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JACK SCHULTZ

1904—1971

A Biographical Memoir by

THOMAS F. ANDERSON

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May 7, 1904–April 29, 1971

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JACK SCHULTZ was one of the last graduate students to get his degree in classical *Drosophila* genetics under Thomas Hunt Morgan. This was in 1929. For the rest of his life, Jack's goal was to understand, in molecular terms, how a set of genes could direct and control the development of an organism; and he lived to see the results of his pioneering research become the foundation on which such an understanding could be based.

Jack Schultz was born in Astoria, Long Island, New York, on May 7, 1904, the eldest of three sons of Morris and Bessie (Krones) Schultz. Both parents had been members of large Russian–Jewish families of rabbis, farmers, and tradesmen living in two small villages in the area of Minsk, near the Polish border. During the political difficulties of the 1880s and early 1890s in Russia, the young adults of both the Schultz and Krones families tended to be ardent socialists and became involved in revolutionary activities. Some perished in the abortive revolution; others were forced to flee the country. Thus, around 1896, Morris Schultz cut short his training at trade school and came to New York. Bessie Krones also had attended a socialist worker's school and, in addition, helped her family make ends meet by running a knitting machine at home. About 1897 she, too, left her village in Russia to come to New York. Somewhat later Morris Schultz was able to help several members

of their families join them. Other members stayed in Russia until World War II, when a few managed to evade death at the hands of the Nazis by escaping to Argentina.

Jack's parents met soon after they arrived in New York and were married seven years later. Morris Schultz was a gentle soul and a great reader who had liberal, but not extreme, views. Besides being associated with the group that founded the Jewish daily newspaper, *Forward,* he soon became engaged in various businesses, mostly in establishing and operating neighborhood grocery stores in various industrial communities in the New York City vicinity: west New York, Astoria, Passaic, Clifton, and finally, Long Beach. He was always closely and sympathetically involved with the factory workers to whom he supplied food.

Immediately after arriving in this country, Jack's mother found work in a knitwear factory and presently became forelady there. She was an energetic and vivacious, kind, yet demanding woman, with a strong influence over the activities of those around her. With a reputation as an excellent cook of traditional dishes, she was devoted to her home and to a large circle of relatives.

Jack had two younger brothers, Mortimer, who was born in 1907, and Charles, born in 1912. Their parents were ambitious for all three children and were determined to give them cultural advantages that they themselves had been denied in Russia. The children attended public schools and received, in addition, some religious training in the Jewish schools of their communities. Although their father found it difficult, he did manage to send his sons to college and to help with the financing of their graduate studies. Mortimer became a high school teacher of science in Long Beach, New York, and served as chairman of the science department there for many years before he retired. Charles, who has literary interests, has been on the advertising staff of *Women's Wear Daily* for many years.

Jack was a studious child, an omnivorous reader at a very early age, as indeed he was throughout his life. He was rapidly promoted through grade school, and was therefore much younger and smaller than his classmates. This, no doubt, accounted at least partially for his not being at all interested in athletic activities and for his not being entirely accepted socially by his fellow students. The partial isolation that he experienced served only to reinforce his intellectual interests. His teachers and older relatives considered him a brilliant and independent, but highly impractical, boy. During these years Jack took violin lessons and frequently accompanied his mother on her Saturday afternoon expeditions to the Metropolitan Opera House. Later he took up the flute, which he played occasionally, with great pleasure, for many years. At Clifton High School he became deeply interested in the humanities; this interest was stimulated in large part by his teacher of French, Miss Mary Smith. She discovered Jack's unusual facility with languages and encouraged him to explore the best in the literature of all the languages he had the opportunity to learn. Later in life this proficiency was to help him cement close friendships with people of many nationalities.

During his first two years at Columbia University, he concentrated on the humanities. He entered eagerly into the stimulating atmosphere of undergraduate life in New York City in the early 1920s, when there was a sudden surge of excitement in the theater, painting, literature, social philosophy, and music. This was an important stage in his development, for Jack retained an active interest in the humanities throughout the rest of his life.

It was only in his junior year that Jack first became seriously interested in making plans for a definite career. He had decided to take a premedical course when he was suddenly, and happily, diverted. Like most young men of those times, he needed extra money for books, concert tickets, and the like; so he answered a

bulletin board ad for someone to wash bottles and make fly food in the laboratory of Professor Thomas Hunt Morgan. Thus, as luck would have it, he was drawn to the celebrated "Fly Room" in the department of zoology. Morgan soon recognized him as a promising young man, and Jack responded by rapidly learning the revolutionary genetic principles that were being established by Morgan and his group. Calvin B. Bridges and Alfred H. Sturtevant were especially kind in introducing him to the new genetic theories and techniques. Their experiments and thinking, more perhaps than those of anyone else, influenced Schultz's later scientific work. Even as a novice, Jack not only listened to what was going on in the Fly Room but was soon tentatively contributing some small points of his own to the discussions. In the course of a few years, he was named a University Scholar, a Teaching Assistant in Zoology, and a National Research Council Fellow. More important, he enrolled as a graduate student under the guidance of T. H. Morgan, the world's foremost geneticist, and of Edmund B. Wilson, the most outstanding cytologist in the United States.

Jack received his bachelor's degree in 1924, his master's in 1925, and his doctorate in 1929. His Ph.D. thesis showed that the large *"Minute"* class of mutations in *Drosophila* all produced nearly identical somatic effects, and yet occurred at many different loci. Evidently a large number of independent mutations could lead to similar phenotypic effects on development. Although many theories have been advanced to explain them, the molecular mechanism for these effects remains a mystery to this day.

In his thesis Jack acknowledged the many kindnesses of Morgan, Bridges, and Sturtevant. He also thanked two visitors to the laboratory: Dr. Curt Stern and Dr. Helen Redfield. Stern was a postdoctoral student from the Kaiser Wilhelm Institute in Berlin, who had come to Columbia as a Fellow of the International Education Board. Stern himself had been

concerned with the mosaic, normal-appearing patches in Minute flies that occurred when somatic crossing-over eliminated the Minute region of a chromosome. Jack and Curt both enjoyed and profited from the close scientific relationship that was established at Columbia and that lasted throughout the rest of Jack's life.

Helen Redfield had, as an undergraduate at Rice Institute, been introduced to the new developments in genetics by Hermann J. Muller and Edgar Altenburg. Although she was at that time acting as Assistant in Mathematics, she was fascinated by the *Drosophila* work and was encouraged to carry out simple experiments using the sex-linked lethal genes then being extensively studied by Muller and Altenburg. For graduate work she went to the University of California at Berkeley, where in the department of zoology she served as Teaching Fellow and received her Ph.D. under the direction of Samuel J. Holmes. She came to Morgan's laboratory at Columbia in 1925 as a Fellow of the National Research Council. Here, in addition to completing her study of the maternal inheritance of a sex-limited lethal effect, she embarked on new studies on crossing-over in triploids. There soon developed among the younger members of the group at the Columbia laboratory an unusually rich and rewarding comradeship; and, since Jack's and Helen's interests were so closely related, they became special allies in the discussions and activities. Presently they began the collaborative work on interchromosomal effects on crossing-over that was to continue for many years. They were married in 1926.

At Columbia Jack was also closely associated with Selig Hecht and his newly formed group studying the biophysics of vision. Like Hecht, Jack was convinced of the then revolutionary, but now almost axiomatic, idea that biological problems could be understood in chemical or physical terms only if appropriate physico-chemical methods were used to study them.

This no doubt led to his early analyses of the absorption spectra of the eye pigments of various mutant stocks of *Drosophila.* This work suggested that the pigments were metabolically related and anticipated the hypothesis by Boris Ephrussi and George W. Beadle (1935), and by Beadle and Edward L. Tatum (1941), that each enzyme in a metabolic pathway is the product of a specific gene acting on a specific substrate. Thus, if a mutant gene fails to make an effective enzyme, the substrate of that enzyme (an intermediate pigment in the *Drosophila* case) might accumulate in the tissue involved (to give the eye its mutant color, for example).

In 1928 Jack and Helen moved to Pasadena where Morgan and his group were setting up a new laboratory at the California Institute of Technology, under the auspices of the Carnegie Institution of Washington. The two Schultz children, Peter and Jill, were born in Pasadena and spent most of their early childhood there. At this stage Helen preferred to devote only part of her time working at the laboratory on interchromosomal effects. The results of her experiments may be briefly summarized: In the first place, there were demonstrated, in structural homozygotes with normal sequence, hitherto unsuspected positive and negative correlations of crossing-over in given regions of nonhomologous chromosomes. Some of the positive correlations were believed to be the result of response to common environmental factors, such as the persistence of the polarized pattern of pairing of chromosomes seen at meiosis. However, other correlations, and the negative correlations in particular, gave evidence of a real interchromosomal influence. Extensive data were gathered on the facilitation of crossing-over by heterologous inversions (a phenomenon previously noted by C. B. Bridges and others) with special attention to the effects of combined inversions on interference and to differential responses of different regions to different inversions. The heterochromatic regions were shown to be important in these inter-

chromosomal effects. Also, the regional differences found between triploids and diploids, both in structurally homozygous and in structurally heterozygous types, indicated that the effects of triploidy on crossing-over are to be considered an example of the phenomenon of interchromosomal influence.

At Cal Tech Jack attacked many problems in *Drosophila* genetics, collaborating with Sturtevant, Bridges, Theodosius Dobzhansky, David G. Catcheside, and others in showing how genes control development and how their effects are modified by suppressor genes. With Morgan and Bridges (and after Bridges' death, with Viola Curry) he co-authored eleven of the group's annual reports to the Carnegie Institution under the title, "Constitution of the germinal material in relation to heredity." Today such a title would imply that the group was reporting results in molecular biology, but the reports actually concerned the classical genetics of *Drosophila*: descriptions of new mutants, dose effects in sex determination, position effects, the elaboration of salivary gland chromosome maps, effects of X rays on crossing-over, etc. Jack contributed his share to the papers that resulted from this work and even participated in a study with Albert Tyler on the reversibility of fertilization of *Urechis* eggs. There is a legend that it took only two weeks for Jack to teach J. B. S. Haldane the basic genetics of *Drosophila*.

But Jack was primarily interested in the molecular biology implied by the impressive title of the Carnegie reports; he wanted to know the *chemical* constitution of the genetic material and how it functioned not only in heredity, but how it functioned to produce the phenotype. It had become obvious that chromosomes contained the genes, but their chemical composition and chemical role in directing development of the phenotype were not amenable to study by the classical staining methods available in Morgan's laboratory.

Fortunately, at that time Torbjörn O. Caspersson in Stockholm was developing methods for the microspectrophotometry

of cells in the ultraviolet end of the spectrum; Jack, with his training in both genetics and biophysics, was the ideal person to use these methods in following the metabolism of the nucleic acids in cells. So in 1937, under the auspices of the Rockefeller Foundation, he went to work with Caspersson. Jack and his family spent two very pleasant and stimulating years with their new Swedish friends in Stockholm; those with whom they formed especially warm and long-lasting friendships included the Casperssons, the Gert Bonniers, and the John Runnströms.

In the laboratory, Jack and Caspersson soon showed that there is indeed a relation between the metabolism of the two kinds of nucleic acids: The nucleolus was found to contain large amounts of pentose nucleic acid, whereas the chromosomes themselves largely contain deoxypentose nucleic acid. Moreover, the observation that the cytoplasm of rapidly dividing cells is rich in pentose nucleic acid as compared to resting cells gave them a glimmer of current thought as to the mechanism of gene action: mRNA synthesis, ribosome synthesis, tRNA synthesis, and protein synthesis. Jack's review of this and of other work, published as early as 1941, "The evidence of the nucleoprotein nature of the gene," concludes, "At the present time the properties of the genes and of nucleoprotein metabolism are evidently parallel: specificity, self reproduction, relations to synthesis and distribution of nucleoproteins in the cell, all are what they should be were the genes nucleoproteins. It would seem therefore, that our present task is to develop the physiology of the nucleoproteins into an effective physiology of the genes."

When one also recalls that in 1932 Jack had been involved with Bridges in the discovery of specific suppressor genes, one can appreciate his reaction to current concepts of how gene action is controlled by interactions among operons, repressors, and inducers: It was one of *déjà vu*. As an explorer, Jack had long before sketched that intellectual territory, but its scientific

relevance became generally accepted only years later after other molecular biologists had settled into it and painstakingly harvested specific chemical evidence for its reality.

When World War II broke out, Helen and the children sailed for the United States, but Jack tarried in Edinburgh long enough to attend the International Genetics Congress and barely managed to catch one of the last civilian boats home.

Back in Pasadena, he wanted to continue the work he and Caspersson had begun. But, as George Rudkin tells us, "The years following [Jack's] return from Sweden were marked by the search for financial support for the acquisition and operation of the complicated, expensive instrumentation of the type developed in Stockholm, this in an era when grants were rare and in a laboratory where simple equipment was stressed. The period (1939–1943) ended with a harried year spent partly as visiting professor with Lewis John Stadler, at Missouri, working on variegation in corn, partly at Cal Tech and partly at Woods Hole, not far from the Marine Laboratory of the Philadelphia-based Lankenau Hospital Research Institute at North Truro, Massachusetts. That same period saw the completion of a new review, this time from a chemical point of view, 'The Gene as a Chemical Unit,' much of which is still illuminating thirty years later. In 1943, he joined the Lankenau organization, then under the directorship of Dr. Stanley P. Reimann.

"Reimann was in the process of building up The Institute for Cancer Research (as it was later called), which was dedicated to the proposition that logical solution(s) to the cancer problem would come from an understanding of the basic mechanisms underlying development and growth. Jack enthusiastically brought his expertise in genetics, embryology, and physiology to this new enterprise. He became immersed in trying to understand the many facets of cancer and, as one of the few geneticists in the field, wrote a number of classical reviews on the subject."

Jack and Helen were warmly welcomed to the Philadelphia

scene by members of the faculty of the University of Pennsylvania, particularly by Charles W. Metz and his associates. The Schultz family lived first in the village of Ithan, on the Main Line west of Philadelphia. In 1949, when the Institute moved from its crowded and makeshift quarters at the old Lankenau Hospital on Girard Avenue, to its modern new building in Fox Chase, they moved to Elkins Park and finally settled in Huntingdon Valley, a suburb in the northeast, where they could happily do some gardening. Jack and Helen also spent many delightful summers at Cold Spring Harbor with such friends as Milislav Demerec, Theodosius Dobzhansky, Curt Stern, Ernst W. Caspari, Berwind P. Kaufmann, Alfred E. Mirsky, and Barbara McClintock.

In his own laboratory, Jack and his colleagues worked on projects in many areas. With human material easily available from the Lankenau Hospital, Dr. Reimann soon induced Jack to study human chromosomes. As a result, in 1946 he and Patricia St. Lawrence were able to map two of the chromosomes associated with the nucleolus in preparations of human pachytene chromosomes and to show that, like the pachytene chromosomes of other species, they have distinctive chromomere patterns. This area of research has been continued at The Institute for Cancer Research by Jack's former student, David Hungerford.

Another project involved devising minimal media for growing *Drosophila* cultures as a preparation for studying the one-gene-one-enzyme hypothesis in a higher organism. Although it was found that different stocks indeed had different requirements for such substances as tryptophan, the project was eventually dropped because of the difficulty in getting clear-cut non-leaky, nutritional mutants. In another, somewhat related project, Jack and Elizabeth K. Patterson followed the activities of such enzymes as the peptidases during the development of specific organs in *Drosophila*. Measurements of the nucleic acid

contents of the eggs and larvae of various *Drosophila* stocks and species were made first with Leo Levenbook and then for many years with Elizabeth Travaglini. It was found that the eggs of different species contained remarkably different extrachromosomal DNAs.

Meanwhile, Jack had been accumulating sufficient funds to acquire the expensive microspectrophotometers necessary to make quantitative measurements of the nucleic acid contents of the bands in salivary gland chromosomes. Eventually he and George Rudkin were able to estimate the extent of polyteny of these chromosomes by comparing their DNA contents with those of chromosomes in other tissues. But the biggest harvest came in studies of giant chromosomes in *Rhynchosciara,* in which they discovered that certain bands increased their DNA content in the process of "puffing"—a stage in which the genes in these bands become active and synthesize messenger RNA. This was an important observation, for it dispelled the old dogma that each cell in a multicellular organism contains a set of genetic material that is identical to that contained in the diploid cells of the germ line. This paved the way for the discovery of disproportionate replication of other genes, particularly those involved in the production of ribosomal RNA. The work also showed that the compacted, or "heterochromatic," chromosome regions, with which Jack's name had been associated since his days at Cal Tech, are relatively inactive, whereas the extended or "euchromatic" regions are available for transcription into the RNA messages that direct protein synthesis.

The use of *Drosophila* for testing the activities of various carcinogens was also studied, and it was found that some of these agents produced interesting developmental abnormalities; however, the results were never published *in toto.* In fact, whereas Jack was willing and even eager to talk about his own work in private or public, he was most reluctant to sit down and write up the details for publication. But although he

seemed to lose interest in writing what he had already done, an important element in this apparent neglect was his conviction that a scientific paper should be of real theoretical relevance and must not represent merely the stockpiling of data in yet another publication. Thus, in his own work, which was largely of a pioneering nature and therefore theoretically risky, he was apt to make new plans and to wait for the completion of critical experiments—those that would bring the stubborn data into satisfactory focus. The result was that many of the data were not published *in extenso*. It should be remembered also that during the years at the Institute, he was devoting much time and energy to the general development and coordination of basic research there. Much more time and energy was spent, for example, on meetings elsewhere dealing with grant applications or to the consideration and reviewing of such material as papers for publication (those by many outsiders as well as by Institute staff), and so on. His nature was such that he practically never refused a request; thus he was unable to protect himself, even when failing health demanded just that. And so it unfortunately happened that much of Jack's experimental work was brought to the attention of colleagues only through lectures and discussion or through abstracts in the proceedings of meetings he attended.

Jack exerted a profound influence on the Institute by wandering through its laboratories and engaging his colleagues in relaxed, stochastic discussions of science, music, literature, or the theater. These peripatetic discussions were extremely valuable. Not only was Jack active and perceptive in selecting and recruiting personnel, but it was his friendly, inquiring, and enthusiastic nature to delve into the biological projects of all his colleagues and to offer helpful advice and guidance freely. Jack's effectiveness in these endeavors was greatly facilitated by his astonishingly broad comprehension and competence, as well as by his charm and appreciative wit.

Sometimes he would suggest a definitive experiment that others would perform. For example, a basic problem in embryological differentiation had long been to determine whether embryonic nuclei become irreversibly differentiated as the cells themselves diversify. Jack suggested to Robert Briggs, who was then at the Institute, that one way to test this would be to provide enucleated eggs with nuclei obtained from embryos at progressive stages of development. If the egg then developed into a mature individual, this would mean that the donor nucleus had not been irreversibly differentiated at the stage in question; on the other hand, if the development of the egg stopped at an earlier stage, the nucleus it received presumably had been irreversibly changed. With Jack's encouragement, Briggs and Thomas J. King then developed methods for successfully transplanting nuclei and showed that frog eggs implanted with nuclei from a very early stage (blastula) develop more successfully than those provided with nuclei from later stages (gastrula and neurula).

A second productive project at the Institute was spurred on by Jack's resolve that one should thoroughly investigate the genetics of tumor cells and compare them with the genetics of the cells in the tissues from which they had originated. He recognized that the material of choice for such studies would be the free-living ascites forms of transplantable solid tumors; because individual ascites cells multiply rapidly, it should be feasible to study the chromosomes of dividing cells of these tumors by the standard squash and staining techniques with which he was so familiar. Furthermore, if means could be found to make cells of different types fuse with each other, one should be able to develop techniques for studying their genetics in much the same way that the genetics of bacteria had been so successfully pursued. Jack was thus led to invite George Klein to come to the Institute from Sweden to instruct him and Theodore S. Hauschka in working with ascites tumors. Shortly

thereafter, the Swedish cytologist, Albert Levan, joined the group. They soon made the startling discovery that some tumor cells were like diploid normal cells in having two chromosomes of each kind, whereas others had four or more chromosomes of each kind. Moreover, they found that the higher the ploidy of a tumor, the greater the range of host strains of mice to which the tumor could be successfully transplanted. They concluded that increases in the number of chromosomes are somehow associated with alterations in the tumor's transplantation antigens in such a way that the tumor is less susceptible to rejection by an otherwise incompatible host.

Jack also realized that one could not develop a genetics of somatic cells unless one had a large number of well-defined mutations. It was well known that such mutations are difficult to induce in the readily available diploid cultures in which each cell contains two chromosomes of each kind. Jack suggested that the difficulty might be overcome by working with haploid cells, *i.e.*, cells that contain only one chromosome of each kind. For in such a haploid cell, one might expect that a mutation might be able to express itself phenotypically without having to overcome the influence of its wild type allele that would normally be present in a diploid cell. Jack therefore encouraged Jerome J. Freed to isolate haploid cell lines from parthenogenic frog embryos. Freed was later joined in this work by his wife, Liselotte Mezger-Freed, and together they did indeed isolate such haploid lines. However, when they tested Jack's hypothesis, they found to their, as to any geneticist's, chagrin that haploid and diploid lines had nearly the same apparent mutation rates. Lisa favored an explanation that involved inherited units in the cell membrane. Needless to say, the search for an explanation of the Freeds's unexpected result is still going on.

Jack's mere presence at the Institute often led members of the staff into cooperative research with other scientists in the Philadelphia area. For example, when Peter Nowell at the

University of Pennsylvania recognized that the cultures of human leukemic cells he was developing could provide a convenient source for human chromosomes, his department head, Dr. Dale R. Coman, suggested that he contact Jack because of Jack's experience in studying human chromosomes. Jack, in turn, referred Nowell to his student, David A. Hungerford. The ensuing collaboration between Nowell and Hungerford was most fruitful; among other things, they discovered the so-called Philadelphia chromosome that is associated with chronic granulocytic leukemia.

One of the most congenial and productive people whom Jack helped to bring to the Institute was Beatrice Mintz. Jack had created an atmosphere in the Institute in which she felt free to undertake a major project—that of producing animals with cellular genetic markers chosen at will. The plan was to combine cells of two early mouse embryos of different genetic origins and then implant the composite into a foster mother to develop into a single mosaic or allophenic animal. Obviously, such a project was risky; even if the experiment worked, it might take many years of discouraging trial and error before a result could be obtained. And indeed, several years were required to develop the necessary techniques. Finally, in 1965, when the first allophenic mice with visible coat color markers were born, Bea could hardly wait to show them to Jack and Helen. When Jack saw the striped baby mice he exploded, "Wow!", with wonder and delight. It was immediately clear that he perceived the significance of the coat patterns on the young mice duplicated from one individual to another and the promise they held for unravelling the developmental order in any other tissue in which appropriate markers might be available.

Jack was very generous in giving of his time, especially to younger people. He never presumed to direct their work, yet often when one of them had a new idea or new data he would find himself intuitively knocking at Jack's door to share his

discovery and benefit from Jack's broad knowledge and incisive scientific perceptions. Jack encouraged the student to develop an appreciation of, rather than a disparagement for, the complexity of biological systems. Whenever a manuscript came to him for review, as was often the case, he would praise what was valid in it and criticize the spurious parts without giving offense. He would insist that the style be clear and the meaning unambiguous. "Why don't you say exactly what you mean?" He had the ability to give most of his colleagues the feeling that they were special individuals, and he seemed to be a second father to many.

Jack asserted that he never in his whole life played a sport such as tennis, a card game such as bridge, or a table game such as chess. This is a slight exaggeration, for although he never seriously participated in such games, still he was known to have played tennis and chess with Helen and the children—albeit somewhat unenthusiastically. More to his taste were noncompetitive activities: gardening, swimming, tramping in many quiet countrysides and along isolated mountain trails, trips to exotic desert regions with the Dobzhanskys and others at Cal Tech or motorboating with the Casperssons in Sweden. He and Helen especially enjoyed canoeing among the Elizabeth Islands during those summers spent by Morgan's group at Woods Hole and, during all of their life together, exploring at leisure villages and cities encountered both in this country and abroad, in a serious attempt to arrive at some real understanding of the life of all kinds of people. On the other hand, Jack was interested in the publicized personalities of competitive sports and talked to his friends about them—not because he cared for the popular sporting events, but rather because the participants (both the active and the passive) remained to him psychological curiosities.

Jack was unusually fond of intellectual play with words, ideas, and attitudes. He was an expert at some of Eric Berne's

nondestructive "games people play." Somewhat related to this, perhaps, was his great love for seminars, which for him took on the aspects of an anticipated fete or celebration. Listening to a good lecture, he would soak up the information as it was presented, and after the talk could usually be counted on to lead a lively discussion in which, without any apparent preparation, he would bring up a set of recondite facts and views that would broaden the audience's perspective and nicely wrap up the topic at hand.

Reimann's retirement as director in 1956 produced a crisis, for it appeared that the Institute's Board might appoint a nonscientist to run the affairs of the Institute and that basic research might be jeopardized. Some of the senior staff left the Institute, but Jack, together with the embryologist Tom King, the crystallographer A. Lindo Patterson, and the three biochemists Gerrit Toennies, Hugh J. Creech, and Sidney Weinhouse, stayed on to form a nucleus of scientists that held the remaining staff together. In 1957 the Board wisely appointed Timothy R. Talbot, Jr., a physician and hematologist, to be Director of the Institute. Jack was of great aid to the new Director in helping the Institute to recover and gain strength. As Talbot himself has written, "[Jack's] motive was to assure that the Institute would once again develop a growing diversity and excellence. There was literally no limit to the number of hours that Jack devoted to this process. No meeting with him was ever without some new input, some lucid presentation of biological phenomena, some new concept that we explored and debated, some warm perception of a colleague or commentary on the world in which we lived. He was always cutting through to the heart of the matter, and with exquisite graciousness. . . .

"While he was exerting his influence through and upon me, he was also in intimate contact with all of the Institute. There were few fields of science to which he could not direct his attention intelligently, and much of his time was devoted to the

scientific and personal encouragement of the people around him. Jack's intellectual capabilities were awe-inspiring. He could read at a glance what most of us had to struggle through. He had almost total recall, but unlike many encyclopedic minds, his analytical digestion of all that he absorbed and his ability to synthesize new ideas were truly phenomenal. The good fortune for all of us is that these great abilities were housed in a framework of love and compassion and concern for society. In addition, he had a foundation in philosophy and art almost equal to that which he had in science."

In the spring of 1961, Jack accepted an invitation from the Department of Genetics and his old friend, Curt Stern, to spend a term as visiting professor at the University of California at Berkeley. His lecture, "New Ideas," given at the Third Annual Graduate Students' Genetics Colloquium, serves as a fitting memento of that visit, and it revealed to scientists Jack's talent as an essayist.

Besides his many activities at the Institute, Jack served on the editorial boards of the *Journal of Heredity, The American Naturalist,* and *Genetics.* He was elected Vice President (Zoology) of the American Association for the Advancement of Science in 1961, President of the Genetics Society of America in 1963, and President of the American Society of Naturalists in 1968. In his presidential addresses and posthumously published essays, we see a fusion of scientific and literary erudition that reveals Jack's understanding of, and sympathy for, the human condition. He was elected to the National Academy of Sciences in 1969, a few weeks before his sixty-fifth birthday and his mandatory retirement.

As Senior Member Emeritus, Jack felt himself partially released from his unofficial stewardship of biological affairs at the Institute and thus more free to devote his enthusiasm and energies to his own research. With Kenneth Tartof, he worked on gene amplification in bobbed stocks of *Drosophila;* and with

Francis Ashton, he continued his electron microscopic studies of the fine structure of *Drosophila* chromosomes.

But he had little time left. Some years earlier he had begun to have attacks of angina. A heart attack on April 29, 1971, proved fatal.

Jack Schultz is survived by his widow, Dr. Helen Redfield Schultz, by his son, Dr. Peter R. Schultz, by his daughter, Judith Jillian (Mrs. Richard Frisch); and by five grandchildren.

As one of his foreign collaborators has said, "To discuss problems with Jack was a unique occasion. You got more through personal talk with him than through his publications, for Jack had a lot to say that he hadn't published." Many colleagues throughout the world, as well as those at the Institute, can attest to their indebtedness to his scientific insight as well as to his warmth and humanity. He is sorely missed by all of us who knew him.

THE EARLY HISTORY of Jack Schultz's parents and the story of Jack's early life were kindly made available by Mrs. Jack Schultz.

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KEY TO ABBREVIATIONS

Am. Nat. = American Naturalist
Anat. Rec. = Anatomical Record
Cancer Res. = Cancer Research
Carnegie Inst. Wash. Year Book = Carnegie Institution of Washington Year Book
Cold Spring Harbor Symp. Quant. Biol. = Cold Spring Harbor Symposium on Quantitative Biology
Exp. Cell Res. = Experimental Cell Research
Fed. Proc. = Federation Proceedings
J. Cell. Biol. = Journal of Cellular Biology
J. Exp. Zool. = Journal of Experimental Zoology
J. Genet. = Journal of Genetics
J. Gen. Physiol. = Journal of General Physiology
J. Histochem. Cytochem. = Journal of Histochemistry and Cytochemistry
Proc. Am. Assoc. Cancer Res. = Proceedings of the American Association for Cancer Research
Proc. ——— Int. Congr. Genet. = Proceedings of the ——— International Congress of Genetics
Proc. Natl. Acad. Sci. = Proceedings of the National Academy of Sciences of the United States of America
Rec. Genet. Soc. Am. = Records of the Genetics Society of America

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