NATIONAL ACADEMY OF SCIENCES

JOHN TORRENCE TATE

1889—1950

A Biographical Memoir by

ALFRED O. C. NIER AND JOHN H. VAN VLECK

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July 28, 1889–May 27, 1950

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On June 21, 1966, the physics building of the University of Minnesota, which previously had only a functional designation, was named the "John T. Tate Laboratory of Physics," a fitting tribute to a man who had helped so much in bringing America to the forefront in physics and in making Minnesota one of its leading centers.

EARLY LIFE

Tate was born in Adams County, Iowa, on July 28, 1889, the son of Samuel A. and Minnie Ralston Tate. The area was a rural one and the nearest sizable town, of about 1,000 population, was Lenox, slightly over the line in an adjacent county. This Tate consequently listed as his town of birth, and the fact that it was not in Adams County caused considerable confusion in his clearance papers and other documents during World War II.

Tate's father was a country doctor of Scottish descent, whose ancestors had come to America before the Revolutionary War. Several generations of them were Presbyterian ministers in this country. His mother was of Irish descent.

Tate's mother died when he was about ten years old. After that he was sent to live in New York City with the family of his father's brother. Two important considerations led to this decision. Educational facilities at that time obviously were better in New York than in rural Iowa. Also, the nomadic life of a widowed country doctor could not offer much in the way of a home atmosphere for a boy.

In New York, young Tate attended the Horace Mann School. By the time he was in high school, he exhibited a fondness for science. He used to experiment at home with a small chemistry set, and he created one or two small explosions in the house. His high school yearbook had a rhyme for each member of the graduating class, and the one for Tate was "terribly taciturn Tate, with HCl on his pate."

UNIVERSITY EDUCATION

After finishing high school, Tate entered the University of Nebraska as an electrical engineering major. He presumably chose this institution so he might see something of his father. About this time, the latter had accepted an assignment as physician on the Rosebud Indian Reservation, located in South Dakota, just north of the Nebraska line. The young Tate helped support himself in college by taking a summer position involving maintaining the power plant of the reservation.

After being graduated from the university in 1910, he completed two years of graduate work there, and received an M.A. in 1912. He had shifted from engineering to physics, and the paper he published in the *Physical Review* in 1912, "The Theoretical and Experimental Determination of Reflection Coefficients of Absorbing Media," was essentially his M.A. dissertation.

It was something of a tradition for physics students at Nebraska to continue their graduate work at the University of Berlin, as many of its senior staff (Almy, Brace, Skinner, Tuckerman, and others) had done so. This Tate was able to do in 1912, with the aid of a loan from his brother, and perhaps a legacy from his father who had died in 1911. He took his Ph.D. only two years later under James Franck, who had not yet left Berlin for the University of Göttingen. His dissertation was "The Heat of Vaporization of Metals," a title that implies chemistry. There is no reference to this piece in *Science Abstracts,* so apparently it was not published in a scientific journal even in abridged form. This may be because of the onset of World War I, which probably forced Tate to return to America earlier than he otherwise would have done. Dr. Paul Foote informs us that he thinks Tate published his dissertation as a pamphlet.

THE NEBRASKA AND EARLY MINNESOTA YEARS, 1914–1917

It is not surprising that, after receiving his doctorate, Tate was offered an instructorship at the University of Nebraska, which he accepted. A year later he was made an assistant professor. During the academic year 1915–1916, Professor Anthony Zeleny of the University of Minnesota, on sabbatical leave at Princeton University, was instructed to look for promising young men while he was in the East. How he became acquainted with Tate is not known, but on June 3, 1916, he wrote to Professor Henry Erikson, chairman of the Minnesota physics department, strongly urging that Tate be considered. By June 26 Tate had visited Minnesota, created a most favorable impression, and received an offer of a position. By June 29 he had accepted the offer. Initially his position was only as instructor at $1500, but he was promised that he would be considered for promotion to assistant professor at the end of the year if he made good. The promotion possibility was tendered with some reluctance, but was rationalized on the grounds that it was so late in the year and that Tate had created such a favorable impression. That Tate made good cannot be doubted. He received this promotion as well as two others in the next few years, with the result that by 1920 he was a full professor at the age of only thirty-one! Except for the interruptions occasioned by World Wars I and II, he served on the Minnesota faculty continuously for thirty-four years.

In his first year at the University of Minnesota, Tate collaborated extensively with Paul D. Foote, then in his last year of graduate work there. The two men had already been fellow students and laboratory assistants at Nebraska in 1909–1911. The year 1916–1917 saw a quite remarkable group of young men in the Minnesota physics department. Dr. Foote writes us, "Tate was one of my teachers. In fact all of the younger staff took courses under each other. Tate taught me statistical mechanics, and the group, including Arthur Compton, Tate, McKeehan, Klopsteg and others, were in my class on radiation theory."

WORLD WAR I AND RESEARCH AT THE BUREAU OF STANDARDS, 1917–1918

During World War I Tate served as a lieutenant in the Signal Corps, and at the close of the war he was stationed in Washington, D.C., where Foote had already moved to a position at the Bureau of Standards. Prior to entering the Army, Tate himself may have had a temporary summer position at the Bureau, as its roster for 1917 lists him as an employee. The two men continued collaborating on some of the problems they had studied at Minnesota. They published two papers connected with the latent heat of evaporation of metals, thereby showing continued interest in the area in which Tate had worked for his Ph.D. Something of particular importance is revealed when Foote writes that "by working evenings and Sundays at my laboratory at the Bureau of Standards, we were able to publish several papers on critical potentials."

The general subject of electron impact and critical potentials is probably the research area in which the most notable work of Tate and his research students was performed over the years. His first paper on this subject in 1917 was most timely in its appearance. Bohr's theory of the atom, announced only shortly before, predicted that electrons in atoms should be found only in discrete energy levels, and transitions between levels would result in absorption or emission of radiation according to the relation $Ve = h\nu$, connecting critical potentials and spectral frequencies. Tate's early work indeed verified the existence of energy levels and showed the distinction between the critical energy required to excite radiation and that required to produce ionization. This was of considerable importance at the time, as it furnished unmistakable evidence that the quantum concept was inevitable, though it was then still in embryonic form since the true quantum mechanics was not evolved by Heisenberg, Schrödinger, and others until about a decade later. Whether having been with Franck earlier in Berlin had stimulated Tate's interest in electron impact phenomena, we cannot say for sure. Franck himself did outstanding work in this field after Tate left Germany, but as far as we know, the two men never collaborated on this subject, and Tate may have been attracted independently into the then new field.

TEACHING AND RESEARCH AT MINNESOTA, 1919–1940

When Tate returned to the University of Minnesota, in January 1919, he shared the teaching of graduate courses with W. F. G. Swann, who was the principal adviser of graduate students during the early 1920s. It was during this period that Tate developed a comprehensive course in classical physics, "Introduction to Theoretical Physics," which he taught every year but two until 1937. The course was taken by all beginning graduate students in physics and an occasional undergraduate bold enough to enroll. It was also taken by many graduate students in mathematics, chemistry, and engineering, so that over the years a great many students were exposed to and inspired by Tate's elegant lectures. Students agreed that he was one of the best, if not the best, teacher they had ever had.

During the early 1920s, he also developed a course entitled, "Seminar in Contemporary Experimental Physics." In it were discussed the latest developments in physics, experimental or theoretical. Occasionally students presented papers, but more commonly Tate did the talking. Graduate students took this yearlong course once for credit, then attended on a noncredit basis for most of the remainder of their student days. Other staff members were frequent visitors.

During this period Tate attended many meetings of the American Physical Society, in fact virtually all of them after he became Editor-in-Chief of the *Physical Review*. Upon his return from a meeting, he invariably reviewed for the class the important papers he had heard. The receipt of an exciting manuscript at the *Physical Review* office almost certainly resulted in its presentation to the class, often without advance preparation, since the paper might have arrived only the hour before the class met. Tate had the almost uncanny ability to extract the essential information from a long paper and, without preparation, present it in a way that everyone understood. His lectures were filled with ideas for possible research problems. In his classes one literally lived on the forefront of knowledge.

When Swann left Minnesota in 1923, the main responsibility for advising graduate students in experimental physics fell on Tate's shoulders, and during the twenty years prior to World War II he was the adviser for twenty-seven of the forty-eight students who obtained their Ph.D.s in physics. John T. Tate did not, however, operate a diploma mill. Life as a graduate student under his direction was not an easy lot. Candidates for the Ph.D. degree were expected to stand on their own feet and to persist until they overcame the inevitable stumbling blocks faced in research. It is no wonder that, with such training, so many of his students later distinguished themselves in positions of leadership and accomplishment. One of them, Walter Brattain, shared the Nobel Prize in Physics in 1956 for his contribution to the invention and development of the transistor.

As the *Physical Review* grew and Tate became active in the establishment and guidance of the American Institute of Physics, he had less and less free time. Travel alone occupied considerable time, as this was before the day of regular air travel, and a trip to New York from Minneapolis required a day and a half in each direction. Throughout his busiest years he taught his two courses, giving eight lectures per week, except for absent days when a substitute filled in. He graded all of his examinations himself.

In spite of the pressure, his office door was always open, and students and colleagues wandered in and out. Nevertheless, for the new graduate student a trip to Tate's office was a traumatic experience. Tate was basically a shy man with an air of aloofness about him. This, coupled with the great respect in which he was held and the knowledge that he was a very busy person, meant that he was regarded with considerable awe by all but his closest friends. One did not go to his office to idle away the time! More relaxed were his sessions with the advanced graduate students when, in the late afternoon after clearing up his *Physical Review* work, he wandered down the research alley and went from room to room to smoke and chat.

He had little time to perform research himself and preferred to help others develop programs. His name often did not appear on papers he had helped initiate. His own name usually appeared last on joint publications with paid assistants, and in at least one case when his name had to appear to justify the expenditure of funds, he apologized to a postdoctoral assistant for the circumstance.

Tate's advice, counsel, and interest were a great stimulus and comfort not only to his students, but also to his colleagues on the faculty of the Minnesota physics department. To this, both writers can testify from personal experience. (Alfred O. C. Nier has been a member of that faculty since 1938, and John H. Van Vleck was a member from 1923 to 1928.)

During the 1920s, an era of atomic physics, Tate's students worked mostly on problems relating to the impact of electrons on gases. Particularly noteworthy was some of the work in the 1929–1931 period. Walker Bleakney had built an instrument for studying ionization processes in gases. It had a collimated monoenergetic electron beam whose energy could be adjusted. In addition, an m/e analysis could be made of the ions produced. When mercury vapor was introduced, it was possible to observe the various multiply charged ions of mercury formed by electron impact, as well as the onset potential for each ion and the ionization cross section. This introduced a new era in mass spectroscopy and led to subsequent developments and applications that have had an enormous impact on other areas of science and technology. To cite but one example, we can quote from a cryptic entry in the handwritten ledger kept by Henry Erikson, for many years chairman of the physics department. "In March and April 1940 Nier established U 235 as responsible for the slow fission in uranium. This gave rise to a considerable interest." In referring to these words, James Gray says in his history of the University of Minnesota, "The reticence of Professor Erikson's comments cannot be duplicated in the literature of science or in all the literature of human affairs. . . ."

In 1929–1930, E. U. Condon was on the Minnesota faculty working on the theory of molecular binding, employing the new quantum mechanics just then coming into use. One prediction of the theory was that in a diatomic molecule or molecular ion there could be a repulsive potential energy curve as well as an attractive one. If so, a molecule excited by electrons of sufficient energy should reach the repulsive state and subsequently dissociate into an atom and an ion, the particles having measurable kinetic energy. At the dedication of the John T. Tate Laboratory of Physics in 1966, E. U. Condon related in his characteristically entertaining manner the circumstances at the time, and how he, Tate, and Bleakney discussed the feasibility of an experiment to test the theory. It turned out that Bleakney's mercury apparatus was ideally suited for a crucial experiment, and indeed a few days later Bleakney observed the energetic atomic hydrogen ions formed in the dissociation process.

Tate not only expected his students to be self-reliant, but he also expected experiments to be done correctly. After all, he was editor of the *Physical Review* and felt a special obligation to see that results reported from *his* laboratory were not in error. As a former student, Alfred O. C. Nier can testify to this attitude. Gray, again in his history of the University of Minnesota, writes, "A teacher with the hardihood to insist that all his students must make a decent attempt at being geniuses is likely to produce many of outstanding talent. Tate's success may be measured by the fact that in the period when the volume *Men of Science* made a practice of starring those names that seemed particularly bright, Minnesota graduates in physics were nearly as numerous among the elite as were graduates of the Massachusetts Institute of Technology."

Eloquent testimony to the fact that experiments conducted under Tate's direction were performed with care can be found in references on ionization of molecules by electron impact. New workers in the field, even today, proudly establish their credibility by announcing that they were able to confirm the measurements made by Tate and his graduate student, P. T. Smith, some forty-five years earlier!

The 1930s saw the emergence of nuclear physics as a new frontier awaiting exploration, and Tate was determined that Minnesota be a participant in the action. In 1933 the late John H. Williams accepted the position of research assistant to Tate. He was employed to carry on the work on ionization of gases, but before a year had passed he was encouraged by Tate to start a program in nuclear physics. The department owned a 275-keV transformer–kenetron–condenser, a source of high voltage that when supplemented by an ion source, an ion accelerating tube, and other accessories made possible the study of nuclear disintegration processes in light elements.

It was soon realized that to perform significant work in the expanding field of nuclear physics, higher energies would be required. Work was started on a Van de Graaff generator to give energies of one million electron volts, but it was never finished because it soon became apparent that a more ambitious program was in order. In 1936 it was decided to construct a pressure Van de Graaff generator that would provide energies of at least three million electron volts. Because the cost was beyond the resources of the institution, outside help was sought. It was a time when there was a growing appreciation of the potential for applying the fruits of nuclear physics research to medicine and biology. Tate headed a distinguished committee of University researchers representing the several areas of concern, who approached the Rockefeller Foundation for a grant of $36,000 to build a Van de Graaff generator and to finance a program of interdisciplinary research using the facility. On April 7, 1937, the trustees of the Rockefeller Foundation approved the request and the program was launched, the design of the machine being put under the direction of Tate's young protégé, John Williams.

Although Tate was primarily an experimental physicist, he had a keen appreciation and understanding of what was going on in theory and this quality was a great help in his research. Many physicists educated early in the present century, when classical physics was well entrenched and quantum theory was a parvenu, were never able adequately to assimilate, or in many cases even to accept, the basic ideas of quantum mechanics. Tate was not a man of this type. When Heisenberg, Schrödinger, and others developed the true quantum mechanics around 1926, he quickly realized its importance. When a lecture course on this subject was given by one of the writers (incidentally one of the earliest, if not the earliest, such course in the United

States), he attended conscientiously, remarking, "I must learn this stuff."

TATE'S CAREER AS EDITOR

In 1926 Tate was named Managing Editor of the American Physical Society, a position he held until his untimely death in 1950. As Editor-in-Chief of the *Physical Review,* he saw the annual journal pages more than quadruple and the number of subscribers triple. In fact, the *Physical Review* became the leading research journal of physics in the world. In 1929 Tate started the very successful quarterly journal, *Reviews of Modern Physics,* and in 1931 a second new journal, *Physics,* later renamed the *Journal of Applied Physics.*

In his history of the University of Minnesota, Gray comments on the choice of Tate as editor: "His reputation in the profession was so great that the editorship of the *Physical Review* went to him when he was still a young man, and this was the first time that it had been allowed to pass beyond the Allegheny Mountains. His extraordinary ability to digest every experience that came to him made the most of what might have been, to another man, a dull routine assignment."

It is fortunate that Tate's initial appointment as the chief editor of the *Physical Review* practically coincided with the "quantum–mechanical revolution." It would have been a calamity had the post been filled by someone not appreciative of or sympathetic to the great developments that suddenly burgeoned in theoretical physics. But Tate showed rare judgment and common sense in not delaying by much refereeing noteworthy papers dealing with various applications of quantum mechanics; this was important, for America was somewhat at a disadvantage compared to the centers of Europe, where the revolution had germinated. One of the authors remembers how the refereeing of a paper submitted by D. M. Dennison—"The Rotation of Molecules" (a calculation made at

Copenhagen with matrix mechanics)—consisted of Tate's showing him the manuscript in the *Physical Review* office. It was the author's perusal of this article that perhaps triggered his lifelong interest in electric and magnetic susceptibilities, and he recalls receiving a wire from Dennison giving him permission to utilize the results of the manuscript in advance of formal publication.

In the late 1920s, Tate, along with other prominent physicists, saw the need for bringing together the several societies representing different branches of physics; in 1931 he was one of the founders of the American Institute of Physics. It was natural that he be chosen one of the initial members of the governing board of the Institute, and as a result of successive renominations by the American Physical Society, he remained a member until his death. From 1936 to 1939 he served as Chairman of the Board.

TATE'S BRIEF ROLE AS DEAN

That Tate's interests went beyond physics was well known at the University of Minnesota. In 1930 the University established a new college for students of high ability whose educational objectives crossed traditional college lines. It was only natural that Tate, known for his interest in liberal education, should be chosen to head the select college. Because the college was only experimental, he was not given the title of "dean," but he enjoyed the privileges of the post. In 1937 he was named dean of the University's largest unit, the College of Science, Literature, and the Arts. While he retained his editorships and supervised a few graduate students and postdoctoral assistants, he no longer found time to teach the courses for which he had become so well known. His tenure as dean was destined to be short. He had hardly become established in the position before World War II broke out, and again he was called to the service of his country. In 1943, when it became apparent that he could not soon return to the University, he resigned his deanship to make it possible for others to plan for the future.

THE WAR PERIOD, 1941–1945

As the war progressed and the Low Countries fell, it became clear that the submarine had come into this conflict a more dangerous weapon than it had been in World War I. Improved means had to be found for detecting and destroying submarines. When the National Defense Research Committee (NDRC) was created in 1940, the Navy asked its aid in the defeat of the submarine. In response, the NDRC set up in early 1941 an organization later known as Division 6. It had, in the words of Frank B. Jewett, President of the National Academy of Sciences at the time, the following objectives: "(1) The most complete investigation possible of all the factors and phenomena involved in the accurate detection of submerged or partially submerged submarines and in anti-submarine devices, and (2) the development of equipment and methods for use of promising means for detection to the point where their final embodiment in form satisfactory for Naval operations can be undertaken by the regular Bureaus of the Navy."

John Tate was chosen to lead this awesome effort. The success of Division 6 in carrying out its assignments is now recorded history. Tate's effective leadership of this complex organization is best summarized in the words of Gaylord Harnwell, who wrote in a foreword to the *History of Division 6* in 1951, "That this contribution was effective is due in major part to the deep and sympathetic understanding of the problems of nature and men which identified the wise leadership of the Division's chief, John T. Tate." In addition to serving as Chief of NDRC Division of Subsurface Warfare, Tate was scientific adviser to the Commander-in-Chief, United States Fleet; Assistant Chief of the Office of Field Services of the Office of Scientific Research and Development in charge of Operations Research;

and Chief and Member of the Rocket Ordnance Division of the NDRC.

RETURN TO MINNESOTA

On January 1, 1946, Tate returned to the Minnesota campus as Research Professor of Physics, picking up where he had left off nine years before. He taught one course and began a modest research program involving a few students. Now, the *Physical Review* began its rapid postwar expansion, and more and more of Tate's time was devoted to it. From 1946 to 1949 he served as Chairman of the Board of Governors of the Argonne National Laboratory. He continued in his role as an adviser to the government, and at the time of his death in 1950 was Chairman of the Committee on Undersea Warfare of the National Research Council.

During the war virtually all research in physics at Minnesota stopped as almost all of the regular faculty were away, working on defense-related research. When they returned and were joined by other young colleagues, Tate was a central figure, a pillar of strength, helping them get support for their research and counseling them as needed.

TATE'S PERSONALITY

Many facets of Tate's personality deserve comment. Among them are his modesty and unselfishness. For this reason, as we have already indicated, his contributions to research cannot be judged by the number of papers in his bibliography alone. Several times in the 1930s, he drove his car all the way from Minnesota to meetings of the American Physical Society in Washington, D.C., or Chicago. Although he rather enjoyed driving, his main motivation was that he could thus transport several of his students to the meeting in question. Certainly, they could not have gone there otherwise, for those were the days of the Depression rather than of government-sponsored research contracts.

Tate's characteristic modesty and consideration for others are well illustrated in exchanges of correspondence between himself and J. W. Buchta, Chairman of the Department of Physics at Minnesota. Upon Tate's resignation as dean, the regents of the University suggested that his very special status be recognized by naming him Research Professor of Physics, but they left it to him to decide if he wanted such a title. On February 21, 1944, he wrote to Buchta:

"President Coffey has just informed me of the regents' action. From my point of view I question a title which would, in any way, set me apart from others. On the other hand, as I told President Coffey when I saw him in January, if in his judgment the title Research Professor would be of value to the University or the Physics Department, I would not be adverse to having it.

"I see ways in which having such a title in the Department might be of value to it in that it would give concrete evidence that research in physics is given emphasis by the Board of Regents. . . ."

In another letter dated October 26, 1943, he said:

"For some time I have had it in mind to suggest that you recommend to McConnell that the salaries of the men in the Physics Department who are on leave (in service to the U.S.) be raised in much the same way as you would anticipate they would have been raised had they remained on duty. To do this would give them assurance that the University wants them to return and intends to treat them properly. I recall this was done in my case during the last war and still recall the pleasure it gave me and the feeling that I was still regarded as a permanent member of the University staff."

Tate had unusual patience. We will cite two incidents that reflect this quality. One was at an open business meeting of the American Physical Society a year or two after he had taken over as Editor-in-Chief of the *Physical Review*. His predecessor in that capacity arose to criticize him publicly on the ground that the average length of a paper published was longer than in the previous administration. Tate might well have rejoined that the greater length was only a reasonable manifestation of the rapidly improving quality of American physics at the time, to say nothing of the added complexity of theoretical papers occasioned by the burgeoning quantum mechanics. However, he bit his lip and said nothing. Another time one of us found him painstakingly copying out the many equations in a paper of a distinguished theoretical physicist because the author's handwriting, though beautiful in appearance, was not sufficiently legible for the printer. Many editors would have sent the paper back to the author for rewriting, but this would have caused delay at a time when theoretical developments were moving fast.

Tate was not by temperament a fighter. Although the dictums of the *Physical Review* forbade the use of radical signs, he decided it was easier to make an exception rather than to struggle perennially with one distinguished chemical physicist who was particularly recalcitrant about having radicals replaced by fractional exponents. Tate won victories through his tact rather than by "slugging it out." In 1926 the new library of the University of Minnesota was completed. Grants from the legislature for construction of the building had been obtained by the regents on the ground that there would be a central library facility. To the great irritation of the members of the physics department, the physics books were all moved from their building to the central library. The resulting inconvenience was a reason one prominent physicist gave for leaving after only one year at Minnesota. Tate did not resist the moving of the books, but when one of us visited Minneapolis only a few years later, the physics library had somehow been returned to the physics building where it belonged.

Tate's loyalty to Minnesota was great and unfailing over the years. We know of at least two offers he declined from prestigious institutions: one a research professorship, and the other an influential administrative post. Both offers were of the type he would have accepted had he been interested in getting his name in the limelight as often as possible.

Tate did not go out of his way to seek public speaking engagements of a general character. However, when he was enticed to the lecture platform, his speeches were outstanding. He impressed his audiences with his sincerity, dignity, and substantial thoughts. He felt that scientists had an obligation to disclose some of their philosophy and the meaning of their profession to those in other disciplines. Unfortunately, his addresses on such occasions as a joint meeting of Phi Beta Kappa and Sigma Xi or the centennial celebration of Rockford College were not published, as far as we know, although his son has some of the manuscripts. A favorite topic of his was "Science and Human Values," a manifestation of his belief that science is not a separate entity but rather a necessary ingredient in a liberal education. The manuscript of an unpublished commencement address has so many literary and historical references that an uninformed reader would deem it the work of a professor of English or history.

Tate's "outside," or recreational, interests were many and varied. He was fond of golf. At one time he was the champion billiard player of the University of Minnesota faculty, and during his undergraduate days he ranked as a collegiate tennis champion. He was an enthusiastic and skilled photographer. He returned from his studies in Berlin with hundreds of photographs, including one of the last meeting of the Kaiser and two other crowned heads of Europe in a procession before the war. He was also a talented drawer. His son recalls some quite professional-looking sketches of "Gibson Girls" he made in his youth. Since Tate was an experimental physicist, it is not surprising that in the early days of radio he assembled his own radio receiver with a crystal detector. He enjoyed attending most of the home games of the University of Minnesota football team. He liked to play a game or two of billiards or a rubber of bridge after lunch at the Campus Club, at least until the time that his life was excessively burdened by the *Physical Review* and administrative work.

HONORS OF VARIED NATURE

In 1941 Tate was elected to the American Philosophical Society and in 1942 to the National Academy of Sciences. In his student days he was named to Phi Beta Kappa and Sigma Xi. He was, naturally, a member or fellow of the five constituent societies of the American Institute of Physics, which he helped found (viz., the American Physical Society, the Optical Society of America, the Acoustical Society of America, the American Association of Physics Teachers, and the Society of Rheology). The American Physical Society chose Jack Tate, as he was known to his friends, as its President in 1939.

He received honorary doctorates from the University of Nebraska (1938) and from the Case School of Applied Science (1945). In recognition of his services in World War II, Tate was awarded the Presidential Medal for Merit by the U.S. Government and the King George's Medal for Service in the Cause of Freedom by the British Government. The citation accompanying the Presidential Medal included the statement "With never-ceasing energy and patience, he brought to his task great technical knowledge and analytic ability which he combined with sound and dispassionate judgment. Dr. Tate's selflessness of purpose, steadfast devotion to duty and his telling contributions to the vital cause of our country cannot be measured."

The American Institute of Physics established the John Torrence Tate International Gold Medal in his honor. Appropriately, services that further international understanding and exchange are considered to be of primary importance in selecting the medal's recipient. The Tate Medal was presented to

Paul Rosbaud in 1961, to Sir Harold W. Thomson in 1966, and to Gilberto Bernardini in 1972.

FAMILY LIFE

Tate married Lois Beatrice Fossler on December 28, 1917, in Lincoln, Nebraska. He had already moved to Minnesota a year earlier, and his bride was someone he had known while he was still on the Nebraska faculty. She soon became active in campus life, especially the activities of the Faculty Women's Club. She was very understanding of the demands of his profession, which included frequent trips away from home. Lois and Jack were avid bridge players and spent many delightful evenings with friends who shared this interest. Lois's death in 1939 made the war years, strenuous ones for all physicists, particularly trying and lonely ones for Tate.

On June 30, 1945, he married Madeline Margarite Mitchell. She had been the entire office force (other than Tate himself) of the *Physical Review* when its headquarters were first moved to Minneapolis. When the American Institute of Physics was created in 1931, she was made its Publication Manager, heading a sizable staff in New York.

He had one son, John T. Tate, Jr., by his first marriage. The younger Tate is a distinguished mathematician and a professor at Harvard University. Like his father, he is a member of the National Academy of Sciences. He is the only American-born mathematician of the celebrated "Bourbaki," the *nom de plume* of a group of mathematicians, mainly French, who have set about rewriting all the foundations of mathematics in modern terms. Thus, for two generations the name of John Torrence Tate has made its impact on the world of science.

FINALE

Tate suffered a stroke in December 1949, but he recovered sufficiently to be able to work at a reduced rate and to attend the meetings of the National Academy of Sciences and the

American Philosophical Society the following spring. Then on May 27, 1950, he succumbed to a cerebral hemorrhage. It is tragic that America had to lose one of its leading figures in science when he was but sixty. Had he lived a year longer, he would have served as Managing Editor of the American Physical Society for a quarter of a century. Prior to his death, some of his friends were already secretly planning a special issue of the *Reviews of Modern Physics* to appear in 1951, dedicated to him in commemoration of this milestone and with articles by former students and colleagues. This issue did appear, but alas, not as a jubilee edition, but as a memorial.

THE AUTHORS have benefitted from reading the biographical memoir by K. K. Darrow on pp. 325–28 of the *Year Book of the American Philosophical Society* for 1951. Tate's role in the Minnesota faculty is described on pp. 416–24 of *The University of Minnesota, 1851–1951* by James Gray (University of Minnesota Press, 1951). The article written by Roger Stuewer for *The Dictionary of American Biography* contains detailed references to obituaries and archival material relating to Tate (unpublished manuscripts, tape recordings of speeches about him, etc.)

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KEY TO ABBREVIATIONS

Phys. Rev. = Physical Review
Rev. Sci. Instrum. = Review of Scientific Instruments

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