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THOMAS FOXEN ANDERSON
1911–1991

A Biographical Memoir by

ROBERT P. PERRY

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THOMAS FOXEN ANDERSON

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BY ROBERT P. PERRY

THOMAS F. ("TOM") ANDERSON was internationally known for his pioneering use of the electron microscope to study viruses and bacteria. His ability to master the instrument in its early stages of development, his invention of an ingenious method for specimen preservation, and his acute perspicacity in interpreting his observations resulted in pictures of historic importance. These included the first micrographs to clearly show infectious viruses attaching to and reproducing in their bacterial hosts and elegant detailed images of male (donor) bacteria transferring genetic information to female recipients. His research achievements helped elucidate several important mechanistic principles of virus-host interactions.

Tom was born in Manitowoc, Wisconsin. His father, Anton Oliver, the first of seven children, was born on a farm in central Wisconsin, which his parents had homesteaded shortly after they arrived from Norway. Anton graduated from high school in the nearby village of Amherst and studied electrical engineering for two years at Lawrence College in Appleton before joining the Navy and serving as the chief electrician on the battleship USS *Texas*. After his honorable discharge from the Navy, Anton married Mabel Foxen, a young woman

from Amherst, who was also of Norwegian descent. They settled in the beautiful little town of Manitowoc on the western shore of Lake Michigan and had two children: Tom and his younger brother, Norman.

Anton organized and built the Oslo Power and Light Company, which supplied electricity to power lines connecting the many small towns and farms of Manitowoc County. He also established the Anderson Electric Company to wire subscribers' buildings and to sell and repair electrical fixtures and appliances. As a result, Tom grew up not only with electrical toys but also with some knowledge of generators and motors, power lines, and transformers.

Tom's mother was an accomplished pianist. After graduation from Amherst High School, she studied music for two years at the Lutheran Seminary in Red Wing, Minnesota. Tom loved to hear her play the piano, and he also enjoyed music on the Andersons' radio, one of the first in the town of Manitowoc. Although Tom's paternal grandfather and maternal grandmother died shortly before his birth, their surviving spouses married each other and provided him and his brother, Norman, with a single set of double-loving and -spoiling grandparents. Their many children and grandchildren constituted an extended family, which provided Tom with a very pleasant and memorable childhood.

Tom became acquainted with bacterial diseases at a very young age. In this pre-antibiotic era, his brother developed a chronic mastoiditis, and sadly, when Tom was only nine years old, his mother died of tuberculosis after a long illness. Fortunately, his father's second wife, Edna Halvorsen, took over the care of the children as if they were her own. Because of Norman's illness, Anton sold his holdings in Manitowoc and searched for a climate that might be more beneficial to his son's health. The Andersons tried four locations: Tampa, Florida (1923-1924); Amherst, Wisconsin

(1924-1925); Rockford, Illinois (1925-1926); and Glendale, California, where they finally settled.

Scientists are often asked about aspects of their early education that might have stimulated them toward a career in science. In Tom Anderson's case, it may have been a botany course at Rockford High School taught by Miss Agnes Brown. As described in an autobiographical essay by Anderson, Miss Brown, although physically handicapped, guided her students on many field trips to neighboring fields and woods to collect specimens that would later be dissected and studied with compound light microscopes. As he viewed the intricate architecture of plant tissues and cells, Tom gained an early insight into how the great variety and specificity of biological structures appear to steadily increase as one examines them in ever-increasing detail. Under Miss Brown's tutelage, textbook concepts like cells and chromosomes became real objects once he had seen them.

Tom's second and third scientific loves were chemistry and physics. Excellent courses at Glendale High School and a chemistry set at home effectively developed these interests. After graduation, he successfully passed the entrance examination at the California Institute of Technology, and began his studies there in 1928. At this time the departments of physics and chemistry, led by Robert A. Millikan and A. A. Noyes, were well established with distinguished faculties. Biology was just getting started under the guidance of the geneticist T. H. Morgan. The courses were demanding, but Tom worked hard and received excellent grades. In his view the most rewarding courses were those that revealed scientific principles. Less attractive to him were those that required excessive memorization or dealt with abstract formalisms. He gravitated toward physical chemistry and was introduced to scientific research by the inorganic chemist Don M. Yost. In a senior project with another undergraduate,

Folke Skoog, Tom determined the free energy of formation of iodine monobromide in carbon tetrachloride solutions. The data, which confirmed and extended earlier work, resulted in Tom's first publication, a paper in the *Journal of the American Chemical Society*.

After receiving his B.S. degree in 1932, Tom spent a year in Kasmir Fajan's Physikalisch-Chemisches Institut in Munich. This laboratory was concerned with the determination of refractive indices of various substances to the highest possible degree of precision. With Peter Wulff, Tom used an inexpensive spectrograph equipped with aluminum-coated mirrors to measure the dispersion of cesium chloride crystals in the ultraviolet. The interpretation of his data was made according to old classical theories of refraction developed by Lorentz, rather than the newer quantum mechanics, which had not yet effectively penetrated the thinking of the Munich group. When Tom returned to Caltech, he was persuaded to give a seminar on this research before an audience that included Linus Pauling. About midway through the seminar, Pauling commandeered the blackboard and, much to Tom's chagrin, sketched out the quantum theory of mole refractions. When he had finally finished, Tom continued his rigid presentation, erasing everything that Pauling had written and causing the audience to roar with laughter. Although this episode was alarming at the time, it obviously had a lasting effect on Tom's development into a mature scientist.

Tom resumed his research with Don Yost and studied the Raman spectra of various inorganic compounds, using vibrational frequencies to determine their thermodynamic constants. For his dissertation research, he showed how isotopes affected vibrational frequencies in boron compounds and in deuterium gas. For deuterium, in addition to effects on vibrational and rotational frequencies, the nuclear spin affected selection rules without influencing the force con-

stants between atoms. All told, five publications resulted from this research.

After receiving his Ph.D. degree in 1936, Tom went to the University of Chicago to work with William D. Harkins on the properties of surface films. With a very simple and inexpensive film balance, he studied films formed by the combination of calcium ions with fatty acids and by cytochrome C monolayers. Decades later cytochrome C surface films were used by Kleinschmidt and Zahn to coat nucleic acids and give them sufficient contrast to be visible in the electron microscope.

Although brief, the year in the highly competitive Harkins laboratory provided Tom with other lessons for an aspiring scientist, which he related in his autobiographical essay. One was that claims of priority for discoveries based on unpublished data sequestered in old lab notebooks are unacceptable. An investigator should either have the courage to publish the best possible interpretation of the data and be prepared to suffer criticism if wrong or relinquish any future claims of priority. Another lesson stemmed from Harkins's habit of riding herd on his assistants and postdocs by daily inquisitional visits to their lab benches and by creating temporary outcasts among the group. Such a tense atmosphere would not foster creativity in people of Tom's temperament. For obvious reasons, he was anxious to change venues for his postdoctoral training. The opportunity came in the summer of 1937 when he was offered a position at the University of Wisconsin, where he would investigate the effects of ultraviolet light on yeast cells with B. M. Duggar and later serve as a laboratory assistant in Farrington Daniels's physical chemistry course.

The most pleasant part of Tom's Chicago experience was his meeting and falling in love with his future wife, Wilma Fay Ecton. Wilma, who came from Kansas City,

Missouri, was at the University of Chicago studying for a career as a lawyer and a judge. Tom and Wilma met at the International House, a popular place on campus for dining and social activities. Their courtship continued after Tom's move to Wisconsin, and they were married in North Kansas City on December 28, 1937. They later had two children, Thomas Foxen Jr. in 1942 and Jessie Dale in 1946.

A crucial event in Anderson's career occurred in 1940 when he was awarded a fellowship, funded by RCA and administered by the National Research Council, to help explore biological applications of the electron microscope. Invented in Germany in the 1930s and later developed independently at the RCA Laboratories, the electron microscope greatly improved one's ability to peer into the world of very tiny objects. Entities that had heretofore remained invisible when magnified a thousandfold by the light microscope suddenly could be seen at magnifications of 10,000 to 50,000. The potential impact of this instrument on biology was enormous. The fellowship was directed by a committee of prominent biologists from all over the United States. The committee, which was chaired by Stuart Mudd, a bacteriologist from the University of Pennsylvania, probably selected Anderson because of his strong background in physics and chemistry and his biological research experience in the Duggar laboratory. Working at an intense pace in the RCA laboratory of Vladimir Zworkin in Camden, New Jersey, Tom collaborated with a steady stream of microbiologists, embryologists, and geneticists, who were all eager to visualize their favorite specimens in a totally new way.

The Camden laboratory had three electron microscopes. One instrument, designated as EMA, was designed by Ladislaus Marton, a Belgian, who had constructed and used an earlier model in Brussels in the mid 1930s. The EMA was difficult to use because it required frequent cleaning to remove con-

tamination of the vacuum system. A second instrument, EMB, developed with the help of James Hillier, an electronics engineer from Toronto, was easier to use and became the prototype for RCA's first commercial electron microscope. The third microscope was an experimental high-voltage instrument. Tom's initial observations were made with the EMA. He switched to the EMB when it became available in July 1940, and he carried out some experiments with the high-voltage instrument after it was put into operation in mid-1941.

Everything that Tom and his collaborators looked at was novel in those days. He and Harry Morton observed that the reduction of potassium tellurite occurred within the cells of *Corynebacterium diphtheriae*. Tom, Stuart Mudd, Katherine Polevitzky, and Leslie Chambers were able to visualize for the first time flagella and the details of cell wall structures of various bacilli. He and Wendell Stanley were able to measure directly the sizes and shapes of various plant virus particles, and, in so doing, confirm the dimensions previously inferred from diffusion, ultracentrifugation, and flow birefringence measurements of viral suspensions. Importantly, the electron microscope had given these investigators the power to actually see as individual objects things that had been only mental concepts. Shades of Tom's early experience in Ms. Brown's botany class!

Other notable observations included the combination of antibodies with specific viral or flagellar antigens and the beautiful stereoscopic pictures of insect structures obtained with A. Glenn Richards Jr. One paper, published with Richards in 1942, describes the iridescent wing scales of blue morpho butterflies, where the optical path length between layers on the scales was found to be one half the wavelength of the blue light that is selectively reflected from them. This paper has the distinction of being cited 53 times

in scientific literature published after 1991, a remarkable durability for research carried out a half-century earlier. In fact, such long-term durability, which testifies to the solidity of experimental observations and the deep insight of the interpretation of such observations, is a salient feature of Tom's research. Sixteen of his papers published more than 30 years ago continue to be cited in the current literature.

Tom supplied three important ingredients to the collaborative projects. First, he pursued these projects with great enthusiasm. He was willing to spend long and irregular hours working with his collaborators. Second, he had a thorough knowledge of the physical and chemical principles that governed the performance of the instrument and the quality of the specimen preparations. Such knowledge enabled him to make judicious adjustments of parameters and conditions that could spell the difference between success and failure in revealing fragile structures. Third, his easy-going personality, his calm unflappable demeanor, and his highly logical and orderly approach to problems maintained tranquility in the laboratory, thereby greatly enhancing the productivity of his numerous and diverse projects. As a result, some 31 papers resulted from his two years' work as an NRC-RCA fellow.

One of Tom's most exciting discoveries during this period was made in late 1941 and early 1942 when he, Salvador Luria, and a little later Max Delbrück looked at preparations of the viruses that infect bacteria, the bacteriophages. Studying a variety of phage strains active on the bacterium *Escherichia coli*, they observed uniform sperm-shaped objects with distinct head and tail structures. The initial observations with Luria showed that different strains had different morphologies, indicating that there are multiple families of bacteriophages rather than a single type as had previously been believed. Helmut Ruska, working concurrently in Germany with an

electron microscope designed by his brother, Ernst, observed similar structures, although he was unable to distinguish clearly the phage from bacterial debris or to examine pure preparations of different phage strains. Unfortunately, World War II prevented Anderson and Ruska from having any open discussion of their results.

A more detailed study was made in the summer of 1942 at the Marine Biological Laboratory in Woods Hole, Massachusetts, where RCA had installed an EMB so that it could be seen by the visiting biologists. Together with Luria and Delbrück, Tom examined the infectivity and growth of phage α, later know as T1, and γ, later known as T2, each of which has a characteristic shape and size. Their micrographs clearly demonstrated the adsorption of virus on the host bacterium and, after a predicted time, the lysis of the host with the liberation of virus particles of only the infecting type. Thus, the phage "bred" true morphologically through each round of infection. These very important observations were contrary to a popular notion that bacteria harbored phage precursors that are converted to mature viruses upon infection. This provided the first compelling evidence that phages were not specified by genes of their hosts, but rather that they probably had genes of their own.

When his NRC-RCA Fellowship expired in September 1942, Tom decided that of the many fields that had been opened by the electron microscope, the study of bacteriophages offered the most interest and excitement. Thus began a lifelong commitment to phage research. He took a position in the Johnson Foundation for Medical Biophysics, then directed by Detlev W. Bronk, where Leslie A. Chambers had recently obtained an EMB for his studies of microbial pathogens. In addition to his phage research, Tom collaborated with Chambers, Mudd, and others on studies of pathogenic organisms, such as rickettsia and pneumococcus. During

the next decade, Tom made several important discoveries, several of which, as he recounted later, were serendipitous. One such discovery was made when he was investigating the effects of ultraviolet light on the virus-host complex. For these experiments he had to use a UV-transparent minimal medium rather than the nutrient broth that was routinely used for the phage studies. He noted that, although the plating efficiency of T2 phage in this medium was normal, that of phages T4 and T6 was very low. Tracking down the explanation of this unexpected result, he found that the T4 and T6 phages would not attach to their host unless activated by an aromatic amino acid cofactor like L-tryptophan, which was present in the nutrient broth but not in the minimal medium. The cofactor phenomenon represented the first directly observed example of allosterism, for, as it was later shown, these cofactors cause the phage's long tail fibers to be released from the tail sheath so that the connectors on their tips can engage receptors on the surface of the host.

In 1946 Tom was appointed to the Penn faculty as an assistant professor of biophysics. He was promoted to associate professor in 1950. During this period, his pursuit of the cofactor phenomenon led to another serendipitous discovery, namely, the release of DNA from phage heads by osmotic shock. In experiments designed to determine how activation of T4 by tryptophan depends on salt concentration, Tom noted that the phage was inactivated if it was incubated in NaCl at a concentration greater than 2M and then rapidly diluted into a solution of low osmotic pressure. Following up this initial finding, he observed the empty heads of the osmotically shocked phage and the greatly increased viscosity of the disrupted preparations, indicating a loss of DNA. This was confirmed by Roger Herriott's chemical analysis, and, therefore, it could be concluded that DNA is required for the phage's infectivity.

According to Tom, one of the best ideas that he ever had was that of the critical point method for drying specimens for the electron microscope. It was obvious to him early on that most biological specimens were flattened by surface tension forces when dried in air on standard electron microscope grids. He was especially anxious to eliminate these surface tension artifacts, which seemed to be responsible for his uncertainty as to whether bacteriophage attached to their hosts by their heads or their tails. The extant electron micrographs could support either view. Exploiting his background in physical chemistry, he posed the key question: Given a material immersed in a liquid, how can one transfer it to a gas or vacuum without having a phase boundary, with its attendant surface tension, pass through it? The answer seemed obvious to him: Eliminate the phase boundary by raising the temperature of the ensemble above the critical point of the liquid, thus converting the liquid to a gas. Then let the gas escape at the higher temperature, which will leave the specimen high and dry. Because water, the liquid that specimens are usually immersed in, has a critical temperature of 374°C, which would likely destroy most biological material, he cleverly devised a procedure to replace the water with liquid carbon dioxide, which has a critical temperature of only 31°C, by stepwise passage of the specimen through series of miscible liquids. Using inexpensive components, he constructed an apparatus to prepare specimens by this method and quickly answered his quandary about phage attachment. The phages adsorb to receptive host cells by the tips of their tails. Tom presented beautiful stereoscopic pictures of phages and other biological material prepared by this method at the First Congress of Electron Microscopy meeting, held in the charming amphitheater of the Jardin des Plantes in Paris in 1952. His audience was

stunned by the excellent quality of these pictures, and, appropriately, they accorded him their highest praise.

A few years later, Tom took a sabbatical leave to work at the Institut Pasteur in Paris with André Lwoff, Francois Jacob, and Elie Wollman on bacterial conjugation, a phenomenon originally described by Joshua Lederberg. Assembling a critical point apparatus from components that he brought with him, Tom was able to make highly detailed stereoscopic electron micrographs of pairs of mating bacteria connected by a narrow tube through which DNA could pass from the male to the female strain. These vivid pictures and their interpretation were published in a 1957 paper by Anderson, Wollman, and Jacob in the *Annales de L'Institut Pasteur*. This paper was a paragon of clarity, elegant experimentation, and incisive analysis. The pictures have become the classic illustrations of bacterial conjugation in scientific textbooks. An amusing popularization of this work occurred when one of the pictures was used to illustrate a story in the magazine *Paris Match*, which was titled simply "La Vie." The picture caption was "Un Accouplement de Bacterie."

The 18-month stay in Paris, which was supported by prestigious fellowship awards to Tom from the Fulbright Scholarship Fund and the Guggenheim Foundation, was certainly a highlight in the lives of the Anderson family. The rich cultural experience, the challenge of a foreign language, and the vibrant scientific atmosphere of the Pasteur Institute all combined to make this a memorable experience for Tom, Wilma, and their two children.

In the latter part of his stay in Paris, Tom decided to investigate the recombination between male and female genes that occurs in the zygote after conjugation. With a light microscope and a micromanipulator, he devised a system to isolate the individual progeny of the zygote through successive cell divisions. With this system, he and Lwoff's

technician, R. René Mazé, were able to follow the pedigrees of more than a score of exconjugants. The results were surprising and confusing. In contrast to the male exconjugants, which divided regularly after separating from the females, the female exconjugants (the zygotic progeny) divided erratically and exhibited a diverse array of morphological abnormalities, which in some cases led to eventual death. At that time, the lack of knowledge of the yet-to-be discovered episomal plasmids and the poor understanding of genetic recombination mechanisms prevented Tom from providing a reasonable explanation of these strange results. Nevertheless, he decided to publish them, adhering to the adage of Albert Einstein that is engraved near his statue on the grounds of the National Academies: "The right to search for truth implies also a duty; one must not conceal any part of what one has recognized to be true."

In 1957 Tom returned to the Johnson Foundation and the University of Pennsylvania and in 1958 was promoted to professor of biology. It was during this period that I first met him. I came to the Johnson Foundation for postdoctoral training with Britton Chance and was mainly involved in projects dealing with mitochondria and respiration. In a study with synchronized populations of *E. coli*, I wanted to verify the degree of synchrony by examining the bacteria with the electron microscope at various stages of the cell division cycle. At this time, Tom had a very simple microscope that he put at my disposal. Although this microscope was perfectly adequate for my purposes, it did not have sufficiently high resolution for Tom to take advantage of the powerful new negative staining technique, which had recently been developed. The opportunity to obtain such a microscope came when he was offered a senior position at the Institute for Cancer Research (ICR) and a chance to initiate electron microscope studies at that institution. Located

in northeast Philadelphia, the ICR not only had very pleasant surroundings but also a firm commitment to basic research in biology, a tradition established by its first director, Stanley Reimann, and carried on by his successor, Timothy Talbot. Tom happily accepted the offer, which also came with a substantial increase in salary. He joined ICR in 1958 and maintained his affiliation with Penn as an adjunct professor in both the biophysics and biology departments.

As I was completing my research at the Johnson Foundation, I received an American Cancer Society Fellowship to take additional postdoctoral training in a world-renowned laboratory of cell biology in Brussels, Belgium. Before I departed for Brussels in January 1959, Tom inquired whether I might like to join him in his new laboratory when I returned to the States. This was an attractive offer, because it was unlikely that I would be able to find an equivalent academic or research position in this country while living abroad. After a few months of deliberation, I decided to accept the offer and to begin work at the ICR in the summer of 1960. This turned out to be one of the best decisions that I ever made.

Tom's generosity and support were evident from the moment my wife and I and our two small children arrived at the Philadelphia airport, somewhat haggard after traveling for more than 25 hours because of extended flight delays. He drove us to his home, where we were put up for the night and allowed to get some much-needed rest. At this time the Andersons were still living near the university, but they would soon be moving to a lovely split-level home in Fox Chase. The next day he brought us to a comfortably furnished home near the ICR, which had been rented for our temporary use until we could find something more permanent. Tom and Wilma even made sure that we had the necessary groceries and household supplies. This was

certainly a warm welcome, which grew into a lifelong friendship between the Anderson and Perry families.

In his new lab at the ICR, Tom was using his state-of-the-art Siemens microscope to investigate the fine structures of phages. In one study, carried out with Nobuto Yamamoto, a young research associate from Japan, an interesting phenomenon termed "genomic masking" was discovered. These studies involved a temperate phage that infects the bacterium *Salmonella typhimurium*. At a low frequency, bacteria infected with phage P22 produced, in addition to the P22 progeny, a variant form with a morphologically distinct tail structure. It turned out that the variant was the result of an exchange between a latent capsid-encoding gene in the bacterial genome and the normal capsid gene of the infecting phage. This observation was one of the earliest examples of such genetic exchange.

Throughout the 1960s, the Anderson laboratory continued to be at the forefront of the bacteriophage field. As the techniques for specimen preparation were perfected, including thin sectioning combined with negative staining, finer and finer ultrastructure could be visualized. Tom was fascinated by the symmetry properties of the viral structures, particularly the connection between the icosahedral phage heads, which have fivefold symmetry and the phage tails, which have hexagonal symmetry. He wrote thoughtfully about this interesting relationship, which he considered to be one of nature's mysteries. In a notable study Tom and Manfred Bayer, a research associate from Germany, described in exquisite detail the surface structure of *E. coli*. This study revealed membrane patches that were later found to be sites of viral attachment. In another elegant series of experiments, he and his graduate student, Lee D. Simon, presented some superb electron micrographs showing T2 and T4 phages in the process of infecting their hosts. In these pictures one

could visualize changes in the shape of the delicate tail fibers, repositioning of the short tail pins, and contraction of the tail sheath. One could also see structural changes in the tail base plate and the needle through which DNA is injected into the bacterium. These extraordinarily detailed pictures have graced the pages of many textbooks.

In these research projects Tom usually gave his young collaborators leeway to work independently and to follow their own instincts as much as they desired. As a mentor, he was accessible for discussions of results, exchanges of ideas, and suggestions based on his sound knowledge of physical principles. He played a major role in the write-ups of the experiments, insisting that they be logically presented and critically interpreted. Between 1960 and 1977 Tom had four graduate students and six research associates, some of whom were later appointed to the ICR staff. I did not directly participate in experiments with Tom but rather decided to follow up some exciting experiments with eukaryotic cells that I had initiated in Brussels. Nevertheless, Tom was very supportive of my research. He gave me adequate space in his lab, provided me with a technical assistant, and initially even shared with me some financial support from his National Science Foundation grant. As he did with his collaborators, he also helped me by cogent discussions of my research and by critical reviews of my manuscripts.

In addition to his phage research, Tom was also very busy on other fronts. His reputation as an electron microscope virtuoso led several researchers to seek his collaboration in projects with various animal viruses. He was a member of the Council and the Executive Board of the Biophysical Society and served as its president in 1965. He also served as president of the International Federation of Electron Microscope Societies and hosted the international congress that was held in Philadelphia in 1962. This was an enor-

mous job that consumed an inordinate amount of his time. In addition, he chaired the U.S. National Committee of the International Union for Pure and Applied Biophysics from 1965 to 1969 and served on the editorial boards of several journals. A more complete list of his professional commitments is given at the end of this memoir. In between all these activities, Tom found time to write several insightful reviews dealing with the structural and genetic properties of bacterial viruses and the electron microscopy of microorganisms.

Tom continued his research until the mid-1970s. From 1977 to 1983 he directed the postdoctoral training program in basic research at Fox Chase. Although he officially retired in 1983, he maintained an active presence at the ICR for several years. After his retirement he had the luxury to spend more time painting. Tom, an outstanding watercolor artist, created many beautiful landscape paintings that exhibited a remarkable use of perspective and subtle applications of shimmering light and shadows. He also enjoyed playing golf with friends, former colleagues, and especially with his brother, Norman, when the brothers and their wives took winter vacations in Florida. After a series of strokes, Tom died on August 11, 1991.

Anderson received numerous awards in recognition of his scientific achievements. He was elected to the National Academy of Sciences in 1964 and served as chairman of its Genetics Section from 1985 to 1988. He was elected president of the Electron Microscope Society of America in 1955 and received its Distinguished Award in 1978. He also received the Pasteur Institute's Silver Medal in 1957 and was elected an honorary member of the German and French electron microscope societies.

Tom Anderson had exceptionally keen powers of observation and a remarkable ability for logically sound reason-

ing. He would frequently cut through to the core of problems, asking critical questions that would expose gaps and flaws in current concepts. A desire to answer these clearly framed questions often provided the impetus for the design of new experiments or the invention of more powerful methodology. He firmly believed that serendipity played a major role in scientific discovery, requiring only that the experimenter be prepared to accept an unexpected result with an open mind and then resolve to eventually provide a cogent explanation for it. He once wrote, "Nature is trying to tell us something, the investigator's goal is to get the message." Tom was generous with his time and concerns for other people's problems. His high ideals and ethical standards were greatly admired by all who knew him.

I OBTAINED A substantial amount of personal information from two autobiographical essays: "Some Personal Memories of Research," published in the *Annual Review of Microbiology* in 1975, and "Reflections on Phage Genetics," published in the *Annual Review of Genetics* in 1981. I obtained additional information from an article by John H. Reisner, "A Glimpse of the Anderson Papers," published in the *Electron Microscope Society Bulletin*, vol. 22, pp. 50-58, and from several conversations with Wilma E. Anderson.

HONORS AND DISTINCTIONS

Deutsche Gesselschaft für Elektronenmikroskopie
Société Francaise de Microscopie Electronique (Honorary)
Society of General Physiologists
American Association for the Advancement of Science
Sigma Xi
Electron Microscope Society of America (President, 1955)
Biophysical Society (President, 1965)
American Society of Naturalists
American Society of Microbiology
International Federation of Electron Microscope Societies (President, 1959-1963)

Biophysical Society (Member, Council and Executive Board, 1959-1965)
Associate Editor of *Virology* (1960-1966)
Member of the Editorial Board of *Bacteriological Reviews* (1967-1969)
National Academy of Sciences
U.S. National Committee, International Union for Pure and Applied Biophysics (Chairman, 1965-1969)
International Union for Pure and Applied Biophysics, Member, Executive Committee of the Commission on Subcellular Biophysics (1971-1977)
International Union for Microbiology, Member, Committee on Nomenclature of Bacteriophages (1968-1971)
Member of the Editorial Board of *Intervirology* (1972)

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