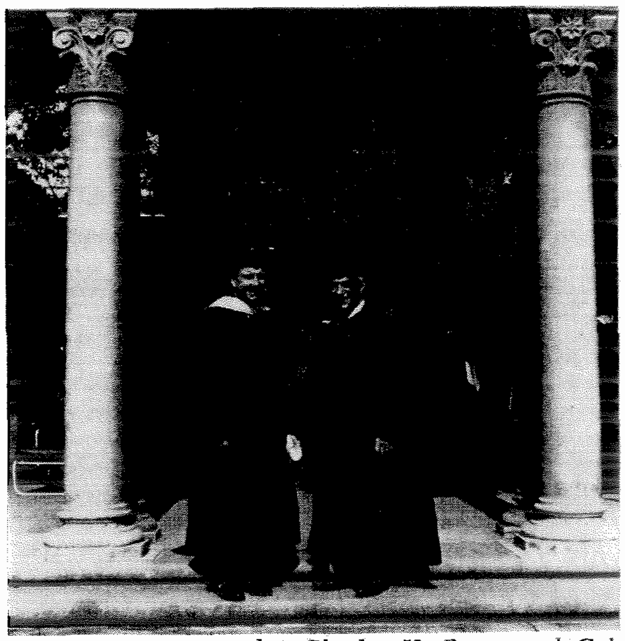
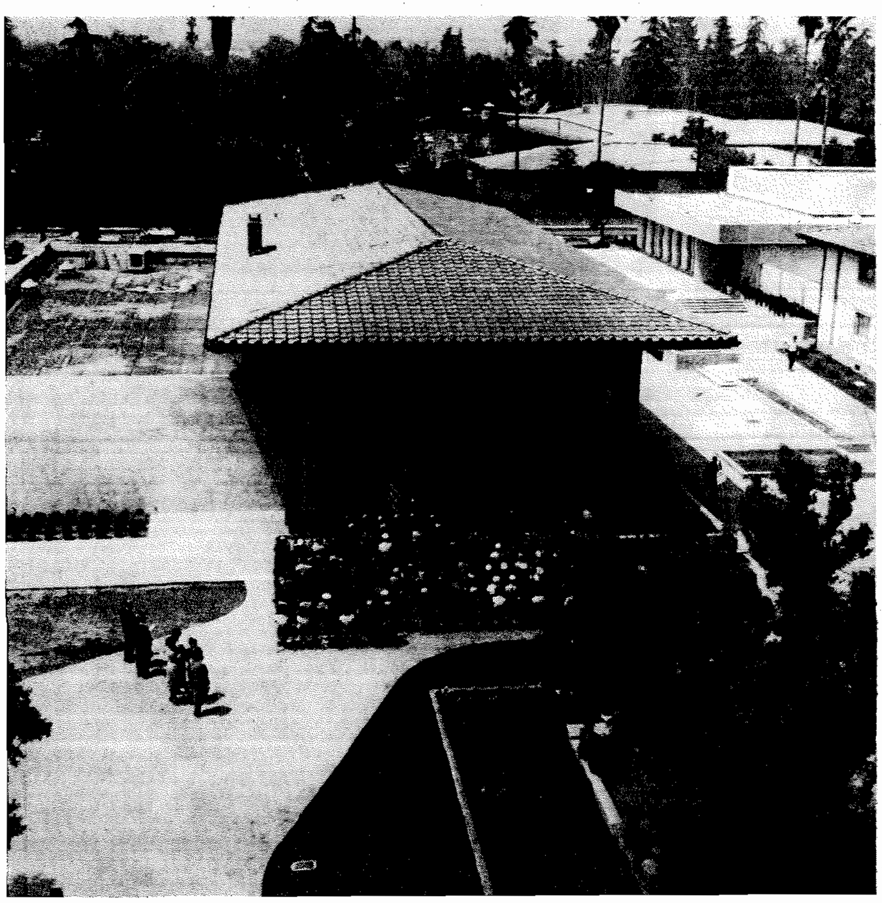
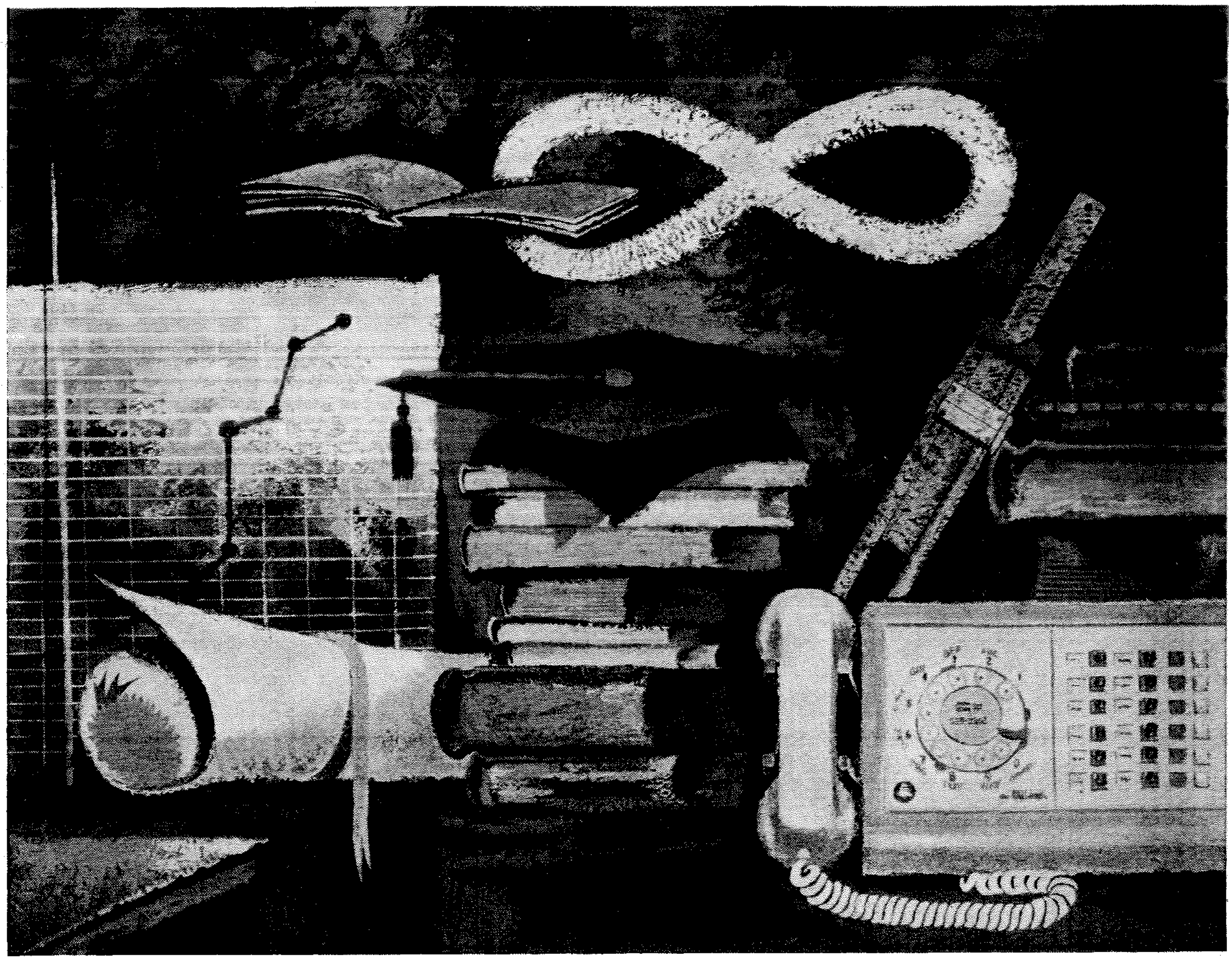
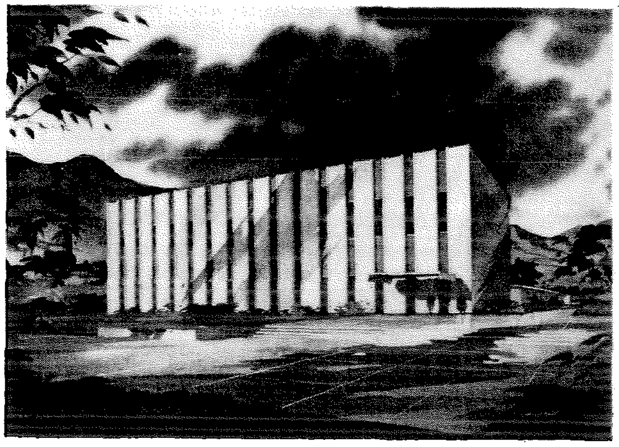


*Commencement Speaker Charles H. Percy and Caltech's President DuBridge.*



STUDENT CENTER
*Caltech's $600,000 Winnett Student Center was formally dedicated on June 8, shortly before the Institute's 68th annual commencement exercises. It gives Caltech undergraduates a center for extracurricular activities for the first time. The Center is the gift of P. G. Winnett, Caltech trustee and chairman of the board of Bullock's, Inc.*





### *New Computing Center*

A new computing center of unprecedented speed and versatility will be opened at Caltech next year, launching what will probably be the most significant research effort of the next decade at the Institute.

The center will occupy a three-story, 21,000-square-foot building to be located on the northeast corner of San Pasqual Street and Chester Avenue. The main floor will house two IBM computers and additional communication and control equipment to be developed at Caltech. This complete system is expected to handle problems in education and research that are beyond the reach of any computer operating today.

The new center will be named for the late Willis H. Booth, who was director of many prominent corporations, including IBM. A gift of $350,000 from the Booth Ferris Foundation of New York City, and of $400,000 from the National Science Foundation, is financing the center. Construction will get under way next September.

### *Crown City Award*

Caltech is the first winner of the Crown City Award, established by the Pasadena Chamber of Commerce and presented at the Chamber's annual banquet last month. The selection was made on the basis of participation in community projects, individual service in community organizations by management and employees, cooperation with schools, sponsorship of community activities, industrial beautification, bringing national recognition to Pasadena, and contributions to health and welfare agencies.

# Personals

### 1903

*Richard W. Shoemaker* of Grass Valley, California, was honored this spring by the Engineering Council of Sacramento Valley for his contribution to the growth and development of the electrical power industry and the engineering profession. He has about 25 patents in his name, and is still active with the American Institute of Electrical Engineers. In 1953 he was honored by the Caltech Alumni Association on the golden anniversary of his graduation.

### 1907

*Samuel B. Morris* died on March 6 after a long illness. He was 71. He served as general manager of the Pasadena City Water Department and of the L.A. Department of Water and Power. From 1935 to 1944 he was professor of engineering and dean of the school of engineering at Stanford. Morris Dam on the San Gabriel River was dedicated in his honor in 1934. At the time of his death he was a member of the California State Water Commission. A widower, he leaves two sons, Brooks and Robert.

### 1927

*Clarence L. Haserot* died of a heart attack in Detroit on March 7 while on a business trip. He was the West Coast representative of the Acheson Colloids Company in Los Angeles, and was also secretary of the American Society of Lubricating Engineers. He leaves his widow, four sons – Jerold, Richard, Roger and Douglas – and three grandchildren.

### 1930

*Ezra C. Posner, MS,* died on December 20, 1961, of complications following surgery. He had been with Lockheed Aircraft Company in Los Angeles for 23 years, most recently as a design specialist. He leaves his wife and two daughters, Audrey and Sharon.

### 1933

*Edwin N. Davis,* MS, died on January 28 of a heart attack. He was assistant agricultural engineer for the Colorado State University. He leaves his wife and a daughter, Mrs. Roger Dale.

### 1936

*Robert T. Gelder,* materials research and development engineer in the missiles and space division of the Douglas Aircraft Company in Santa Monica, died of a heart attack on February 18. He leaves his wife and a son, Robert.

### 1937

*Ellsworth W. Cornwall* died of a heart attack on February 24 in Pacific Palisades. He was specialist design engineer at the Douglas Aircraft Company until June 1961, when he joined Section 355 of the Jet Propulsion Laboratory as an engineering specialist. Bill is survived by his wife and two daughters – Dianne, 18, and Sandra, 14.

### 1948

*James E. Martin* died of a heart attack on March 24 in Los Angeles. He was a civil engineer and executive assistant to the State Assistant District Highway Engineer for the State of California Division of Highways. He had been with the division for 14 years. He leaves his wife, a daughter, Cecilia, and two sons, Loren and Brion.

### 1950

*Geoffrey H. Grey,* vice president and treasurer of the Dynamics Instrumentation Company in Monterey Park, died of heart complications on February 8.

### 1959

*Lieut. Andrew C. Sergi,* MS, died on February 17 of injuries received in an automobile accident. He held the rank of 2nd Lieutenant in the 5th Infantry Division at Fort Carson, Colorado.

## STAND UP AND BE COUNTED

The Alumni Fund concluded solicitations for the 1961-62 year with a letter to all alumni from President DuBridge. The grand total for the 1961-62 solicitation is as follows:

| | |
|---|---|
| Alumni contributing to 1961-62 Alumni Fund | 1708 |
| Amount contributed to endowment principal | $46,157 |
| Amount contributed to other campus purposes | $17,224 |
| Grand Total | $63,381 |

Alumni participation was 21.8 percent. This figure can certainly be improved on in future years.

– Claude B. Nolte '37
Director, Caltech Alumni Fund

# Kodak reports on:

**how a young physicist's wife earns while he learns . . . liquid crystals . . . a trace a little darker, a background a little lighter**

## Great blocks of sensitivity

KODAK Nuclear Track Pellicles, Type NTB4, are hereby announced. This merchandise is manufactured for the simple purpose of understanding the fine structure of the universe. Prizes (or at least respectful attention at high-energy physics conferences) may be won for the ingenious use of this merchandise. Try particle accelerators, reactors, satellites, spacecraft, balloons, mountain peaks, rooftops, submarines, deep mines. We offer no new suggestions on use. We have done our part by devoting a great deal of the time and talent of what we hope are the world's best photographic emulsion technologists to the problem of substantially exceeding the highest previously available sensitivity and manufacturing the product to high standards of uniformity and within the continental limits of the United States. We have succeeded. To wit, minimum-ionization track is delineated by no fewer than 30 grains per 100 microns of track length. The silver-to-gelatin ratio is grotesquely high.

Pellicles are 3″ x 4″, 4″ x 4″, 4″ x 6″, or any other size rectangles of unmounted photographic emulsion around 600 microns thick. A nominal thickness is given on the label and held to $\pm 5\%$ over the pellicle, the box of pellicles, and the whole blooming batch of pellicles. They are shipped immediately after packaging. Customers stack them into great blocks of emulsion, sometimes as much as a cubic foot of solid, three-dimensional sensitivity. Somewhere inside may terminate the journey of a nucleus that has been moving fast in a relativistic straight line ever since Creation.

The pellicles are marked by the customer, usually with x-rays, for position in the stack. For processing they are mounted on gel-coated glass plates with a mounting gel. Plates and gel come in the package. Processing is quite an operation. It takes 7½ days. The fixing alone takes 72 hours. Sharp changes of pH or osmotic pressure would ruin everything. After drying, each pellicle is microtomed. In scanning under the microscope for significant tracks, it is helpful to be able to count on good equipment and a well-trained staff of a few hundred graduate students' wives.

*Before embarking on all this, you will want to check out a few more details with Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y.*

## Skepticism, smecticism, and commercialism

What a skeptical fellow is the genial chief control chemist for EASTMAN Organic Chemicals! Genial but skeptical. That's OK. Skepticism is essential in the man without whose signature nothing leaves the place. Geniality is optional.

*N-p-Methoxybenzylidene-p-phenylazoaniline* (EASTMAN 8545) and the related *p-Anisaldazine* (EASTMAN 8546) melted cloudy. Said he: "They are not pure. Take them back." He said it genially. He was wrong. He did not know that these two compounds display the very unusual physical phenomenon of liquid crystal formation.* Liquid crystals can be either smectic or nematic. The smectic ones act as though they were crystalline in two dimensions and liquid in one dimension. The nematic ones are solid in one dimension and liquid in two. Some of these thermotropic mesomorphs show a million times the optical rotatory power of quartz of similar thickness.

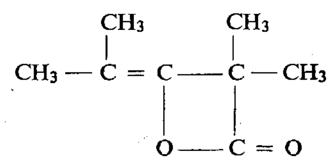
It's all in the literature. Even these two particular compounds are mentioned. The g. b. s. c. c. c. claims to believe now and has signed the papers.

*These EASTMAN Organic Chemicals are obtainable from Distillation Products Industries, Rochester 3, N. Y. (Division of Eastman Kodak Company).*

*One learns about EASTMAN Organic Chemicals at about the same time as one learns how to use chemicals professionally. We find this a very pretty state of affairs and so do the customers. They can get any of some 3900 compounds, in small bottles, from a single source, with a minimum of salesmanship, utterly clean of ulterior motives, no free samples.*

*Do not confuse EASTMAN* Organic *Chemicals with EASTMAN* Industrial *Chemicals, which are also organic but very few of which are priced higher than a penny a gram because the salesman has the ulterior motive of building your interest into tankcar orders. These would come from Eastman Chemical Products, Inc., Kingsport, Tenn. (Subsidiary of Eastman Kodak Company).*

*A typical EASTMAN Industrial Chemical at the commercially nascent stage is* 2,2,4-Trimethyl-3-hydroxy-3-pentenoic Acid, β-Lactone, *to be known as TMBL and represented as*



*This structural formula is expected to inspire a wise, commercially motivated reader to ask himself, "Wouldn't this make a lovely starting material for our (********)?" We would then inform him that in pilot-plant quantities it is priced at $3.50 per pound, that we can send him a technical data report which explores its properties and reactions in a preliminary way, that from the host of compounds derivable from our wealth of isobutyraldehyde and our devotion to ketene chemistry we selected this one for study largely for its fetching look. We can probably ship 5 gallons from stock; an order for a drum might have to wait as much as six weeks, depending on the work load in the pilot plant.*

## More time for happiness

Nearly all recently designed oscillographs put out immediately visible traces. They work because of a photo paper called KODAK LINAGRAPH Direct Print. The trace is drawn by a tiny high-intensity light spot, rich in u-v. The paper thereupon emerges into the open without application of chemicals. The image remains visible for weeks because light energy falling on this paper at ambient rates has much less blackening effect on the background than it has on the areas that have been touched by the brilliant image.

Being vigorous Americans, we must move on. No resting is permitted on the oars. Where do we go from here? We put up a statistic. Never mind where it came from. The statistic says that 90% of all recording is done slower than 100 cycles/-sec. So we issue a new product called KODAK LINAGRAPH 591 Paper. If the customer is willing to accept 0.4 the speed of the first product, he can have darker traces against a lighter background for a longer span of time between emergence from the oscillograph and the final arrest of fading by a ride through our PERMANIZING Developer.

*If the man from whom you buy your photorecording supplies is too busy to develop in you a connoisseur's taste in recording paper, ask Eastman Kodak Company, Photorecording Methods Division, Rochester 4, N. Y. There is no price premium. We just want you to be as happy as possible. The thin-base variety is KODAK LINAGRAPH 592 Paper.*

*O. Lehmann, *Flüssige Kristalle und ihr scheinbares Leben*, Voss, Leipzig (1921)

*Price subject to change without notice.*

*An interview with General Electric's W. Scott Hill*

One of a series...

*Manager—Engineering Recruiting*

# How to Make the Most of Your First Five Years

**MR. HILL has managerial responsibility for General Electric's college recruiting activities for engineers, scientists, PhD's and technicians for the engineering function of the Company. Long active in technical personnel development within General Electric, he also serves as vice president of the Engineers' Council for Professional Development, board member of the Engineering Manpower Commission, director of the Engineering Societies Personnel Service and as an officer or member of a variety of technical societies.**

**Q. Mr. Hill, I've heard that my first five years in industry may be the most critical of my career. Do you agree?**

A. Definitely. It is during this stage that you'll be sharpening your career objectives, broadening your knowledge and experience, finding your place in professional practice and developing work and study habits that you may follow throughout your career. It's a period fraught with challenge and opportunity—and possible pitfalls.

Recognizing the importance of this period, the Engineers' Council for Professional Development has published an excellent kit of material for young engineers. It is titled "Your First 5 Years." I would strongly recommend you obtain a copy.*

**Q. What can I do to make best use of these important years?**

A. First of all, be sure that the company you join provides ample opportunity for professional development during this critical phase of your career.

Then, develop a planned, organized personal development program—tailored to your own strengths, weaknesses and aspirations—to make the most of these opportunities. This, of course, calls for a critical self appraisal, and periodic reappraisals. You will find an extremely useful guide for this purpose in the "First 5 Years" kit I just mentioned.

**Q. How does General Electric encourage self development during this period?**

A. In many ways. Because we recognize professional self-development as a never-ending process, we encourage technical employees to continue their education not only during their early years but throughout their careers.

We do this through a variety of programs and incentives. General Electric's Tuition Refund Program, for example, provides up to 100% reimbursement for tuition and fees incurred for graduate study. Another enables the selected graduate with proper qualifications to obtain a master's degree, tuition free, while earning up to 75% of his full-time salary. These programs are supplemented by a wide range of technical and nontechnical in-plant courses conducted at the graduate level by recognized Company experts.

Frequent personal appraisals and encouragement for participation in professional societies are still other ways in which G.E. assists professional employees to develop their full potential.

**Q. What about training programs? Just how valuable are they to the young engineer?**

A. Quite valuable, generally. But there are exceptions. Many seniors and graduate students, for example, already have clearly defined career goals and professional interests and demonstrated abilities in a specific field. In such cases, direct placement in a specific position may be the better alternative.

Training programs, on the other hand, provide the opportunity to gain valuable on-the-job experience in several fields while broadening your base of knowledge through related course study. This kind of training enables you to bring your career objectives into sharp focus and provides a solid foundation for your development, whether your interests tend toward specialization or management. This is particularly true in a highly diversified company like General Electric where young technical graduates are exposed to many facets of engineering and to a variety of product areas.

**Q. What types of training programs does your company offer, Mr. Hill?**

A. General Electric conducts a number of them. Those attracting the majority of technical graduates are the Engineering and Science, Technical Marketing and Manufacturing Training Programs. Each includes on-the-job experience on full-time rotating assignments supplemented by a formal study curriculum.

**Q. You mentioned professional societies. Do you feel there is any advantage in joining early in your career?**

A. I do indeed. In fact, I would recommend you join a student chapter on your campus now if you haven't already done so.

Professional societies offer the young engineer many opportunities to expand his fund of knowledge through association with leaders in his profession, to gain recognition in his field, and to make a real contribution to his profession. Because General Electric benefits directly, the Company often helps defray expenses incurred by professional employees engaged in the activities of these organizations.

**Q. Is there anything I can do now to better prepare myself for the transition from college campus to industry?**

A. There are many things, naturally, most of which you are already doing in the course of your education.

But there is one important area you may be overlooking. I would suggest you recognize now that your job—whatever it is—is going to be made easier by the ability to communicate . . . effectively. Learn to sell yourself and your ideas. Our own experience at General Electric—and industry-wide surveys as well—indicates that the lack of this ability can be one of the major shortcomings of young technical graduates.

**The kit "Your First 5 Years," published by the Engineers' Council for Professional Development, normally sells for $2.00. While our limited supply lasts, however, you may obtain a copy by simply writing General Electric Company, Section 699-04, Schenectady, New York.*

*(An equal opportunity employer.)*

*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**