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ORCHIDS OF NEW GRANADA

BY ALAN KAPULER AND VINCENT HASCALL

The authors of this article are Graduate Fellows of The Rockefeller University who spent last summer in Colombia collecting orchids, some of which may be seen in the magnificent color photographs on the following pages as well as in the University greenhouse. The purpose of the trip was to gather herbarium specimens and live plants for the collection of the Instituto de Ciencias Naturales de la Universidad Nacional in Bogotá.

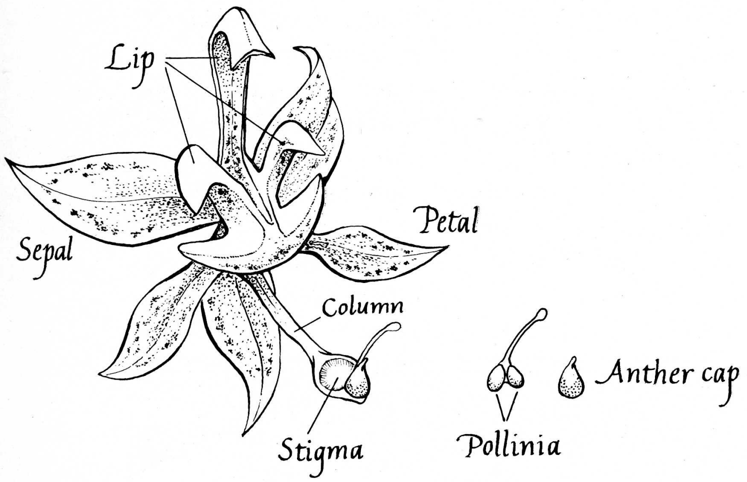
Dr. Leslie Garay, curator of the Oakes Ames Herbarium at Harvard, and Dr. Alvaro Fernandez Perez, Director of Botany of the Instituto de Ciencias Naturales, are compiling a definitive work on the rich orchid flora of Colombia. This undertaking will require years of patient research in the library and herbarium and extensive field work. The authors appreciate the warm hospitality of Dr. Fernandez and his counsel and technical assistance which made much of their collecting trip possible.

In their travels Mr. Kapuler and Mr. Hascall followed routes once taken by Alexander von Humboldt, one of the most renowned and revered explorers of South America. During his one trip to the New World (1799-1804), von Humboldt made large collections and profound observations in many fields — botany, zoology, geology and geophysics, and anthropology — observations which have established guidelines for much of the scientific endeavor in South America today, including the work here reported. His travels covered what was then known as the Spanish colony of New Granada, at its greatest extent including modern Colombia, Ecuador, Panama, and Venezuela.

After driving from New York to Panama, we took a steamer to Cartagena. Our journey continued by river boat up the Magdalena River and eventually we reached Bogotá. Subsequent trips were made by air to Leticia and Quibdo and by car to southern parts of the Colombian Andes. The numbers on the map, which show the approximate locale where we collected the flowers, appear as superscripts in the text and captions.

NOWHERE IN THE plant world have such variety and ingenuity been applied to insure propagation of the species as in the *Orchidaceae*. Many distinguished scholars have been fascinated by the unique and intricate modifications necessary for their reproduction. Among the first was Robert Brown, who de-

Sigmatostalix minax Rchb. f.[1] ×4



voted many years to a study of the reproductive morphology of the orchid flower. His work on this subject culminated in 1831 in a brilliant paper presented before the Linnean Society of London in which he discussed the necessity for physical contact between the pollen and the stigmatic surfaces of the flower for the eventual development of seeds. It was in the same paper that he discussed a structure which he called the nucleus, noting that it was present in all cells. Another contributor to the field of orchidology was then preparing for his voyage on the *Beagle;* thirty-one years later, in 1862, Charles Darwin contributed his keen biological insight to the problems of orchid pollination in a monograph, "Various Contrivances by which British and Foreign Orchids Are Fertilized by Insects."

The study of pollination has been a source of admiration and occasional frustration to those scientists who in the tradition of Brown and Darwin have sought the often elusive mechanisms. A glimpse at the characteristic morphology of the orchid flower serves to delineate their problem. Most members of the orchid family have modified the familiar anthers and dusty pollen found in corn and lilies. Simultaneously, they have evolved a unique, hence diagnostic, structure known as the column. This organ holds both the female stigmatic surface, a viscous sticky region which receives the pollen, and the male pollinium, a compact, waxy mass of individual pollen grains. *See the drawing at left.* The structural matrix of the column evolved through the fusion of the filaments which bore the anthers, with the style which originally held the stigma. Rather than rely on the winds or on transient beetles for dispersal of individual pollen grains, the 15,000 to 30,000 species of orchids depend mainly upon bees, wasps, butterflies, hummingbirds, and moths for securing pollination. These vectors transport the entire pollinium from the apex of one column to the stigma of another flower, thus achieving the simultaneous transfer of thousands of pollen grains. The development of many ovules in the ovary facilitates production of immense numbers of seeds with each successful pollination event. The widely distributed American orchid, *Cycnoches chlorochilon,* specimens of which we collected near Leticia in the Amazonas of Colombia, is reported to have had 3,770,000 seeds in one fertilized ovary. Other orchids are not so prolific, but the dynamics are clear. Pollinators are highly specific, making pollination events rare. The pollinia, however, insure maximal efficiency for transfer of pollen, and the presence of many ovules insures production of large numbers of seeds should pollination occur.

Pollinator and plant often show remarkable specific adaptation to one another in their morphology. Darwin, realizing this, made an interesting prediction after examining a species of African orchid, *Angraecum sesquipedale.* He observed an astonishingly long nectary which extended as much as 18 inches and contained nectar in the distal end. He confidently concluded that a pollinator must exist which could take advantage of this unusual food supply. "The pollinia would not be withdrawn till some huge moth with a wonderful long proboscis tried to drain the last drop. If such great moths were to become extinct in Madagascar, assuredly the *Angraecum* would become extinct also. On the other hand, as the nectar, at least in the lower part of the spur, is stored safe from depredation by other insects, the extinction of the *Angraecum* would probably be a serious loss to those moths." It was not until many years after his prediction that a moth with a proboscis of sufficient length to drain the nectary was discovered and found to be the pollinator of this species. Insects may also be attracted by odoriferous secretions of the flower. A striking case

occurs in many *Bulbophyllum* species found in New Guinea. The odor they produce, that of rotting meat, attracts their pollinators, carrion flies. A similar example is found in an American orchid, *Stanhopea wardii,* which we collected in San Agustin. Its four-to-five-inch flowers appear once a year, last one to two days, and emit an intense odor of chocolate which attracts a group of iridescent bees.

The seeds themselves are small and light. The individual seed contains no food reserve such as is often present for the developing embryo in other angiosperms. It may weigh as little as a few micrograms and, unlike the pollen, is freely dispersed by the wind. The data from the repopulation of the island of Krakatoa, following the complete destruction of its plant life by a volcanic eruption in 1883, illustrate this dispersal capacity. Fifteen years after the eruption, 17 of the 53 species of plants observed had arisen from windborne seeds. Eight of the 17 were grasses, five were composites, and four were orchids.

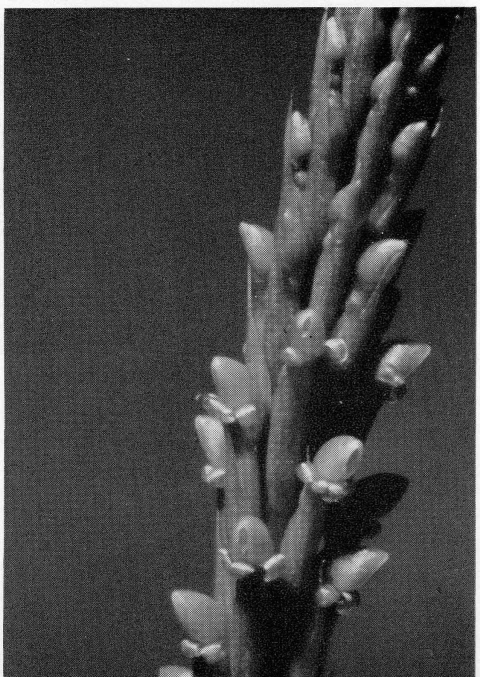
In view of the large numbers of seeds produced and their ease of distribution, why are there so few individuals of so many species? For example, it is possible to find a very rare species such as *Sigmatostalix minax*[1] in the field and search unsuccessfully for a second specimen. Insight into this question was gained by studying the growth of plants from seed in the laboratory. Germination of more than 50 percent of the seeds of some species can be obtained by sowing them on an agar medium containing mineral salts and high concentrations of glucose. The carbohydrate source is the critical factor. In nature it is supplied by endophytic fungi which the seeds of all orchids must encounter for successful development. As the embryo develops, it digests the intracellular fungus to provide itself with metabolites. When the seedling develops chloroplasts, it becomes photoautotrophic and then loses its dependence upon the fungus.

The probability of reaching maturity is not high even for those few seeds which find the proper germinating conditions, because from three to ten years are needed before flowering will occur. Since the seedlings are more sensitive to ecological hardships than are adult plants, few mature adults result, although a multitude of seeds is initially produced. However, high frequency production of new individuals is not needed to maintain the natural balance of plants because the lifetime of an individual clone is virtually unlimited. New growths are made once or more each year, or growth is continuous. Over a great period of time, then, a delicate balance between pollination, seed production, and plant maturation has been established, resulting in many species being represented by small populations of individuals.

For those familiar with corsage orchids, the photograph of *Sobralia violacea alba*[6] strikes a classic pose. The most prominent feature of the flower is its large

Platystele sp. nov.[2] (right), *head of pin* (left) ×10

Prescottia stachyoides (Sw.) Lindl.[3] ×¾



Restrepia antennifera Lindl.[4] ×1½ (facing)

Elleanthus aureus (P. and E.) Rchb. f.[5] ×¼ (upper left)

Sobralia violacea alba Lindl.[6] ×½ (upper right)

Cleistes rosea Lindl.[7] ×½ (lower left)

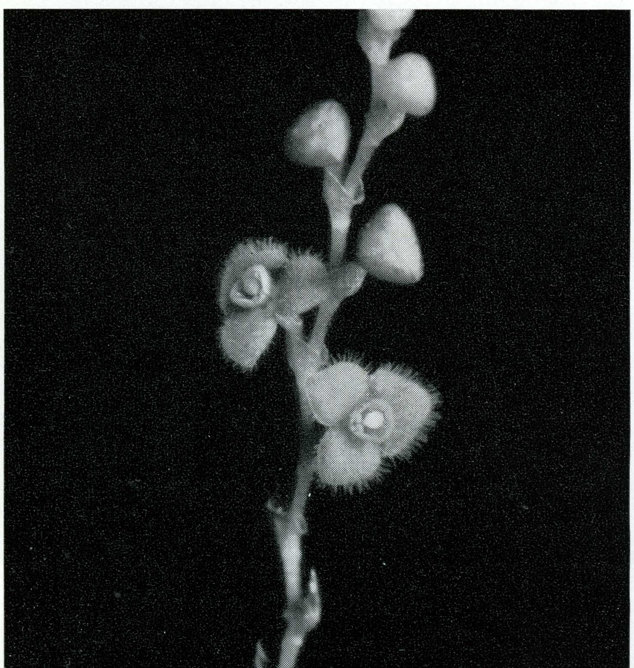
Lepanthes tracheia Rchb. f.[8] ×2 (lower right)

and showy lip, a modified petal. Two simple petals and an outer whorl of three sepals complete the perianth of the flower. *Cleistes rosea*[7], closely related to the genus *Sobralia,* has a similar flower structure. Various degrees of fusion, reduction, and modification of these segments occur in groups within the family. A colorful example is *Lepanthes tracheia*[8]. The petals and lip are reduced and the prominent segments seen in the photograph are sepals. Even greater reduction of the elements of the corolla occurs in *Stelis microchila*[9]. In *Restrepia antennifera*[4], the ventral sepals are fused and the dorsal sepal and two petals have become filiform. Small flower-size and many-flowered inflorescences, as in *Prescottia stachyoides*[3], *Pleurothallis fraterna*[10], and *Elleanthus aureus*[5], are common characteristics of orchids. In the province of Choco, Colombia, we found what is undoubtedly one of the smallest orchids known: a new species of *Platystele*[2]. The plant stands less than three-quarters of an inch high and the orange and red flowers measure one-sixteenth of an inch across. In contrast, *Sobralia Weberbaueriana* represents the other extreme encountered on our trip: ten-to-fourteen-foot plants, crowned by a cluster of four-to-five-inch-wide pale lavender flowers, frequently jutted out from the sides of road cuts near Bogotá.

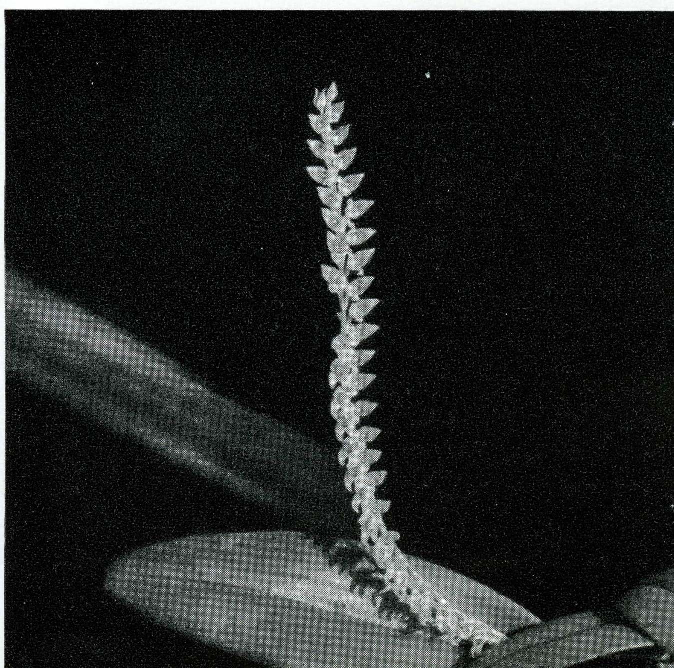
Most old and new world species are found between the Tropics of Capricorn and Cancer, though representatives of the family extend almost to the Arctic Circle. A common misconception, however, is that they reside only in the dense, impenetrable forests of hot and humid lowlands such as those of the Amazon basin. In South America most species inhabit the mountain ranges from 5,000 to 12,000 feet. Colombia, transected by three impressive cordilleras of the Andes, may well have more species (from 3,000 to 4,000) than any other country in the world. Many orchids thrive in the cold, moist conditions found just below high plateau regions called paramos. They grow on the ground partially hidden in wet, spongy carpets of mosses. The paramos themselves, with temperatures seldom reaching 50°F, extend upwards from 9,000 feet and are abundant in Colombia. Their perpetual blanket of clouds gives the landscape a sullen, misty beauty all its own.

"Plants and rocks are related to their soil, their climate, their altitude," Alexander von Humboldt once stated. "All natural objects must be studied in their relationship to each other." Today, in Colombia as in all of Central and South America, the amount of cultivated land is rapidly increasing. Thus the natural objects and their relationships must now include man. Due to the radical changes he brings to their environment, many species of orchids will undoubtedly vanish; in fact some already have. Perhaps the contribution of collectors and taxonomists in the future will include the special responsibility of selecting and preserving such small, economically insignificant and unobtrusive treasures as the *Lepanthes*, the *Platystele*, and the *Stelis*. We hope so.

Stelis microchila Schltr.[9] ×4



Pleurothallis fraterna Lindl.[10] ×½



CONVOCATION FOR CONFERRING DEGREES

9 JUNE 1965

The seventh Annual Convocation was held on June ninth. On that occasion the degree of Doctor of Philosophy was conferred on eleven Rockefeller graduate fellows; Lee Alvin DuBridge, President of California Institute of Technology, was awarded the honorary degree of Doctor of Science.

The Reverend John Coleman Bennett, who has recently become President of the Union Theological Seminary, delivered the Invocation and Benediction.

In accordance with our unique custom, each graduand was presented by a member of the faculty in an address that recounted the candidate's achievements. The degree was then conferred by President Bronk and the graduate was hooded by a marshal.

Thomas Peter Bennett

B.A. THE FLORIDA STATE UNIVERSITY

PRESENTED BY FRITZ A. LIPMANN

All of you by now must have become more or less exposed to the puzzles surrounding the genetic code. These are most fascinating problems with many facets, and it is this area to which Peter Bennett became strongly attracted. The background is, in brief, that four different bases are joined in a fixed sequence in nucleic acids. These bases are the code letters. To be read, they combine into triplets and form a template for the synthesis of proteins. Proteins are composed of 20 different amino acids. In protein synthesis, each triplet places one of the 20 amino acids in sequence. A protein is a ribbon composed of 150 or more amino acids in a specified order. Once synthesized, this ribbon appears to fold into secondary, tertiary, and quaternary structures; in these forms the proteins function in the organism. Now, if the four bases are grouped in threes, a simple calculation shows that this gives 4^3, or 64, combinations. But there are only 20 amino acids to be coded for. Obviously, then, there is a possible redundance of about three to one for each amino acid, i.e., three possible code words for each amino acid. The question is, do several triplets code for the same amino acid, making it a redundant or degenerate code?

It was this question to which Peter Bennett addressed his efforts. An early indication of redundance had come through the application of Lyman Craig's countercurrent separation method to the mixture of short nucleic acids to which the amino acids are fixed by activating enzymes. Each of these activating enzymes specifically fixes one of the 20 amino acids to a corresponding adaptor nucleic acid. This carries a specific triplet through which it is fixed to a matching triplet on the template. Most fortunately, Dr. Goldstein in the Craig laboratory had started separation studies on these short nucleic acids. Thus, Peter Bennett could try the analytically separated compounds for the amino acid leucine, of which there appeared to be many different ones. Using this example of apparent redundancy he showed in various ways that the different soluble nucleic acids for leucine carry different triplets. Here, then, he confirmed unambiguously a redundance of the amino acid code.

Subsequently, Bennett was the first to prove redundancy for another amino acid, serine. He showed a coding difference between two serine-specific countercurrent fractions separated by Goldstein. This was a most welcome further affirmation of the coding multiplicity. The complexity of his various

approaches to prove redundance forbids our describing the very intriguing details. It has been a pleasure for our whole group to participate in this exciting venture.

But I would not be just to Peter Bennett if I talked of him only as a *homo scientificus.* His interests are happily unrestricted, ranging from delight in the curiosities of nature to flying airplanes and experimenting with movie making. Although he intends essentially to stay with biochemistry, and in particular enzymology, he is now expanding his experience by taking a stretch with Dr. Trager in parasitology to study growth of malarial organisms in red blood cells. We wish him all the best for a very promising future; we shall miss him.

Richard Charles Blinkoff

A.B. HAMILTON COLLEGE

PRESENTED BY ZANVIL A. COHN

Richard Blinkoff joined the student program of The Rockefeller Institute after a distinguished career at Hamilton College. Following a period of orientation he became interested in immunology — and this was first expressed in a critique of current theories of antibody formation. His interest came at a time when immunology was undergoing a renaissance. As a result of advances in all aspects of the biological sciences it became possible to approach the mechanisms by which an animal host responds to the introduction of a foreign substance — the antigen — and produces a series of specific globulins — the antibodies. In addition to having great practical importance in resistance to infection and tissue transplantation, antibody formation has fired the imagination of a large portion of the scientific community. What constitutes an antigen? How is its message transmitted? What codes and stimulates a given cell to produce complementary proteins? For a balanced view of these processes, at both cellular and molecular levels, a multidisciplinary approach is mandatory.

It was in this context that Mr. Blinkoff initiated his studies and chose as his experimental model the response of the mouse to a pathogenic bacterium — *Salmonella typhimurium.* He soon developed a sensitive assay in which antibodies immobilized the flagella of freely swimming microorganisms. Employing this technique he found that a single injection of antigen resulted in the formation of two distinct classes of antibody molecules. Using both physical and chemical techniques he demonstrated that the first antibodies to appear were large, heavy molecules — macroglobulins — which were synthesized for a short time and then replaced by more conventional 7S globulins. This observation prompted a more detailed analysis of the factors responsible for the production of these two classes of antibodies.

By removing the spleen surgically, Mr. Blinkoff was able to show that this organ synthesized both heavy and light antibodies and in the same proportions as the lymph nodes. By the use of chemicals which inhibited cell growth and division he discovered that the production of the two antibodies could be dissociated — a normal production of the more primitive macroglobulin occurred, whereas the lighter antibody was blocked. These results in conjunction with other experiments in which he transferred antibody-forming cells to X-irradiated recipients, allowed him to postulate that the two classes of antibody were manufactured independently — initiated, perhaps, by different cell types. This represents a significant advance in our knowledge of the immune response and opens the way for a more detailed cytological analysis.

In addition to Richard's scientific accomplishments and technical skills we are very pleased with other important and more subtle qualities which he has demonstrated: independence of thought and action, intellectual integrity, responsibility, and purpose. It is these traits, as much as any, that will determine his future career as a scholar-investigator.

I would be remiss if I did not acknowledge two of his stanchest supporters, whose contribution is perhaps not fully covered under the term extra-curricular activities — namely, his lovely wife and daughter.

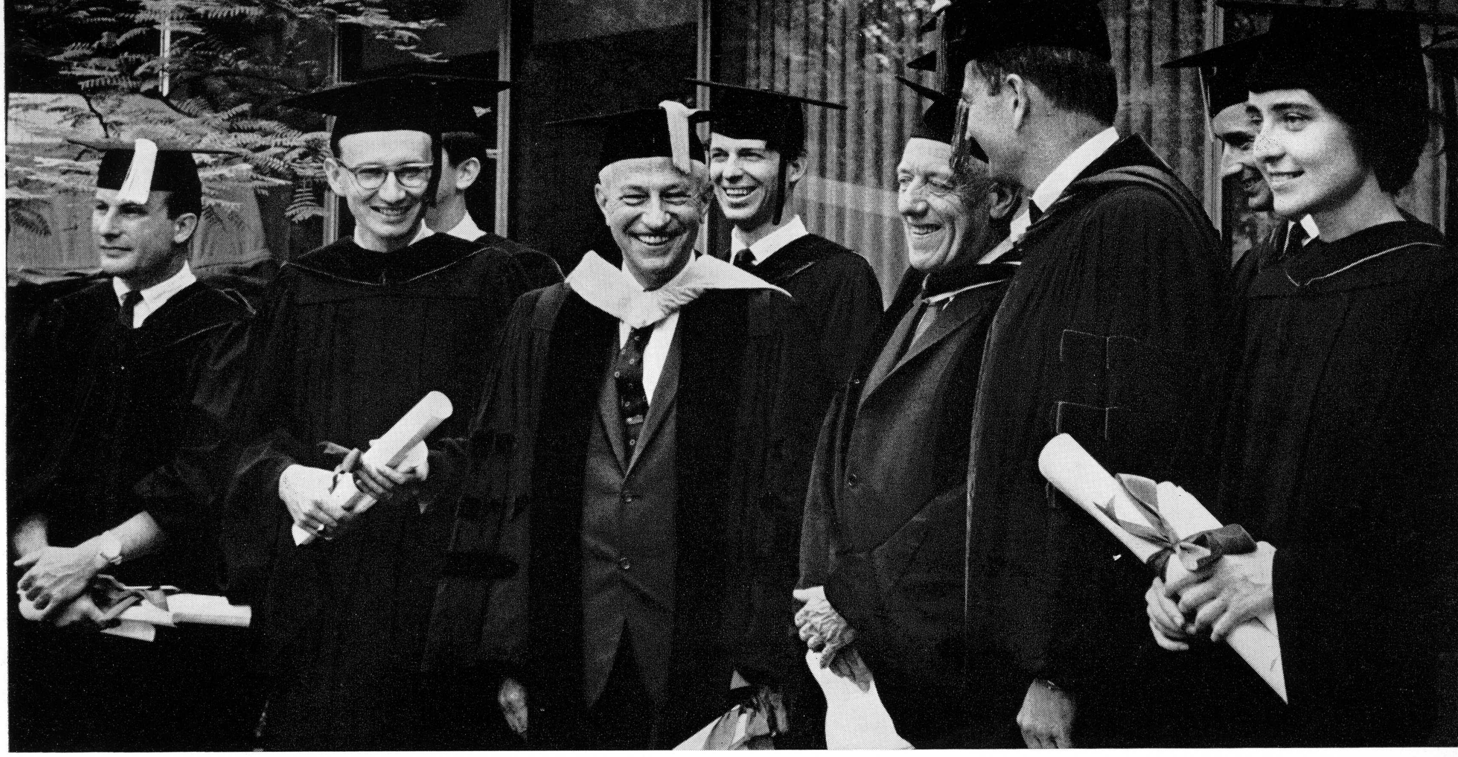
Dr. Bronk, it gives me great pleasure to recommend Richard Blinkoff for the degree of Doctor of Philosophy.

Paul Richards Burgess

B.A. REED COLLEGE · B.A. UNIVERSITY OF OXFORD

PRESENTED BY VICTOR J. WILSON

Following completion of his undergraduate studies at Reed College, Paul Burgess continued his education as a Rhodes Scholar and then came to The



Rockefeller Institute in 1959. From the time of his arrival he has had a strong interest in the mechanisms involved in sensation, that is, in the way in which an animal is made aware of its environment and of the changes that take place in this environment. He has pursued this interest with zest and determination, and during this pursuit has also succeeded, with the help of gentle persuasion, in acquiring the varied scientific background that is the prerequisite for the study of any complex physiological problem.

In his work Burgess has concerned himself with cutaneous sensation. Appropriate stimulation of the skin can elicit four main types of sensation: warmth, cold, touch, and pain. The question of interest is the following: how does an event at the skin, such as contact with an ice cube, give rise to the appropriate sensation, in this case touch and cold? From the work of Adrian and his colleagues we know that various types of stimuli give rise to electrical impulses, called action potentials, in nerve fibers connecting the skin with the central nervous system, and that the stronger the stimulus the more numerous the action potentials. However, we can ask whether there is, for each type of sensation, a separate system of nerves and relays from skin to brain or whether the pathways overlap. If there is overlap, does the same nerve cell transmit coded information about two or more modalities, each modality being represented by a different pattern of activity? Information presently available tells us that in the periphery there is much specificity; each receptor with its nerve fiber is usually much more sensitive to one type of stimulus than another. We can reasonably speak of touch nerve fibers, warm fibers and cold fibers. Does this specificity remain after many peripheral fibers have converged on cells within the central nervous system? This is the problem that Burgess has studied in the spinal cord of the cat.

The spinal cord presents several advantages for the kind of experiment that Burgess has conducted. One of these advantages is that it contains fibers which are nothing more than continuations of the primary fibers from the skin, as well as fibers which receive inputs from different cutaneous nerves. The properties of the two types of fibers can be compared relatively easily. To accomplish this, Burgess has recorded the electrical signals from single nerve fibers in the spinal cord with very fine metal electrodes. Activity in these fibers was evoked by a wide variety of carefully controlled mechanical and thermal stimuli applied to the skin, and the pattern of this evoked activity was analyzed with the help of a digital computer. One result of these carefully thought-out and well-executed experiments is that Burgess has confirmed and extended previous findings of others on the specificity of primary afferent fibers. He has also studied the activity of higher-order cells and has

shown that many are polymodal; that is, they are activated by more than one kind of stimulus and may respond, for example, to touch and heat. However, the responses to touch and heat do not differ in any discernible way. Possibly there is a difference in pattern, but one so subtle that it has not yet become apparent. An alternative is that the coding involves the behavior of groups of cells; many more cells will have to be studied for evaluation of this possibility. In the course of these experiments very few cells have been found that were activated by small temperature changes or were excited only by painful stimuli. It has been suggested in the past that nerve cells involved in the transmission of pain are very small, and one limitation of all available methods is that it is difficult to study small cells successfully. Further work in this direction therefore awaits an improvement in technique.

Paul Burgess has successfully begun an investigation that shows promise of providing us with much more understanding of a difficult and interesting problem. As he leaves us to continue his work at the University of Utah, we can say that we will miss this well-informed, critical, and stimulating colleague and eagerly await the results of his future investigations.

Richard Dana Campbell

A.B. HARVARD COLLEGE

PRESENTED BY PAUL A. WEISS

By fearsome exaggeration, the graceful little water polyp, Hydra, became the vicious monster, Hydra, of Greek mythology. Beheaded, instead of dying, it grew a new head or even two heads in the place of one — that is, till Hercules, through his superior muscularity, finished it off. In the millennia since, brainpower having superseded muscle power, the inexhaustible capacity of little Hydra to regenerate lost heads became a veritable brain teaser for students of life processes. In its diagrammatic simplicity, the little animal became a choice object for research. Innumerable data, observations, and experiments on it have been compiled — and yet, we still do not understand just how it does it. It is so easy to say "it grows a head," or even just "it grows." But what a world of difference between just stating, for instance, that an airplane flies and having insight into how it does it!

In recent years, the Hydra puzzle has gotten to be even more perplexing. We have discovered that its ability to regrow a lost body part is by no means a special emergency device for the repair of lesions, but that even the normal, unmutilated animal is in a continuous process of renovation — cells being lost, while others multiply, with only the tally of the cell population remaining stationary. Even more amazingly, shape and proportions of the animal remain unaltered despite this ceaseless change-over of cells. The structure of the whole persists beyond the transitory existence of its elements, much as the architecture of ancient cathedrals has remained the same, however many of the original building blocks may have been replaced over the centuries.

Here lies the deepest problem of organic form. It called for explanation. One that had been offered was the assumption of a strict lock-step order, according to which layers of new cells would emerge and layers of old ones be shed, sequentially, in a rigorously programmed maneuver. Unfortunately, this speculation ran way ahead of the established facts. For the very premise that cell growth occurs in an orderly space pattern lacked substantiation.

In studies of exemplary clarity, simplicity, and thoroughness, Richard Campbell disproved that premise by determining the true distribution of cell renewal. His result: Far from being regularly patterned, cell reproduction occurs essentially scattered at random and rather uniformly throughout the organism. He got his data by supplementing the less reliable older method of counting mitotic figures with the more crucial technique of labeling cells in the act of reproduction by radioactive isotopes. Tritium-containing thymidine becomes incorporated in replicating chromosomes, and cells thus marked can then be readily identified in tissue sections. Because the label is passed on to daughter cells, one can thus not only record the momentary distribution of growing cells but can trace their progeny through subsequent travels. With painstaking thoroughness Dick Campbell has in this manner assembled the first statistically valid census of cell population dynamics in an animal in stationary growth. Facts have replaced guesswork.

Now, in view of its random scatter, the space pat-

tern of cell growth can, of course, no longer be invoked as explanation for the specific form of the organism as a whole. To have brought this deepest riddle of development, so often overlooked in our myopic preoccupation with ever smaller fractional parts, back into focus, is one of the major merits of Campbell's thesis. It bespeaks his versatility that far from satisfied with having resuscitated the problem, he promptly proceeded to tackle it analytically by looking for electron-microscopic signs of a possible structural framework of body shape. And even though the goal still lies in the future, the way to it has now been pointed.

Thus, Mr. President, by past accomplishment and future outlook, as one who combines analytic and experimental skill with deep love and understanding of living nature, as a biologist in the truest sense, Richard Campbell is eminently qualified for the degree of Doctor of Philosophy from this institution. I take pleasure in presenting him for the award of the degree.

Richard Andrew Cellarius

B.A. REED COLLEGE

PRESENTED BY DAVID C. MAUZERALL

Richard Cellarius came to the Institute with the explicit intention of becoming a teacher and with a strong interest in photosynthesis. At that time the mixing of research and teaching was just beginning at the Institute, and nobody was working directly on photosynthesis. A less single-minded student might well have been discouraged by this awkward set of circumstances. But Richard's pride served him well: the limitation on teachers was overcome by self-teaching. He was active in the summer biology program for high school students. The limitation on photosynthesis was in part caused by the odd geographical distribution of this field of research: it is largely a Western activity. Richard and I pooled our common interests and decided to build a model for the photochemical reactions of photosynthesis. Now, whereas models or analogues are well defined in theoretical studies, in experimental work such model building is somewhat more ambiguous. One must steer between the simplicity of the Scylla and the complexity of the Charybdis. The tendency is to simplify the model until it is irrelevant to the biological system. Or one can easily add complications to the model until it is as difficult to decipher as the original system. The fruitful path is rather narrow — at times it seemed to us to be vanishingly so. Richard's perseverance enabled him to develop a model which duplicates at least two of the fundamental aspects of photochemistry in the chloroplasts. The problem was how to approach or model the influence of the structure of a basic element in the chloroplasts, the photosynthetic unit. The idea was to coat very small particles with chlorophyll, varying both the nature of the surface and the fraction of surface covered by the pigment. This sounds simple enough but was in fact both delicate and treacherous. These protophotosynthetic units were then studied for their spectroscopic and photochemical properties. This may sound complicated, but Richard's good understanding of physical processes and measurements allowed him to glide smoothly by those technical and electronic whirlpools that continually threaten the modern molecular Argonauts. He showed that the pigment on these particles remains photochemically active into the range of concentration in which chlorophyll is found in chloroplasts. Moreover, his interpretation of the properties of the photoexcited states of the pigment requires transfer of energy to photoreactive traps. This kind of energy transfer is thought to be the first step in the conversion of the quantum of light energy into chemical energy in the photosynthetic unit. He has thus duplicated some of the characteristic phenomena of the photoreactions which lead to photosynthesis. The analysis which led to these conclusions involved him in worlds of limited dimensions: threadland and filmland. He could explain the distribution of pigment molecules on the particle surface with a one-dimensional interaction energy between pigment molecules. But the energy transfer between molecules requires two dimensions. Possibly the third dimension will appear as one tries to duplicate other properties of the photosynthetic unit with this model. The advantage of the model is that the hypothesis to explain its behavior can be quantitatively verified as one proceeds step by step to make the model resemble more the actual photosynthetic system. Since practically all of the experimental methods and many of the concepts used in this work were new, not only to our laboratory but to this field of research, many varied labors

had to be accomplished. Richard's increasingly broad knowledge, ranging from physics to plant physiology, led to many profitable arguments. These served as our guides through the more narrow and difficult passages of this work.

Richard is now extending his background in theoretical work by spending a year with Professor Platt at the University of Chicago. I am sure that this is only a halfway house on his return to his beloved West Coast. His varied backgrounds and his clarity of expression will serve him well in teaching. His independence and pride in his thought will serve him well in research. It is with great pleasure that I present Richard Cellarius for the degree of Doctor of Philosophy from The Rockefeller Institute.

Lorna Green

B.SC. MC GILL UNIVERSITY

PRESENTED BY PAUL A. WEISS

To help the searcher, the curious prober into the unknown, to find his way, is a prime mission of a university. When Lorna Green came to this University, she came a *searcher* in the truest sense — filled with that native wonderment and wide-eyed curiosity about Nature and the Universe that is in truth insatiable, and yet forever gropes for satiation. Like many a searcher's quest, hers was for answers to very esoteric questions; her hope, to get there straight by the shortest route, like flying. She had to *learn* that the road to knowledge is down to earth, quite tortuous and with no short cuts; that search, in order to make progress, at least in science, must be channeled through research — a systematic and laborious task. The way she buckled down to it and with unbroken spirit entered on an exacting, and sometimes tedious, tour of work, tenaciously contending with the puckishness of living matter, without letting it dim her zest for searching, is truly noteworthy and praiseworthy. As an experience, it must have felt like the maturation of vision in the newborn, which rises from the initial blur of an unstructured world to gradual perception and focusing of well-delimited objects.

The research object on which she chose to focus was a good one: concrete, significant, approachable by modern means, yet not yet adequately clarified and understood — *the mechanism of color change in higher animals.* Frogs, fish, and others darken or blanch as a visual reflex response to light or darkness. The effectors are special skin cells, which contain black pigment granules. These cells turn dark or light, depending on whether the granules in them are scattered or closely packed. The stimulus to do one or the other comes from the eye through nerves or reflex-activated hormones. The actual cellular

machinery, however, was unknown. The older idea that the whole cell itself expands and contracts has proved untenable. Only the tiny black particles themselves seemed involved. Then how do they manage, like soldiers on maneuvers, to assemble or disperse in obedience to a hormonal command? Do they move actively or are they being shoved? And, either way, what is the moving force? What directs them and then, in turn, reverses their direction? And so on . . . quite specific questions, the answers to which were unknown. If known, they would shed light on the whole broad problem of traffic and traffic control inside of cells in general.

Through Lorna Green's studies, we now have at least some of those answers. No one before had recorded the actual events in such precise detail as she has done by skillfully combining cinemicrography of living pigment cells with drug or hormone administration and other interventions. She turned to the electron microscope for deeper insight. She put her problem under a concentric cross fire from various technical angles. By plotting meticulously the courses of moving granules, the rates and ranges of their excursions, their sequential activation and arrest, exploring even electric correlates, and by comparing all these under diverse conditions—she broadened and strengthened the foundation on which an eventual explanation of the mechanisms of endocellular traffic must rest. Such a theory is not yet at hand. Key information is still lacking. Even so, with undeterred enthusiasm, she proposed at least a tentative interpretation. Whether it will or will not turn out to be the final one is irrelevant. What matters is her inner urge and sense of moral responsibility for not sending undigested and unassimilated data of information out blank into the jungle of contemporary literature, but to make sense of them through thoughtful integration—the very effort from which the title "Doctor of Philosophy" derives its name. She thus has run full circle from speculation to solid facts and back to theory. Novel and striking as the factual results are in themselves, it is the scholarly process of their production—the constant interplay between thought and work—which qualifies Lorna Green for the title, not just of Ph.D., but of a fully spelled-out Doctor of Philosophy.

Mr. President, I am honored to present her for the award of the degree.

Merrill Burr Hille

A.B. CORNELL UNIVERSITY

PRESENTED BY DANIEL E. KOSHLAND, JR.

Merrill Burr Hille entered The Rockefeller Institute from Cornell University wishing to apply her undergraduate training in chemistry to the study of living systems. She chose to study enzymes, those powerful catalysts that direct and control essentially all the dynamic processes of life as we know it. Enzymes are key compounds in biology and medicine. When they are healthy, we are healthy. When they are deficient, disease and death result.

Enzymes are an enigma to the chemist, for these fragile substances synthesized by living systems have catalytic powers and specificity which the modern chemist, with all his technology, has been unable to explain or duplicate.

How could one learn something more about these molecules which remain so mysterious despite the many efforts to probe their secrets? Merrill chose to pursue the problem by attaching to the enzyme a chemical grouping which, in essence, could watch the enzyme at work. Thus, at an atomic level it was hoped that this group would report the action of an enzyme without directly participating in that action. The chemical entity that was to relay the information was, therefore, called a "reporter group."

The next questions that arose were: How could one attach such a group, and what enzyme should be chosen? Einstein once said, "Nature is sophisticated, but she is not unkind," and she was not unkind to Merrill in this case. The enzyme chymotrypsin, which is important in digestion and degradative reactions, is secreted by the pancreas of animals in large amounts. Because of this it has been a favorite of study for many years, and it was originally crystallized by Northrop and Kunitz of The Rockefeller Institute in their great pioneering work. Subsequent studies have shown that this protein contains approximately 240 amino acid residues and that there is a methionine residue only three units away from the serine of the catalytic site. Moreover, it was known that this methionine residue was not essential for the activity of the enzyme. Perhaps, then, it could be used as an anchor point for the reporter group. To

the reporter group Merrill added, by chemical means, a linking arm, a side chain covalently attached to the reporter moiety on one side and containing a group capable of reacting with the methionine residue of chymotrypsin on the other. Using this compound, 2-bromacetamido-4-nitrophenol, she was able to attach one single reporter residue adjacent to the active site of chymotrypsin without destroying the catalytic power of the enzyme.

The next step was to find whether this reporter group would be able to send back signals related to the activity of the enzyme. The reporter group that Merrill used was a nitrophenol, which is a bright yellow compound, and its attachment to the chymotrypsin changed that colorless molecule, so that it too was bright yellow. This change in spectrum was the means by which the changes in the enzyme could be followed. Merrill found that substrates and inhibitors of the enzyme caused characteristic alterations in the spectrum which could be recorded by sensitive electronic instruments. Moreover, these changes were found to bear a relationship to the specificity of the enzyme.

So Merrill had succeeded in her goal and had attached a group to an enzyme, without damaging its activity, which could observe and report the specific properties of that fascinating molecule. At the moment a new tool is added to the service of science it is premature to say with certainty how useful it will be. Only time and further work can answer that question definitively, but already indications are that this new technique is very general and will have wide applicability in biological sciences. Merrill has helped in opening a new window on the molecules of life and the knowledge of the world is enriched by her efforts.

To a research advisor perhaps as exciting as the solving of a problem is the development of a new research scientist. Merrill entered this institution as a trained and intelligent person, but her knowledge, as is appropriate for undergraduate training, was distilled from the work of others. At the Institute she started to generate new knowledge on her own. Her first steps were hesitant, but as she gained experience and insight into the ways of research her confidence and imagination grew. She learned to question the literature, to evaluate her own experiments, and even to question her research advisor. Best of all, she became ingenious in designing experiments to answer her own questions.

Merrill Burr Hille has become a mature and able scientist who graces a laboratory personally and scientifically; and it is with great pleasure that I recommend her to you, Dr. Bronk, for the degree of Doctor of Philosophy.

Gordon David Lange

B.S. CALIFORNIA INSTITUTE OF TECHNOLOGY

PRESENTED BY H. KEFFER HARTLINE

The study of the nervous system has an especially strong appeal to students with interests and talents in both biological and mathematical sciences. David Lange took his undergraduate work at the California Institute of Technology, then studied medicine for two years at Yale University before coming to us. Throughout his studies here his inclinations toward physics and mathematics were strong, but so were his inclinations toward biology—especially neurophysiology. Floyd Ratliff and I cast our net and easily caught a convert to the study of the retina—we need mathematical competence in our business.

Out of the wealth of information our eyes receive from our lighted surroundings, our nervous systems extract that which is useful to us. This processing of sensory data begins in the retina itself, with highly complex interactions of nerve cells and receptors excited to various degrees by the various patterns of light and shade and color in the retinal image. In a world of change, the dynamics of nervous action is of foremost importance, and it was to the dynamics of retinal interaction that Mr. Lange addressed himself in his thesis research.

For a number of years our laboratory has focused its attention on a comparatively simple retinal interaction, basic even to the most highly organized visual systems, but studied to especial advantage in the primitive eye of the common horseshoe crab. This is a process of mutual inhibition of neighboring receptor elements, each by the others, which serves to enhance contrast in the visual image and sharpen contours. With changing patterns, fluctuations in brightness and movements in the retinal image are accentuated.

As a first step in his experimental study Mr. Lange

drove one set of receptors in the retinal mosaic by artificial electrical stimulation, under precise control, and measured the time course of the inhibition they exerted on the discharge of nerve impulses from a receptor in their neighborhood. To understand the results, he drew upon our general knowledge of the cellular mechanisms of excitation and inhibition, made explicit for this very preparation by the experimental studies of former students in our laboratory, notably Alan Adolph, Charles Stevens, and Richard Purple.

Utilizing this specific knowledge Mr. Lange calculated, step by step, nerve impulse by nerve impulse, the course of the individual cellular actions in the interacting system. The model he used to guide the computations was idealized, to be sure, but soundly based on experimental facts. Faithfully and in detail the model portrayed the fluctuations of activity of receptors subjected quite arbitrarily to changing inhibitory influences from neighboring retinal elements. As quantitative agreement between theory and observation emerged, and as seemingly unrelated dynamical effects fell into place in a coherent explanation, I believe Mr. Lange felt rewarded in having chosen to combine his biological and mathematical interests in the study of retinal interaction — even if only in the eye of a horseshoe crab.

I should add here that Mr. Lange has also contributed substantially to Dr. Ratliff's theoretical studies of brightness and border contrast in human vision. Psychophysics is a field in which basic training in physiology and talents in mathematics can be combined to good effect. It will welcome an attractive theoretical model of dynamic retinal interaction.

But it will be many years, and many models — and many horseshoe crabs — before we even begin to understand our own rich experience of the shifting, changing visual scene. At least we have made a beginning in understanding the dynamics of one kind of retinal interaction of fundamental importance in visual physiology. And more, we have been shown one way in which a sound combination of experiment, mathematical theory, and modern computational techniques can make progress in elucidating complex integrative processes in sensory systems. David Lange has earned the degree he is about to receive.

Bernard François Mach

M.D. UNIVERSITY OF GENEVA MEDICAL SCHOOL

PRESENTED BY EDWARD L. TATUM

Bernard François Mach was born in Geneva, Switzerland, the son of a noted physician. Raised and educated in Geneva, and true to family tradition, he entered the University of Geneva Medical School where he received his Medical Doctorate in 1957. Dr. Mach then came to the United States for further medical training, and between 1958 and 1960 served his internship and residency under the late Dr. Walter Bauer at the Massachusetts General Hospital, Harvard University.

Realizing that advances in medicine are becoming increasingly dependent on basic science, Bernard sought and obtained the opportunity of broadening and deepening his scientific knowledge, skills, and understanding as a Graduate Fellow at The Rockefeller Institute, where he began his studies in 1960.

These studies have led Bernard into, and given him training in, many disciplines, ranging from cytology to genetics, microbiology, and biochemistry. Let us briefly trace some of the high points on his scientific travels.

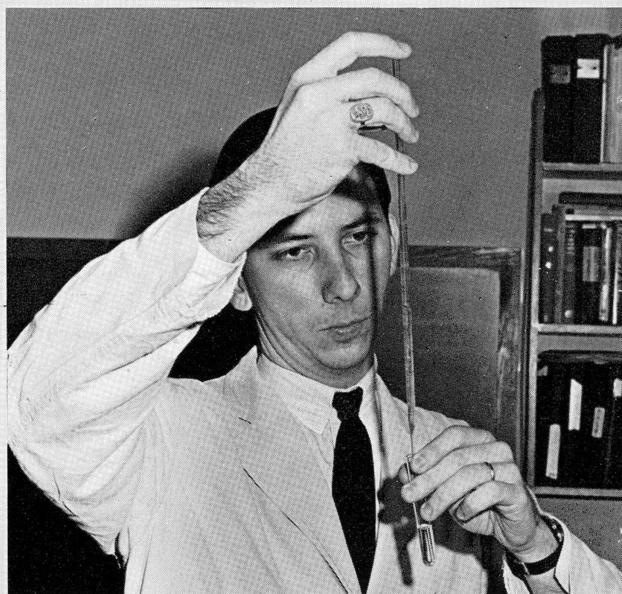
Recognizing the central role of proteins and their synthesis in living organisms, Bernard asked: How can the problems of protein biosynthesis and its control be approached at the simplest level? He soon became interested in the polypeptide antibiotic, tyrocidine. This compound had already had a long association with The Rockefeller Institute; discovered by Dubos, studied by Hotchkiss, and characterized by Craig and King, it consists of a mixture of three related molecules, each containing ten amino acid residues, and differing in the extent of replacement of phenylalanine by tryptophan.

Bernard asked whether this cyclic decapeptide and its synthesis by *Bacillus brevis* could serve as a simple model of protein biosynthesis. He reasoned that if its synthesis were analogous to that of protein the different amino acid replacements would be due to mutation, each tyrocidine being produced by a different mutant in a mixed population of bacteria. However, he soon proved that the population was homogeneous, with each cell producing all three forms of antibiotic, and mutation only completely abolished tyrocidine production.

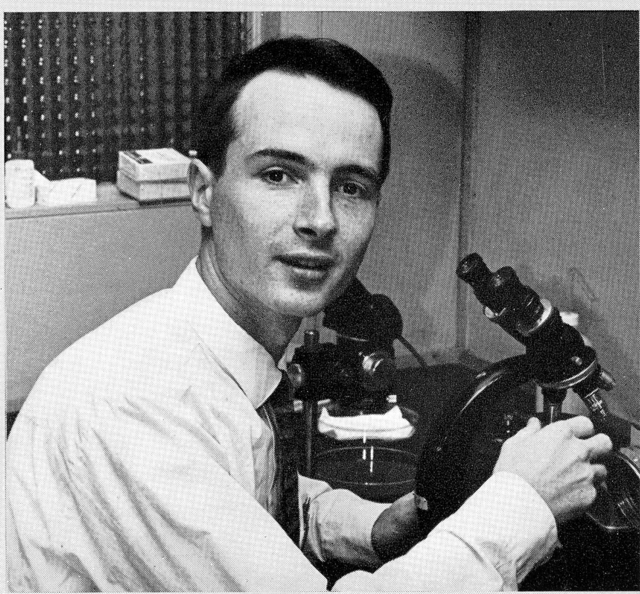
PAUL RICHARDS BURGESS

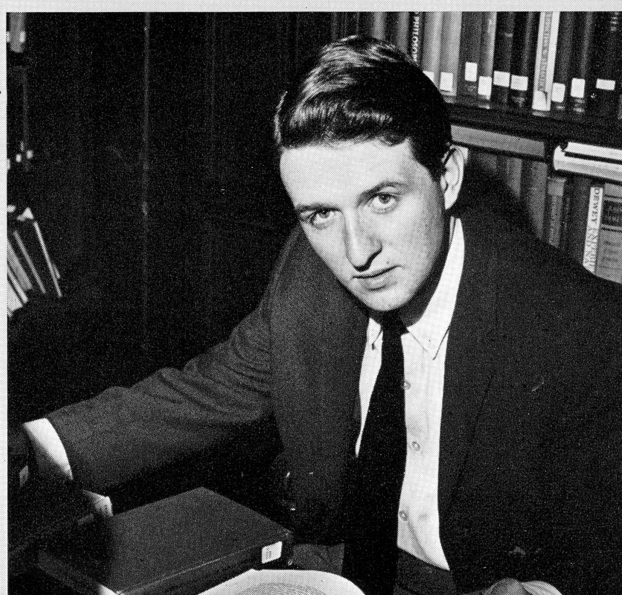
MERRILL BURR HILLE

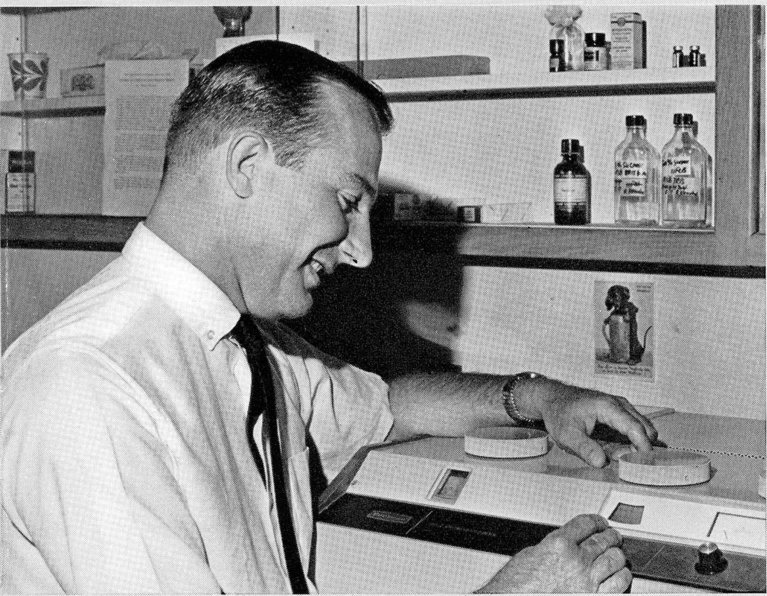
MICHAEL ABRAM RUTTENBERG



THOMAS PETER BENNETT







THOMAS BARTHOLOMEW TOMASI, JR.

LORNA GREEN

GORDON DAVID LANGE

BERNARD FRANÇOIS MACH

RICHARD ANDREW CELLARIUS

Bernard then asked whether antibiotic synthesis was sensitive to recognized inhibitors of protein synthesis, and if its synthesis involved RNA as does that of protein. The answer to each question was unequivocally, no. In fact, suitable inhibitors blocked either protein synthesis, RNA synthesis, or tyrocidine synthesis, independently.

The next question was, what is the basis of control of the distinctive amino acid substitutions in tyrocidines A, B, and C, if it is not, as for proteins, dependent on mutation and different template RNA's? Ingeniously, this question was solved by the discovery that the type of tyrocidine formed is markedly affected by the amino acids available. Thus, an oversupply of phenylalanine led to the production of more tyrocidine A, while a supply of tryptophan led to more C, and even to a fourth and new form, tyrocidine D, containing no phenylalanine. In being altered by such environmental factors, tyrocidine synthesis again differed from protein synthesis.

Thus, Bernard's questions and the experimental answers have led systematically to the discovery of a new class of polypeptide biosynthesis, which has since been confirmed by other workers all over the world, for a number of other peptide antibiotics. His results have raised further intriguing questions, such as: Do both types occur in higher organisms? Where does the dividing line come between the two biosynthetic systems? Is environmental control of amino acid replacement limited to bacterial polypeptide antibiotics?

Finally, I would point out that Bernard has already published five research papers, and at least three more are in preparation. One of these, with Dr. Carolyn Slayman, deals with the effects of tyrocidine on Neurospora membrane integrity; and one, with Mr. Michael Ruttenberg, deals with the structure of tyrocidine D. Another, carried on during this past year as Fellow of the Jane Coffin Childs Memorial Fund, deals with Bernard's excursion into the biosynthesis, characterization, and template function of RNA from immunocompetent tissues of the rat.

We all recognize that science is international, contributing both to the advancement of knowledge on which man's welfare and progress depend, and to cooperation and understanding among nations. In this connection, it seems appropriate here to thank Bernard's native country, Switzerland, on behalf of our country and of The Rockefeller Institute, as well as personally, for lending us Bernard for the past five enjoyable and fruitful years. Our regret on losing him and his charming and capable wife Jaqueline is lessened by the realization that we are contributing in return a mature and accomplished scientist and scholar, and three U.S.-born potential scientists and scholars, to Switzerland, where Bernard is returning to a research position at the Institute of Molecular Biology in Geneva.

Michael Abram Ruttenberg

S.B. MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PRESENTED BY TE PIAO KING

It is an especially pleasant occasion for me to present the next candidate, Mr. Michael Ruttenberg. I have known him for his entire graduate career, first as a student then as a friend. We first met in the summer biochemistry course in 1960. As is customary for students in that course, he was asked to do a laboratory project. This he did on an aspect of the chemistry of tyrocidine, an antibiotic polypeptide. Our friendship continued from that point on and eventually the simple topic of his summer project was enlarged to become the topic of his thesis.

The study of the tyrocidines seems to be a continuing one in this institution. They were first discovered and studied by Drs. Dubos and Hotchkiss in the early 1940's. Later Dr. Craig and his associates showed that the tyrocidines consisted of three closely related cyclic decapeptides. They then deduced the amino acid sequences of two of them. The third isomer, tyrocidine C, was not worked on until Michael appeared on the scene.

As part of his thesis, Michael elucidated the structure of the third isomer. Here he made a significant contribution by developing a new specific method of peptide bond cleavage. By careful experimentations and sound chemical reasoning, he showed that acyl proline bonds can be selectively cleaved by metal hydrides. The basic principle of this reaction will undoubtedly invite further inquiries for its potential applications in protein chemistry.

With his results, we now know that the three tyrocidines differ by the stepwise stereospecific replacement of a single amino acid residue. This precise

knowledge of the structures of these polypeptides is not only of significance for their biochemical studies but also paves the way for their use as models in the understanding of the more complex nature of proteins. For example, Michael has already shown that these polypeptides are good models for studying the aggregation reaction, a feature so commonly encountered with proteins but not yet well understood.

Both Dr. Craig and I are pleased to see these developments in tyrocidine chemistry. But more than that, it is very satisfying to us to see it become the vehicle through which the enthusiasm of a young man is developed into the purposefulness of a mature scholar. We wish him all success in his continuing quest of truth, knowledge, and understanding.

Thomas Bartholomew Tomasi, Jr.

A.B. DARTMOUTH COLLEGE

M.D. UNIVERSITY OF VERMONT COLLEGE OF MEDICINE

PRESENTED BY HENRY G. KUNKEL

Scientific inquiry has always held a unique fascination for the well-trained physician. Much benefit has accrued from this almost traditional interest and its admirable quality is difficult to dispute. However, it is also one which is fraught with certain hazards. There is no greater tragedy than that of the skilled physician who is diverted from his so very essential vocation to a complete preoccupation with research that all too frequently is of inferior quality. Certainly much of the difficulty stems from inadequate training for such a pursuit that is inherent in the usual medical education. It would also seem of the utmost importance that the skilled physician should have some evidence of an aptitude for investigative work before taking the drastic step that so rapidly leads to atrophy of clinical acumen.

Dr. Thomas B. Tomasi came to The Rockefeller Institute as such a highly trained physician with a strong interest in investigative work in the field of immunology. He would have preferred simply to work continuously in the laboratory and even rebelled initially at any diversions from this objective such as course work in the basic sciences. Fortunately he submitted to mild duress and soon became intrigued with his work in mathematics and physical chemistry. All who knew Dr. Tomasi marveled at the transition that occurred. The well-known clinical abbreviation ESR, as many of you know, stands for erythrocyte sedimentation rate—but no longer to Tom Tomasi. It now stood for electron spin resonance.

Dr. Tomasi's research developed rapidly with his increasing familiarity with basic methodology. It centered about the character of antibodies found in external secretions. Three types are well known in blood serum. One of these termed γA globulin represents a minor component usually making up less than twenty percent of the total immune globulins of the serum. With the usual complement of serendipity, Dr. Tomasi made the surprising observation that the γA represented almost the sole antibody protein in a wide variety of external secretions such as saliva, bronchial secretions, intestinal secretions, and many others. He was able to isolate this material from parotid saliva obtained from man and certain experimental animals. Several in this audience I know acted as mildly reluctant subjects for Dr. Tomasi's ingenious procedure of canulating the parotid duct and collecting the parotid saliva. Detailed characterization of the γA protein by a wide variety of sophisticated physical and chemical procedures brought forward an additional important fact. The salivary protein was larger than that of the serum and was actually made up of two proteins: the one, identical to that in the serum; the other, derived from the secreting gland; with the two linked together by disulfide bands.

This work, reported in part several years ago, opened up a new and what has developed into an active branch of immunology. Its significance lies in the potential role of antibodies in these secretions as a first line of defense against pathogenic organisms. In addition the γA protein has been primarily implicated in allergic reactions and its high content in, for example, bronchial secretions may well bear significance in asthmatic and other pulmonary conditions.

Dr. Tomasi was forced to interrupt his studies at The Rockefeller Institute after two years, because of illness in his family. Thereafter he completed his program of work over a period of years by regular short stays at the Institute. It was a difficult assignment because of heavy responsibilities elsewhere, but he persisted with his characteristic energy and

drive. These were always highly contagious and his annual arrival, usually during the spring season, instilled a new spirit throughout the laboratory. I only regret that this stimulation will now cease, but, then again, perhaps the habit is too deeply ingrained and he will arrive again next year despite today's events. I know we would welcome him. Unfortunately, his soon-to-be-acquired professorial duties just might stand in the way. Academic medicine needs a number of men of this background who are so well qualified for teaching and basic research in human biology.

Lee Alvin DuBridge

PRESENTED BY DETLEV W. BRONK

YOU WHO HAVE been degreed in this hour have been thus recognized by your faculty as worthy members of the world-wide community of scholars. In conferring upon you this mark of proficiency in scholarship, we have continued a custom that began more than seven centuries ago. Even then, the quest for knowledge and its teaching was an ancient endeavor. Your calling is as old as man.

This occasion accents both continuity and transition. Knowledge of nature and the spirit and methods of inquiry are deeply rooted in the past. Beyond the unexplored frontiers of understanding are territories of the mind that await your future exploration. We have endeavored to reveal to you the relevance of the past for the present and to aid your fitness for further search and greater understanding. There is a continuity of learning that threads through the transition from generation to generation of scholars.

You and we have lived together in intimate association for a period of years that have been memorable for you and for us. We hope that you have sensed the rich satisfactions of disciplined, exacting thought as well as the exhilarant joy of new discoveries. Those are joys and satisfactions we have wished to give you by the example of the lives we have lived among you.

You, in turn, have enriched our lives with your friendships and the youthful vitality of your curiosity and vision.

We hope that you will always think of us as friends who will support your efforts and will rejoice in your achievements. Parents strive to deserve the affection and the admiration of their sons and daughters. A wise parent also proudly shares his most admired friends with his sons and daughters. For reasons such as that, it has been our custom to associate with our graduates a friend of the faculty who is an accomplished scholar; we honor him for great achievements and noble service. But the signal function here of that eminent scholar is to be spiritual colleague of our graduates.

Niels Bohr and James Conant — Vivian Hill and Henry Moe — Hugh Taylor and our own beloved Peyton Rous have, at previous Convocations, been the exemplars of scholarly ideals and endeavors.

Today, our Faculty and Trustees have chosen one who has a wide range of talents that he has used in many fields of learned and civic service. Lee Alvin DuBridge has already had five illustrious careers.

While still a youthful physicist, he revealed a remarkable flair for research in his studies of the electronic and nuclear properties of matter. But even then, as he developed deep competence in the fundamentals of his science, he recognized the useful applications of his knowledge and its relevance to other fields of science and human welfare.

Without forsaking his research, he proceeded to create a distinguished department of physics in which he was the most inspiring teacher. As Dean of the Faculty of Arts and Sciences, too, his scholarly influence enriched the whole of the University of Rochester. The spectacular service of American scientists in the War of the 1940's is a remarkable tale of how science assumed a major role in modern society.

One of the most brilliant achievements of that far-flung undertaking was the organization and direction of the Radiation Laboratory for development of radar, by Lee DuBridge.

Those notable achievements marked him as uniquely fitted to be President of unique California Institute of Technology.

For two decades he has made our great sister institution greater by resisting the glamour of numbers for the satisfaction of excellence.

Throughout those four phases of his remarkable career, DuBridge has earned the gratitude and affection of countless colleagues in many public institutions with whom he has shared his wisdom. Lee Alvin DuBridge, your many friends and admirers here are grateful for the privilege of conferring on you the degree of Doctor of Science, *honoris causa*.

THE ROCKEFELLER UNIVERSITY NEWS

The Rockefeller University

DAVID ROCKEFELLER, Chairman of the Board of Trustees, and Detlev Bronk, President, have announced that the corporate name of The Rockefeller Institute was changed to The Rockefeller University by action of the Regents of the University of the State of New York (the State Education Department) at their May meeting. This action clarifies the Institute's status as an outstanding institution of graduate and postdoctoral study as well as a distinguished center for research in the natural sciences. It also emphasizes the broadened scope of the Institute's activities and the widening fields of scholarship represented among the interests of faculty and students. The action of the Regents follows by ten years the beginning of graduate study and their change of the Institute's charter in 1955 to permit the granting of degrees.

Asian Sculpture

DURING THE summer months an exhibition of early Asian sculpture is on display in the Caspary Auditorium Gallery. The sculptures, which were loaned to the University by Mr. Lester Wolfe and arranged by Mrs. Patricia Berlin, include works from the second to the seventeenth century AD from Pakistan, India, and Southeast Asia, and represent a great variety of styles ranging from primitive clay figures to the extremely stylized, more familiar, elegant carvings of the Buddha. Of particular interest are red pottery heads from Haniwa, Japan, dating from the second to the sixth century, which were fashioned before the introduction of Buddhism from the mainland of Asia. Most of these primitive pieces, which have a naive and weird charm, are made in the form of hollow cylinders that could be placed on posts outside the tombs as companions and guardians of the dead.

The exhibit was formally opened with a talk by Otto J. Brendel, Professor of Art History and Archaeology at Columbia University. In his lecture "Buddhist Art to Western Eyes," Professor Brendel emphasized the theme that all Buddhist art may actually be considered a narrative art, illustrating the familiar story of Buddha's childhood, his renunciation of palace pleasures, and his subsequent life of contemplation and teaching. Even the well-known seated figures of the Buddha may be considered as excerpted from such a narrative. Professor Brendel also stressed the relationships between Buddhist and Hellenistic art, pointing out such parallels as the draping of the gowns, the representation of seated figures, and the gestures of the hands. In response to a question from the audience, Dr. Brendel remarked that even the many-armed Vishnu, generally considered as uniquely Oriental in stylization, had its counterparts in medieval Occidental art, as in the portrayal of a judge with two heads, one listening to each side of the story.

Mr. Lester Wolfe, who loaned the sculptures, is no stranger to the University. In 1919 he was graduated from the Massachusetts Institute of Technology in the same class as Professor Theodore Shedlovsky, who kindly assisted in arranging for the current exhibition. (Mr. Wolfe, Dr. Shedlovsky recalls, was the only physics major in that entire class.) Following his

Exhibit of early Asian sculpture on display in the Caspary Auditorium Gallery through October 15

graduation, he joined the Naval Aviation Corps where one of his colleagues was a college sophomore named Detlev W. Bronk. Since then Mr. Wolfe has been actively interested in the design and development of aeronautical instruments, and during World War II he served with distinction in the Instrument Division of the Bureau of Aeronautics of the Navy. He has traveled extensively and a number of the items in the collection represent his own archaeological findings. Mr. Wolfe, whose art collection also includes Persian ceramics and modern Mexican art, has made gifts and loans to the Museum of Natural History and the Metropolitan Museum of Art.

Change and Adventure

For Rockefeller graduate fellows, summer is a season of intensive research here and abroad, study and investigation at marine stations, pursuit of scientific avocations, and unusual adventures.

"Orchids of New Granada," which is published in this issue of the Review, is based on the summer activities of Vincent Hascall and Alan Kapuler. Nicholas Acheson spent two summer vacations living with an Indian family in San Cristóbal in the province of Chiapas in southern Mexico. Mr. Acheson, whose initial visit was part of a field study sponsored by the Harvard Department of Anthropology, examined as his special project the Indians' conceptions about familiar animals and their taxonomic classifications of them. In 1963, Larry Simpson went with Dr. George Jackson to the town of Manaus, 1000 miles from the mouth of the Amazon, to survey the viruses and other parasites of the wild animals of the region. Among the souvenirs of this expedition are three (originally two) pacas — large, sleek rodents distantly related to the guinea pig — now in residence on the top floor of Founder's Hall. Equally adventurous were Louise and Albert Cass who last year, with the aid of a local bush pilot and air-dropped supplies, explored the wilds of Alaska.

This summer, as in the past, Rockefeller graduate students are scattered over the world: Mary and Dan Rifkin in Peru; Max Snodderly at the Goethe Institute in Achenmühle, near Munich; Fred Meins with Professor Peter Karlson at Marburg, Germany; Kenneth Nadler at the Stanford Marine Station; James Foch at the Summer Institute of Theoretical Physics in Boulder, assisting Professor Uhlenbeck. Daniel Stroock will be in Poznan, Poland, working with Professor Z. Ciesielski on the interpretation of Professor Kac's Potential Theory.

Foreign Scholars

Early in May the University was host to a group of 50 foreign scholars from the New York area, who visited the campus with the double purpose of learning something about the work here and of becoming more closely acquainted with one another. The group, composed largely of European and Asian students, was addressed first by Professor Theodore Shedlovsky, who spoke briefly on the history of the University. Mr. William Bayless and Professors Mark Kac and Maclyn McCarty then described various aspects of its current program. The talks were followed by a tour which included the hospital, the Mathematics-Physics Library and offices, and the laboratories of Professor Lyman Craig. Following a cocktail party in their honor, the group was entertained by the presentation in full costume of an early opera of Bizet previously performed in New York only at International House. It featured a soprano and a baritone from Japan and a mezzo-soprano from Korea as well as two American singers. The opera was directed, appropriately, by a young Italian who was educated in Europe and is now a citizen of Argentina. As a curtain-raiser, one of the foreign scholars, a professional ballerina from Tokyo, presented several Japanese dancing songs.

The visit to the University was part of a continuing program for foreign scholars which is directed by Dr. Donald Shaughnessy of Columbia University and supported by the State Department. The scholars meet once monthly for dinner, where they are addressed by speakers chosen for their lively, forthright views on various aspects of American life, and, in addition, they visit schools, museums, and other places of interest. On their last visit to the financial district, they were addressed by their host, Mr. David Rockefeller, Chairman of the University's Board of Trustees, who discussed informally the politics of international banking. The advisory committee that helps Dr. Shaughnessy to plan these activities (and of which Dr. Shedlovsky is a member) includes representatives from universities, corporations, and trade unions.

"Dr. Miracle" performed in Caspary Auditorium May 8

Scientist and Humanist

THIS SPRING the activities of Professor René J. Dubos have been peripatetic and heaped with honors. On January 23 he received the honorary degree of Doctor of Science from the University of Pennsylvania on the occasion of the 200th anniversary of the founding of its medical school. In February he gave the anniversary address, "Hippocrates in Modern Dress," to a joint meeting of the Institute of Medicine of Chicago and the Chicago Society of Internal Medicine. On April 15 he received the Pierre Fermat medal from the Académie des Sciences, Inscriptions et Belles Lettres de Toulouse—an honor accompanied by the colorful traditions of the University, including the *Jeux Floraux* with poetry and graceful speeches in true troubadour style. He gave the commencement address at the University of California Medical Center in San Francisco on June 5. His topic was "Health and Human Life." "Ministry to the sick is only one of the forms of service through which the health professions have made themselves indispensable to mankind," he stated. "Another type of service, fully as important, is to help modern societies adapt the achievements of technology to the fundamental needs and aspirations of man's deepest nature." He was awarded the honorary degree of Doctor of Laws by President Kerr on this occasion. The closing words of the citation were "The depth of his thinking and his perceptive concern about the relation of his area of research to the broad aspects of human health and welfare are apparent in his many books and public addresses. We honor today a scientist and humanist *par excellence*."

"Relaxing" at home Professor Dubos has had several projects in hand; among them, the most recent book in the Life Science Library series, *Health and Disease*, edited in collaboration with Maya Pines; the fourth edition of *Bacterial and Mycotic Infections of Man* with Professor James G. Hirsch; and his forthcoming book, *Man Adapting*, scheduled for publication in September.

Alumni

LEE D. PEACHEY, PH.D. 1959, recently Associate Professor of Zoology in Columbia University, has been appointed Associate Professor in the University of Pennsylvania.

Irving H. Goldberg, Ph.D. 1960, has left an associate professorship in the University of Chicago to become Associate Professor of Medicine, with tenure, in Harvard University.

Thomas B. Tomasi, Jr., Ph.D. 1965, has been appointed Professor of Medicine in the New York State University at Buffalo.

Resignations

DR. HOWARD SCHNEIDER has been appointed a Founding Member of the Institute for Biomedical Research of the American Medical Association. The laboratories, in the development of which he will play a major role, will be located in Chicago. Dr. Schneider came to the Rockefeller in 1939 as a Guest Investigator and was advanced through the successive ranks to Associate Professor.

Dr. Murray Rosenberg will join the faculty of the University of Minnesota as Professor of Zoology. Dr. Rosenberg was a Research Associate of Professor Paul Weiss in 1958 and was appointed Assistant Professor in 1960.

Dr. David A. Yphantis has gone to the State University of New York at Buffalo as Professor of Biology. He has been at Rockefeller since 1958, first as Assistant Professor and as Associate Professor since 1964.

NOTES

During June five of the Rockefeller faculty received honorary degrees from other universities and colleges: President Bronk, Doctor of Science, Pennsylvania Military College; Professor Dobzhansky, Doctor of Science, Clarkson College of Technology; Professor Dubos, Doctor of Laws, University of California; Professor Tatum, Doctor of Laws, University of Notre Dame; Professor Trager, Doctor of Science, Rutgers University.

Work has started on construction of the eighth building to be erected on the campus since 1955. The structure, which will house 25,000 square feet of laboratories, is using the old Power House as a foundation. Viewed from the south, it will architecturally balance and resemble Sophie Fricke Hall and to the north will connect with the south wing of the Hospital. Harrison and Abramovitz are the architects and George A. Fuller Company, the general contractors.

Professor Norton D. Zinder was one of a delegation of five sent from the United States who visited Japan's laboratories and universities – and saw some of the beautiful countryside – from May 10 to May 17. Dr. Zinder's trip followed a week-long seminar, held in Honolulu and attended by Japanese and American scientists, on the subject, "The Molecular Basis of Infectious Heredity." The United States-Japan Cooperative Science Program, as it is called, was initiated in June 1961 under an agreement reached between President Kennedy and Prime Minister Hayato Ikeda to promote cooperation in basic scientific research between the two countries.

President Bronk has been elected a trustee of the Woods Hole Oceanographic Institution for a four-year term.

Doctors D. Wayne Woolley and B. W. Gommi presented preliminary evidence that the blood of schizophrenic patients contains a serotonin synergist not contained in the blood sera of normal controls. Speaking at the annual meeting of the National Academy of Sciences on May 12, Dr. Woolley described experiments in which the substance taken from the sera of the patients was found to cause a marked increase in the sensitivity of isolated rat uterus to serotonin. The synergist has not been identified but is thought to be a ganglioside. The July issue of *The Atlantic* carried an article by Dr. Woolley entitled "New Insight into Mental Illness: Philosophical Implications," based on Dr. Woolley's work with phenylketonuric patients and with laboratory animals that show subnormal learning ability apparently due to a serotonin deficiency imposed early in infancy.

Eric H. Davidson, Research Associate, is the author of an article in the June issue of the *Scientific American*. In "Hormones and Genes," Dr. Davidson reviews the accumulating evidence that a major mechanism of action of various hormones is the activation of genes in the target cells. Dr. Davidson, who received his Ph.D. at the University in 1963, is currently collaborating with Professor Alfred Mirsky.

Professor Vincent P. Dole will direct a city-financed program to treat at least 250 additional drug addicts, using methadone in conjunction with supportive therapy and vocational training. The program, which will be carried out under a $1,300,000 contract with Beth Israel Medical Center, is an extension of the test plan for the treatment of addicts now under way under the guidance of Professor Dole at Manhattan General Hospital, a unit of Beth Israel. Several other hospitals in addition to Manhattan General will have addiction clinics under the new plan. The program and the warm, sympathetic approach to the problems of addiction were discussed at length in the June 26 and July 3 issues of *The New Yorker*, in which Dr. Marie Nyswander, Guest Investigator at the Rockefeller, was the subject of the "Profiles" articles on "The Treatment of Patients."

Among the guest speakers at the University in May was Professor D. M. MacKay of the University of Keele, Staffordshire, who spoke on "Perceptual Clues to Visual Mechanisms." In a series of demonstrations in which he used the audience as his bewildered and fascinated experimental subjects, Dr. MacKay illustrated that the eye does not merely transmit an image to the brain – as on a tiny television screen – but rather analyzes, interprets, and describes, imposing logical patterns even where they do not exist.

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