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DETLEV WULF BRONK

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A Biographical Memoir by

FRANK BRINK, JR.

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BY FRANK BRINK, JR.

DETLEV WULF BRONK was born in 1897 in New York City, where his father, Mitchell Bronk, was pastor of the Ascension Baptist Church at 160th Street and Park Avenue. Det received his unusual Christian names through his mother, Marie Wulf, whose father was Detlev Wulf, a businessman in New York City. The family moved to Bayonne, New Jersey in 1900, where his sister, Isabelle, was born in 1903. His later youth (1912–1919) was spent in Troy, New York in the same region of the state where his forebears had lived for many years. Detlev Bronk is a direct descendant of Mattheus Brunck, a "smith" from the Rhenish Palatinate, who came to West Camp, on the Hudson River, in 1710. A grandson of Mattheus, Abraham, settled about 1797 on a farm near Duanesburg, Schenectady county, which became known as "the Bronk Place." Det's grandfather, Abram Bronk, grew up in Florida, New York. In nearby Manchester lived Cynthia Brewster, a descendant of the Elder William Brewster of the Mayflower Colony. Abram and Cynthia were married in 1856 after a prolonged courtship, much of it carried on by letter via packets to and from California. After their marriage Abram farmed "the Bronk Place" from 1856 to 1861, and Det's aunt, Anna Isabella, was born there.

Tracing the history of a contemporary American family that had one line beginning in 1710 and at least one other in 1620

is both interesting and complex. The available letters and documents are far too extensive for review here. Of present relevance is recorded evidence of a continuous thread of scholarship and a love of learning that linked the generations, even in times when practical concerns demanded most of each person's energy and attention. Det's grandfather, Abram, attended Union College for two years. He studied mathematics, was fascinated with astronomy, and read poetry. He was, in succession, a schoolteacher, a "forty-niner" in California,* a farmer in Duanesburg, and a storekeeper in Manchester. He was an able debater and kept notes on rules of public speaking. Also an avid reader who loved books, he left his family "more books than money" when he died in 1870. Abram had attributes that were to characterize his children and grandchildren, even though he died when his children —Isabella, Mitchell, and John—were very young. His widow, Cynthia, a religious woman and a teacher, propagated the thread of scholarship by providing an environment that permitted Mitchell and Isabella to develop their scholarly talents, each earning the degree of Doctor of Philosophy. Their brother, John, became a lawyer. Aunt Belle taught French Language and Literature as a member of the faculty of Swarthmore College from 1901 to 1927; she had a very definite influence upon Det's development and general education during his college years there. Mitchell, a Baptist minister with a Ph.D. in theology, was an author of several books on religious matters both historical and inspirational. His essays covered a variety of subjects including experiences of his own life and times. Mitchell had strong views on the defects in the then current educational system. He wrote of his training: "interminable reviews, tests, and nerve-wracking exams in my opinion are not [a sign of] real scholar-

* Mitchell Bronk, *Discovering My Forty-niner Father* (Philadelphia: Judson Press, 1942).

ship. It does not result in a real love of literature."* According to my recollection of Det's account of his early education, he studied under guidance of his father until the age of ten. He graduated from the eighth grade in Bayonne in 1911, then enrolled in the Troy high school, graduating in 1915.

During his college years at Swarthmore, Det corresponded constantly with his parents. In January 1918, he wrote to his father, "I took the differential equation training although I never may need them, and as far as the general training resulting from mathematics goes I have had quite enough. But since I do not know what I am going to do I suppose I might just as well go on and prepare myself for physics or electrical engineering. It seems a shame sometimes that I cannot decide what to do and then go ahead and fit myself for that work." Perhaps this uncertainty derived from Det's urge to participate in the war effort. Soon after, he proposed in another letter to his father that he leave college and work with the Food Administration Office in Philadelphia. A follow-up letter to his mother asks her to be sure his father answered promptly and added that Aunt Belle approved. He became an inspector, enforcing the law regulating food prices through surprise visits to various food stores. However, as more of the older students enlisted, he wrote to his father, "I can't quite agree with you on the proposition of enlisting and leaving college. I most certainly would never have been content to stay through next year. I suppose a young man feels the call of country more and while cold logic may point to a continuation of college, I have found few red-blooded men who were willing to do so. The nation and the world as I see it is

* "An Old Fashioned Education," *Scribners*, 74 (Nov. 1923), No. 5. Similar opinions were part of the philosophy of higher education developed by his son, who later had an opportunity to implement some changes at The Johns Hopkins University and The Rockefeller University that fostered an individual's love of learning and judged accomplishment without emphasis on course credits and examinations.

facing the ultimate just at present and the most I can do for those principles which I believe right I want to do." In the same letter he added, "The very day after I wrote you last I saw the notice of those two deaths in the paper that you sent me and I thought what a very inappropriate time I had picked to write what I did about naval aviation. But I have only seen the notice of four naval aviators' deaths in the last year, and I not only read the papers but also *Aerial Age* each week and *Naval Air Service*." He stated that he would not go against their wishes but hoped they would see the matter from his viewpoint. He promised to take a long vacation at home before going to the Massachusetts Institute of Technology for ground training. His arguments prevailed and he was learning to fly at Pensacola Airbase in September 1918. At this time Det wrote to his mother,

> I've been up in the air nearly three hours now and drive the plane alone, of course with an instructor in the machine with me. My instructor, by the way, is a Phi Psi from Leland Stanford. It's a wonderful sensation, riding around up there in the clouds, and I wouldn't have missed it for anything in the world. On my first trip the instructor gave me the thrill of a couple of stunts; and I've been flying upside down already; never think anything about it; tho I'd hardly want to do it all by myself just yet. As for fatalities, there hasn't been one here for eight months, and there are always ten or fifteen machines in the air. Gee! I certainly do like it!

Sometime before leaving college to become an aviation cadet, Det had met and courted Helen Alexander Ramsey, a student in Aunt Belle's French language course. Like his grandfather, Abram, he continued his courtship by correspondence, and he and Helen became engaged. In a letter to his mother he gave instructions for carefully choosing an engagement ring. However, the separation was soon over. In December 1918 he earned his wings and was commissioned an Ensign. During the next nine months he was on leave but on call for active service, and in September 1919 he returned to college. He and Helen graduated from Swarthmore College in June 1920.

Det had received a B.S. in electrical engineering. Yet he accepted a position in a brokerage firm in Philadelphia. This did not last long, because in January 1921 he became an instructor in physics at the University of Pennsylvania, simultaneously taking courses in physical measurements, potential theory, and thermionic currents. Subsequent events and letters suggest that during this period he decided that advanced study and research in physics were essential for his future plans. That summer he studied at Harvard, choosing acoustics and advanced calculus in preparation for continuing his graduate studies in physics at the University of Michigan in the fall.

His courtship of Helen must have flourished through this busy period because in September 1921 they were married at Swarthmore in a ceremony performed by his father. Det's part in planning the wedding arrangements was also by correspondence. A letter from his mother assured him that his father had put off getting his haircut until the last moment so that he would look his best at the ceremony. Clearly, Det Bronk had a warm and confident relation with his family, both then and later. In 1946, his father wrote to him, "You have worked hard, sacrificially hard, and doggedly with little pushing except your own gumption, enterprise and ambition, and certainly deserve all the advancement and honors that have come to you—or shall—not to speak of the honor you have put over onto me and the family name. I have wanted to say this to you now, because at eighty-four it doesn't do to put it off." At this time the elder Bronk was living with his daughter in Germantown, Pennsylvania. Isabelle Bronk, a librarian at the University of Pennsylvania, took care of her father until his death in 1950.

In the fall of 1921 Helen and Det went to live in Ann Arbor, Michigan. He continued his graduate studies in physics, and she established their home in a house at 11 Ridgeway, where they lived for five years. Det liked to tell how he rebuilt and improved the house, a necessity then and an avocation later as he acquired

a succession of houses at Sycamore Mills near Media, Pennsylvania; Penzance Point on Cape Cod; and Seal Harbor in Maine; and a cabin near Petersburg, New York. He planned the house at Sycamore Mills for several years and worked with the architect constantly as it was being built. During many more years the improvement of the grounds around this house and its maintenance and repair, including new roof shingles, were family projects, as was the construction of the cabin. Only the presidential houses at Johns Hopkins and Rockefeller University escaped his personal handiwork. Helen transformed all of these places into pleasant homes for them and their sons, John Everton Ramsey, Adrian Mitchell, and Mitchell Herbert. An important part of their family life was devoted to frequent hospitable gatherings of friends in their home. The Sunday night dinners at Hill House in Sycamore Mills were notable for good food, friendship, and interesting discussions. Scientists in the Johnson Foundation and graduate students were privileged to join the Bronk family and to meet visiting scientists. Det considered such occasions an enjoyable and valuable part of life, and Helen was an exceptionally gracious and friendly hostess. She participated fully in this aspect of his busy life. In this way she enriched the lives of her children and supported Det's efforts to emphasize essential qualities of a scholarly life. Their excursions to foreign places began in 1928 when they lived in Cambridge, England while Det worked with E. D. Adrian as a post-doctoral fellow. There were many other occasions for traveling together over almost fifty years. The final trip was to attend the 250th Anniversary celebration of the Russian Academy of Sciences in Moscow, shortly before Det's death.

MOTIVATIONS, OPPORTUNITIES, AND DECISIONS

In June 1922 Det received an M.S. from the University of Michigan and was enrolled as an applicant for the Ph.D. degree in physics. At that time he was working with Professors W. F.

Colby and C. F. Meyer on "An Extension of the Fundamental Infra Red Absorption Band of HCl." Four papers published between 1923 and 1927 with Bronk as co-author were based upon his measurements of the molecular spectra of several gases, using a diffraction grating for improved resolution.

In July 1924 he made inquiries for possible positions in engineering and academic physics. Of great significance for his future was a letter to Professor Arthur Willis Goodspeed, at the University of Pennsylvania, asking for a position there. In reply, Goodspeed said that all of the faculty in physics would be delighted to have him back "with a view of becoming a fixture." Because there was no vacancy then, Goodspeed and Charles Blizard Bazzoni came up with a different proposal. The latter was seeking funds to start a group in physics concerned only with research and instruction of graduate students. Bazzoni asked Bronk to consider such an appointment for the specific purpose of continuing investigation of the infra-red spectra of molecules. His letter starts, "As you know I have been developing a research section in this department in which I have endeavored to instill those ideals which are essential to the maintenance of the output in pure science. . . . There has been relatively little difficulty in acquiring a fair equipment, . . . the difficulty has been to get men mentally and temperamentally suitably constituted to carry out such work." This unusual opportunity must have seemed very tempting to Det, but he turned down the offer in September 1924 because a new vista of physical investigations of physiological mechanisms had attracted his attention. At this critical juncture in his professional development Bronk dropped the idea of finishing his degree in physics. He described this sequence of changes in a letter to Bazzoni: "The object of my going into the department of physiology for this year was to get a good grounding in biological and medical sciences which would enable me to effectively carry on research in bio-physics. Dr. Randall [H. M. Randall, Professor of Physics at the University

of Michigan] has always encouraged me in the belief that there is a large and undeveloped field in the investigation of physical laws in living organisms and has said that he would be glad to have such work carried on in his department. . . ." Bazzoni informed Det that H. C. Bazett, the Professor of Physiology at the University of Pennsylvania, wanted a physicist who was interested in working in physiology. This contact eventually led to correspondence and a meeting between Bronk and Bazett. In February 1925 Bazett asked Bronk to consider coming to his department to oversee work of a graduate student who wanted to do research in x-ray analysis of the structure of fibrin and muscle. In reply Bronk revealed that his main interest was the study of the nerve impulse, "its generation, conduction, transmission across the synapse, and manner of activation."

However, Det was not ready to accept any position. A letter to Bazett states, "I am not certain that I will be able to complete my thesis in time to take my degree this June—possibly not until the latter part of the summer. Last Spring, when I decided to take my degree in both physiology and physics, I found it necessary to give up the field of infra-red spectroscopy in which I had published three researches and in which I had a thesis well under way. In addition to building up a new research technique I have had to do much reading in Physiology and to take such courses as Physiological Chemistry, Histology, and Nervous Anatomy." And in March 1925 he wrote again, "I have finally developed what I believe to be entirely new methods for measuring conductivity, for determining pH, and for amplifying with vacuum tubes without drift or distortion. I am exceedingly anxious to use these methods on some very interesting problems which I have in mind and for which I have the set-ups practically completed. This work will carry me through the better part of another year."

In collaboration with Robert Gesell he published (1926–1928) seven papers based upon research related to his thesis.

They dealt with physiological properties of the respiratory and cardiovascular systems and with neural excitation of secretion from the salivary glands in mammals. He perceived clearly that physiological phenomena provided a rich field for discovery of fundamental biological mechanisms through research based upon physical methods. His letters to Professor Bazett at Penn and to President Frank Aydelotte at Swarthmore seeking an appointment earnestly proclaim that biophysics can be developed into a powerful intellectual discipline for understanding "the living state of matter." His research reports for the years 1923 to 1928 marked the transition of a physicist into a biophysicist concerned with the physical analysis of physiological processes in animals. The scientific roots of Det Bronk in engineering and physics are evident throughout his published research. The early investigations of blood flow exhibit a physicist's concern for improving quantitative measurements and a physiologist's insight into the importance of the neural mechanisms for controlling distribution of blood in an organism, a problem involving a knowledge of physics and of the engineering of machine-like control systems.

Letters written to him in 1924 and 1925 indicate that he was also considering a management or engineering post in commercial firms. For example, in January 1926 he decided not to accept a position with C–T Electric, a Philadelphia company manufacturing electric trucks. Of particular interest are several handwritten preliminary versions of his letters of application in which he develops a description of his qualifications for each post. Such a letter to James Gilbert White is particularly informative about Det's ideas in 1926:

> I took my undergraduate work in electrical engineering at Swarthmore College from which I graduated in 1920. As evidence of the nature of my work while there I might say that on graduation I was awarded the College medal for "character, scholarship, and leadership". I was president of the Student Government Association, a varsity debater, editor of the College

Annual and Weekly, captain of the varsity debating team, and a member of two varsity athletic teams. My summer months were spent with the General Electric Company, the Western Electric Company and the Pennsylvania Railroad. During the war, I was secretary to the Philadelphia Food Administrator and later an ensign in the Naval Air Corps.

During my last semester in college I spent half time as assistant power engineer with the Philadelphia Electric Company. The year following graduation I was assistant to Mr. L. J. Schumaker, president of several Philadelphia companies. I then decided that the intensive work and habits of analytical thought and investigation that come in research would be a valuable training so I accepted a position as instructor in Physics at the University of Michigan. Last year I was selected as the physicist to carry on research in the medical school in connection with the application of modern electrical methods to biological problems. I have completed four research publications including my doctor's dissertation.

It has seemed to me that the type of position I am seeking exists in your organization. I do not desire purely technical nor research work; the University has assured me an attractive future should I care to continue in that work. Nor do I wish to go into banking or bond sales. The work I am looking for would lie between the two; it would perhaps be assistant to one of your executives, or involve the analysis of reports, or a study of special conditions in connection with construction or operation—anything that would offer a choice for hard work and growth towards a real opportunity in connection with management and administration. To such an opening I think I could bring habits of study, and analysis, willingness to work nights as well as day, the ability to get along well with people, some experience in writing and speaking, and a familiarity with office and business methods.

However, there were other irons in quite different fires. In April 1925 the Professor of Physics at Swarthmore, Winthrop R. Wright, asked Det to consider an appointment for one year as a physics teacher. In his reply Det revealed his aspirations for a career in research and teaching of biophysics and suggested that such a plan might be worked out at Swarthmore:

My idea rather was that I be appointed assistant professor in bio-physics, to divide my teaching time between physics and biology with perhaps allowance for a course in bio-physics to be devoted to such things as mechanism of the sense organs, protoplasmic and nervous action, the electrical activity of the body, effect of light on living things—in short the physics and chemistry of life. . . . If you like, the one course would be

something to develop in addition to the research, I would be the biophysicist which is something different than one of the younger ones in physics or biology, and my position would be recognition of the field and work which I am trying to develop as one of a very few. In fact I think I will be the first person to take the doctorate in physics and a biological science.

I think my training would well fit me for such a cooperative job. My undergraduate work in engineering, my three years of teaching and study in physics including three researches and the handling of Professor Williams' graduate courses during his absence last year, and my work here in the medical school should enable me to tie together three fields which must come closer. We are coming to the point where we are beginning to know quantitatively and experimentally something about the physical mechanism of life, faint ideas of how we see and hear, how the electrical or nervous impulse travels along the nerve, the osmotic and electrical mechanism of secretion, etc. Such things are the basis of life, and the students of today should have some ideas of these most fundamental discoveries that are beginning to break through, should have their curiosities stimulated. I would like to try the job with a more intellectual group than a class of medical students; they are too professional in their interest. To have research work in such a thrilling field going on should help to stimulate real scientific interest among the students and bring credit to Swarthmore for lending support to a new thing which is on the verge of growing rapidly.

The offer made at this time (1925) was not satisfactory. Bronk was assured an opportunity for research and academic advancement in the newly reorganized department of Physiology at the University of Michigan Medical School. He did not want to give up this position without some similar assurances at Swarthmore. However, it seemed to Aydelotte that this young scientist was asking for too much, too soon, especially since he had not yet completed his thesis. Det wrote a long letter to Aydelotte explaining why he could not accept the appointment at Swarthmore. The main difficulty was insufficient funds to equip a new laboratory for research in physiology and biophysics. In principle, they were in agreement that Swarthmore would be an excellent place in which to promote the instruction of young men in this new combination, physics and biology. Det

repeatedly emphasized that a department of physiology in a medical school created an atmosphere that tended to isolate him from physics. At Swarthmore he could teach physics and physiology and have the unique position of a biophysicist developing a new discipline. However, emphasis on research was necessary, and this research required a level of expenditure to which science departments of small colleges were not accustomed.

The matter was not dropped because all parties concerned liked Det's general proposal. Dr. Wright, the professor of physics, continued his correspondence with Det and his conversations with President Aydelotte. In a letter to the latter, Wright stated his view:

> It is not proposed that Bronk shall come here for research alone. He would teach one of the courses now given in general physics and the course in general physiology (somewhat amplified) and would plan to develop advanced courses in the common field. Whether this field is important enough to warrant Swarthmore in entering it as a pioneer is for you to decide. It is certain that but few men at present are prepared to develop it and that no man could teach it without the chance to investigate as he teaches. It is a science largely of the future, and we seem to have the chance to enter with the leaders.

In June 1926 Det was granted the degree of Doctor of Philosophy in physics and physiology. Professor Bazett of the University of Pennsylvania Medical School offered him an appointment as Instructor in physiology at Penn or space in his laboratory for research if he joined the Swarthmore faculty. The research opportunities at Penn pleased Bronk as did the academic position at Swarthmore in a post especially designed for him. Aydelotte could not give him research support and Bazett could not give him academic rank. In a manner that was to characterize much of his future activities, Det had arranged a collaboration among interested parties that was mutually satisfactory. The solution satisfied everyone and flourished for many years. In fact, it contained the connections that led to the directorship of the

Eldridge Reeves Johnson Foundation for Medical Physics established at the University of Pennsylvania Medical School three years later.

At Penn, in 1926, he helped Dr. M. H. Jacobs direct the research of graduate students in Bazett's department of physiology. For this he was appointed part-time instructor at $600 a year, and thereby earned official access to the laboratory for experimental research in physiology. A reappointment to the same position in 1927 indicates that this unusual arrangement had proved satisfactory to everyone concerned. Bronk thought that an official, though nominal, connection with the University of Pennsylvania Medical School was of value in relation to his research work in physiology.

From July 1926 through January 1928 Det was busy teaching at Swarthmore, developing an Honors program for premedical students there, and continuing his research in Bazett's laboratory at Penn and in the Marine Biological Laboratory (MBL) at Woods Hole during the Summer of 1927. He had one student, Sam Reynolds, doing research for a thesis as part of the requirements for an M.A. from Swarthmore. At that time Jacobs was director of the MBL, so Det was associated with him there and at Penn in directing the work of graduate students in physiology. In January 1927 he initiated steps toward working a year with E. D. Adrian, whose published work on neuronal action potentials was of special interest to Bronk. At the time he did not know Adrian, and his first letter provides an interesting self-description.

My training and experience has been as follows. As an undergraduate I specialized in electrical engineering and practiced engineering for a year following my graduation in 1920. I then went to the University of Michigan as an instructor in physics for the next three years. During that time I gave the advanced courses in alternating currents and vacuum tube work, took graduate courses in physics and mathematics, and did research in the field of infra-red spectroscopy. I next joined the staff of the medical school at the University of Michigan and served as instructor in physiology

for two years until appointed assistant professor last spring. In that time I took the degree of Doctor of Philosophy in Physiology and Physics and did research work on the electrical properties of the submaxillary gland, on the development of a thermo-electric method for determining the volume flow of blood, and on the application of this method to certain problems. This latter work was done in conjunction with Dr. Robert Gesell. Shortly after being appointed assistant professor at Michigan I came to Swarthmore to organize an Honors Course in Physiology. I am also on Dr. Bazett's staff at the University of Pennsylvania School of Medicine.

After he was accepted for research training by E. D. Adrian and A. V. Hill, the next step was to get a National Research Council Fellowship for this purpose. In relation to his application he wrote a letter to Dr. G. C. Huber, Chairman of the Fellowship Committee and a professor of anatomy at the University of Michigan. In it one can read an important viewpoint that guided his later teaching: "I do not wish to become a physicist working in physiology but rather a well-rounded physiologist with a physical and mathematical background." One step in the application procedure was an interview with a member of the fellowship committee. In view of their later association at The Rockefeller University, it is of special interest to know that the interviewer was Dr. Eugene Opie, then on the faculty at the University of Pennsylvania Medical School. Bronk was granted the fellowship for one year. By November 1927 the time of departure for England had been set for late January 1928. Whether he was to go to Adrian or Hill first was unsettled. On Bazett's advice he left that decision to be resolved by those two by the time of his arrival. He started with Adrian at Cambridge, and the work went so well that he did not get to Hill, in London, until November 1928. It is interesting that Bronk asked for an extension of his fellowship but was turned down by the Medical Fellowship Board in a letter dated April 1929.

Opportunities for research and the development of biophysics were numerous for Bronk, with his special preparation

in physics and physiology. At this time Det was considering an offer as director of a proposed Institute of Optics at Rochester, and another in the department of physiology at Columbia University. In connection with the serious consideration of these offers, Bronk had many occasions to put in writing his thoughts about biophysics. In a letter to President Rush Rhees of the University of Rochester he wrote: "Would you be willing to widen the scope of the proposed institute to the extent of making it an Institute of Optics and Bio-Physics? I feel very strongly that the time has already arrived when the medical and biological sciences must depend for a large part of their development upon physics." In a letter to Professor H. B. Williams of Columbia University he wrote: "I was considerably influenced by your advice at Cleveland several years ago that a person with my interests would do better to be primarily affiliated with physiology and retain physics as a secondary interest rather than vice versa. My observation of workers who reverse their emphasis has convinced me of the soundness of your view." However, he had heard rumors of an institute for medical physics at Penn. In a letter to Bazett, March 1928, he specifically asked for "any news regarding the medical physics situation." In November 1928 he wrote Bazett that he had refused the post at Rochester because the proposed medical physics undertaking at Penn would be less restrictive in the range of biophysical research. Indeed, he preferred the arrangement with Aydelotte and Bazett at Penn and Swarthmore so much that he also declined the post at Columbia with Professor Williams. This latter decision was particularly difficult because Bronk's interest in the physical aspects of biological phenomena had been stimulated initially by reading papers published by Professor Williams. His decision may have been facilitated when he learned, while in England, that he was promoted to full professor at Swarthmore (after only one and a half years on the faculty) and head of the Department of Physiology and Zoology.

In January 1929 Bronk returned to Swarthmore College from his very successful year of research with Adrian and Hill in England. This experience and his earlier interest in electrophysiology determined the direction of his research for the next ten years. Indeed, his major scientific interest for the rest of his life was the physical basis of the neuronal activity that is fundamental to the regulatory functions of the nervous system. The creative collaboration with Professor Adrian at Cambridge is recorded in the group of papers published during the years 1928 to 1933. During the time when this scientific research was in progress these two men developed a mutual respect for each other's personal qualities that continued in a life-long friendship. Their studies of motor nerve activity helped Adrian establish the generalization that intensity of nervous action on other cells, including other neurons, is measured by the frequency of the nerve impulses in each neuron and the number of active neurons. This was a fundamental generalization for which Adrian later received (with Charles Sherrington) the Nobel Prize. These generalizations about the neural code were essential to understanding neural control of physiological phenomena, such as cardiovascular and respiratory regulation.

Bronk was now Professor of Biophysics and Dean of Men at Swarthmore. The arrangement seemed permanent—even a new house was to be built for him. He continued his association with Bazett, depending upon the laboratories in the physiological department at the University of Pennsylvania for his research purposes. Through Bazett's influence he was now being considered for the post of director of the new Foundation for Medical Physics to be established in the Hospital of the University of Pennsylvania. It was to be housed in a new building under construction at 36th and Spruce Streets—the Maloney Clinic Building. Alfred Stengel, the Vice-President in Charge of Medical Affairs and Professor of Medicine, was responsible for establishing the new Foundation and its relations to the University's

hospital and the medical school. Through Professor Bazett he knew of Bronk's interest in the project and of his professional qualifications for participating in such an undertaking.

In February 1929 Stengel wrote to Bronk,

> I am delighted to learn, from Dr. Bazett, that you have returned to this country. I am writing to ask if you would not be good enough to see me sometime at your convenience when you may happen to be in Philadelphia, to let me go over certain matters regarding the Physics unit in the new Medical Clinic. I have been anxiously expecting your return, as you know of our needs and have been helpful to us in arriving at some preliminary plans. . . . I would wish, at the same time, to discuss with you other matters regarding the eventual development of this project and the possibility of your interesting yourself in it with us.

The conversations initiated by this letter led directly to an acceptance by Bronk, in April 1929, of an appointment as Johnson Professor of Biophysics and Director of the Eldridge Reeves Johnson Foundation for Medical Physics. In October, a letter to Stengel indicates that a staff had been appointed, that the laboratories were available, and that several investigators, including Ragnar Granit from Stockholm and W. A. H. Rushton from Cambridge, were arriving for a year or more of research in the new facility. Bronk's first major effort to create a unique institution devoted to advanced study and research was under way.

One year later the list of investigators was increased by the addition of John Donal, Frederic Gibbs, Harry Grundfest, and H. K. Hartline. Most of these investigators remained a few years, completing some research project and leaving for permanent positions elsewhere. Hartline, who arrived on the scene in April 1931, was associated with Bronk for forty-four years, continuing his research on vision, and moving with Det as the latter accepted administrative posts in a succession of new pastures where the fostering of science and graduate education on an ever broader basis seemed especially feasible.

In a letter to Adrian in May 1929 Bronk reported his acceptance of this new position as Professor of Biophysics at Penn. "I shall miss the delightful surroundings here [Swarthmore] and the student contacts but I have been so loaded down with teaching and administrative duties this term that I have practically no time for research. I feared this might grow into a permanent condition so I decided it was better to make the change now. I am sure that my period of training with you was one of my strongest qualifications . . . I will try not to disgrace you." It is interesting to read a similar letter that Bronk had received six months earlier, in November 1928, in which Adrian writes:

> I have one bit of news for you. You may have observed that I was more than usually moody in September. The fact was that I was thinking over the offer of a job much as you were in April [1928]. The job in question is a Royal Society research professorship like A. V. Hill's . . . I finally decided that I might as well accept, if only to encourage future candidates by lowering the much too high standard already set by Hill and Starling. So after this term I shall have no college teaching and only some advanced lectures to keep me up to date.
>
> See what you are responsible for! If we hadn't continued to deliver the goods in our work together I should have accepted the omen and refused the post. As it is there are awful misgivings in the background though naturally I can't pretend not to feel a great deal of pride at having the job offered to me.

Clearly, association in research for nine months had made these two men confiding friends—a relation that continued until Det's death.

Bronk regarded the Johnson Foundation as an exceptional opportunity for devoting all of his time to research and the teaching of graduate students. He continued a formal connection with Swarthmore as Lecturer. Indeed, from 1929 to 1932 Aydelotte consulted him on many administrative matters relating to faculty appointments, the Honors program, and the construction of a new laboratory building. From 1932 to 1933 he was was Director of the Department of Physiology and Zoology at

Swarthmore and was appointing and discussing the appointment of faculty as needed. This unorthodox relationship had begun in 1926 with a major appointment at Swarthmore and a research-oriented connection with Bazett at Penn. After 1929 it was a major research appointment at Penn and an academic and administrative connection with Swarthmore. This pattern of simultaneous important posts in several institutions was to characterize his future career. It reflected his predilection for simultaneous involvement in research, teaching, and administration. In fact, in the summer of 1932 he was off to England to work with Adrian again. In May 1934 these formal arrangements with Swarthmore were terminated, but he continued to advise Aydelotte, on request, for many more years.

RESEARCH, BIOPHYSICS, AND THE UNITY OF SCIENCE

One of Det's persistent research interests was the investigation of the neural control of the cardiovascular system in mammals. His work with Gesell provided a preliminary knowledge of cardiovascular physiology and some aspects of the neural control of muscles and glands. His year with Adrian put him in direct contact with ongoing research that was basic to understanding gradations of neural activity in terms of number of active neurons and frequency of impulses in each one. With this knowledge of the neural code and the new techniques for recording from single fibers, he and his collaborators provided, over ten years, essential experimental evidence for our present understanding of the neural regulation of blood pressure.

In physiological systems the neural regulation requires receptors for detecting and measuring the output of the effectors, as any good engineer would know. The transduction of tension and pressure into graded activity of individual neurons was investigated during the years 1929 to 1936. Among the receptors studied were Pacinian corpuscles in the mesentery and pressure receptors in the carotid sinus. Thus, the activity of some recep-

tors essential for cardiovascular regulation was described quantitatively. His first major paper (with G. Stella) on this subject, "Afferent Impulses in the Carotid Sinus and Aortic Nerves," was published in 1932. During the same period the patterns of efferent impulses from sympathetic ganglia were studied in relation to well-known cardiac reflexes. His last paper (1941) on this subject (with R. F. Pitts and M. G. Larrabee) concerned the role of the hypothalamus in cardiovascular control via the sympathetic nervous system, an investigation begun six years earlier. Thus, his investigations included receptors for detecting changes in blood pressure, the central control centers receiving the sensory signals, and the properties of the efferent neuronal systems directly controlling the heart rate and diameter of blood vessels —two of the mechanical factors determining blood pressure. In Det's interpretive reviews of these experiments (see *Harvey Lectures*, 1934), one can readily sense his delighted appreciation of the remarkable properties of this physiological control system. The implications for medical science and for applied physiology were clear to him, forming later a strong intellectual basis for his practical efforts in aviation medicine during World War II. In 1946, he summarized his views on "The Physical Structure and Biological Action of Nerve Cells, with Some References to the Problems of Human Flight." *

A central problem in understanding the action of any system of nerve cells is the description of the processes mediating the excitation of one nerve cell by another. Such synaptic regions occur in sympathetic ganglia, an anatomical component of the neuronal system controlling cardiovascular processes. In 1935 Bronk published a paper (with R. J. Pumphrey) on "Response of a Sympathetic Ganglion to High Frequency Stimulation." He perceived that a peripheral ganglion provided an excellent preparation for studying trans-synaptic excitation. It was gen-

* *American Scientist*, 34(1946):55–76.

erally recognized that properties of such synaptic transmission were basic to the regulatory functions of nervous action. Two evident research problems involved measuring the temporal properties of a neuronal synapse and determining the physical and chemical mechanism involved. In collaboration with M. G. Larrabee and a few others, he devoted much research to this subject from 1934 to 1952. These extensive studies revealed important general properties of trans-synaptic excitation, including the discovery of prolonged effects of previous activity which was a new facet of temporal facilitation. The phenomenon was of special interest at the time because of its possible relation to short-term memory, a mysterious property of some parts of the brain. Indeed, Ragnar Granit selected this discovery, reported in 1947 by Bronk and Larrabee, to be one of the most important contributions from The Johnson Research Foundation. (See Citation for Franklin Medal from the Franklin Institute, 1961.) He stated, "If one of Bronk's contributions should be singled out for special emphasis, surely this is the one to choose. It has had a great influence on physiology." Other scientists emphasize instead his contributions to cardiovascular physiology. In the *Physiological Reviews* for January 1976 one can read that Bronk and Stella "had already elucidated in principle most of the fundamental properties of vasoreceptors known up to now." The papers referred to were published more than forty years ago.

Synaptic excitation involves release of a chemical from presynaptic nerve terminals and excitation of the postsynaptic cell by this chemical. The studies of chemical excitation of nerve cells and axons (1937–1946) were relevant to the finer biophysical analysis of this physiologically important phenomenon. The characteristic response to chemical excitation is a prolonged train of impulses. The cell is responding to potential gradients in the membrane caused by current flow from intrinsic sources of electromotive force. The chemical agent merely produces the conditions at the cell membrane that permit this electric

current to flow. Such self-excitation is a property of axons too, provided the calcium is removed from the environment of the nerve. These studies of self-excitation of axons induced by chemical changes revealed an essential roll of calcium in stabilizing the excitability of axons at a sensitivity permitting conduction of impulses but preventing spontaneous production of impulses. The observations are relevant to the biophysical analysis of electrochemical events in excitable membranes and the role of calcium in such structures. Bronk's initial interest in these phenomena was recorded in 1930, and he fostered such research, with collaborators, as late as 1952, when he was President of The Johns Hopkins University.

Bronk measured, in 1928, the heat production of active nerve, using methods learned from A. V. Hill. From this experience he published, in 1931, a paper on "The Initial and Recovery Heat Production of Vertebrate Nerve." Ten years later he and his collaborators reinstituted investigations of these same energy transactions in terms of the oxygen uptake associated with nervous action, in trans-synaptic excitation and in axonal conduction. These experiments were made possible by developing precise methods for measuring the increased oxygen utilization by active nerve cells. Such biophysical studies relate the electrochemical events at the neuronal surface to the oxidative metabolism essential for maintenance of the ionic contents of nerve cells. Det continued an intellectual interest in this kind of research for the rest of his life. Even when his administrative responsibilities were heavy, he liked to take time to discuss any new finding that related to "the manner in which the organized living state [of cells] is maintained by an expenditure of energy."* He considered investigations of energy transactions in cells to be fundamental for the eventual unification of the conceptual structures of physics and biology, that is, biophysics.

* *Journal of Applied Physics,* 9(1938):139–142.

In 1938, after ten years of research and teaching in biophysics, Bronk evaluated its role in the further development of biology. He argued that the biology of cells must be understood in terms of molecular structures and their temporal changes, as "a problem in physical chemistry."* Therefore, basic biology was to be conceived as the study of structure, biochemistry, and biophysics of cells. He emphasized the need for advanced study of physics and biology because "there is a large body of facts and theories concerning living organisms which is unknown to the physicist."* Obviously, this opinion was derived from his own pioneering efforts twelve years earlier when he decided to take his advanced degree in physics and physiology. This summarizing paper, "The Relation of Physics to the Biological Sciences," closes with an expression of one of his life-long motivations, "the satisfaction which comes to workers in this field, for we have a rare opportunity to glimpse the essential unity of science. To comprehend this is the final objective of every natural philosopher."*

He liked to perform experiments with a potential for discovery but disclaimed interest in systematic, goal-directed research. The diverse experiments were motivated by progress toward a basic biological goal—the description of physiological mechanisms in terms of the properties of the participating cells. Thus, for regulation of blood pressure, the experimentally separable cellular actions were: afferent impulses generated by pressure receptors, activity of hypothalamic neurons processing these incoming signals, efferent impulses activating neurons in peripheral autonomic ganglia, impulses from ganglionic cells modulating the heart rate and activating smooth muscle cells to adjust the diameters of blood vessels. Clearly, the integrated physiological system provided the framework for correlating these experiments. Such a synthesis of cellular events into a mecha-

* *Journal of Applied Physics*, 9(1938):139–142.

nism essential to the integrity of a living animal fascinated Det. In 1939 he wrote, "Only if we think in terms of cellular units and recognize that they are labile structures whose properties are continually fluctuating can we conceive of the fluctuating patterns of behavior carried on by fixed arrangement of cells and fibers." For him, research was an adventure into unknown territory in association with a few like-minded colleagues. He often visualized the ideal laboratory as a large room with several groups of investigators conducting diverse experiments all related to a basic biological problem. Later, when his administrative duties dominated his attention, he seemed content to be in or near a laboratory and to inquire how the last experiment had worked out. He enjoyed an account of a good experiment whether or not he had any part in it. He expected me to relate to him any unusual experiment that I came across in my reading. Two themes permeate Det's efforts to conceptually integrate his experimental observations. One was the common features of the neuronal signaling utilized in the control of a variety of physiological systems. The other was the necessity for a continuous flow of energy for maintenance of the excitability of the cellular components of these systems. His preoccupation with these aspects of organized systems of living cells plainly reflects his original interest in engineering and physics.

A REVERSIBLE TRANSITION, THEN PHYSIOLOGISTS IN WAR

In 1939, for reasons that are not clearly evident, Bronk negotiated and accepted a position as Professor of Physiology and Head of the Department of Physiology in the Medical School of Cornell University. In February 1940 he received the letter from President Edmund E. Day formalizing this appointment. At the same time a proposal to develop biophysics at the Massachusetts Institute of Technology (MIT) was being considered. And in March he was corresponding with Ralph Gerard on the merits of accepting an appointment as Head of

Physiology at the University of Chicago Medical School. Bronk believed that more participation in the teaching of physiology was essential for biophysicists and was pleased that Cornell welcomed him and a group of his associates. The simultaneous offers from Chicago and MIT promoted comparisons and indecision. Perhaps the reluctance for accepting "the group" at MIT was a major factor in his refusal of the offer to help develop biological engineering there. The letter from Karl Compton acknowledging Bronk's refusal of the post indicates his continuing contact as a member of the Visiting Committee for the Department of Biology and Public Health. In his letter refusing the post at Chicago, Det explicitly stated that his main interest then was to create a "school of physiology along lines that do not now exist." He thought this could be done better at Chicago or Cornell than at Penn. He favored Cornell in part because he hoped to utilize the talent at the Rockefeller Institute for Medical Research in the education of his graduate students.

It was during the spring of 1940 that Det began having doubts about leaving the University of Pennsylvania. In May 1940 a letter from A. N. Richards (Vice-President in Charge of Medical Affairs) indicates that he and Richards were informally discussing his remaining at Pennsylvania. In an exchange of letters between Day and Thomas S. Gates (President of the University of Pennsylvania) there is some basis for believing that President Gates may have failed to make clear to Bronk that the prospects for him, the Johnson Research Foundation, and biophysics at Penn were good. There was a brief period in which A. N. Richards of Pennsylvania and President Day of Cornell were discussing by letter the best way to help Det resolve his uncertainties. As late as July, President Day offered him a semester's leave with pay during which he could re-assess his decision. However, Det decided to make the move, and the transfer to Cornell was completed by September. The move was made by Det and other scientists from the Johnson Foundation,

including H. K. Hartline, M. G. Larrabee, F. Brink, P. W. Davies, A. J. Rawson, J. P. Hervey, and G. A. Millikan. For one year they taught physiology to the medical students and pursued their research interests at 68th Street and York Avenue, New York City. A letter from Richards to Det in February 1941 indicates advanced plans for his return to the University of Pennsylvania. The excursion was terminated by Bronk who resigned in March 1941 and returned to his former post in Philadelphia. He took all of his associates with him. A copy of a letter from Richards to President Day in January 1941 clearly indicates that Richards was the prime mover in arranging for Bronk's return to Pennsylvania.

Two features of this episode are explicitly documented in Bronk's available correspondence. In his letter of resignation to President Day and Dean Ladd he states that as the year progressed he began to realize that investigators and graduate students concerned with physiological biophysics need ready access to physicists, chemists, mathematicians, and general biologists. They thrive in an intellectual atmosphere where such scholars are present. The exclusively medical environment of Cornell Medical School and the New York Hospital did not, in his opinion, provide the best circumstances for biophysics to flourish as an independent intellectual enterprise. On the contrary, in a medical school, biophysicists were generally regarded as technical specialists who could help others in medical research. As mentioned earlier, this was a philosophy that Det wanted to avoid in his own development as a biophysicist. The other explicit aspect of this event was the numerous enthusiastic letters he received from faculty members and department heads at the University of Pennsylvania welcoming him back. It is interesting to note that Richards and Bazett now agreed to let Bronk and the research staff of the Johnson Foundation participate in teaching physiology to medical students as they had done at Cornell.

The Institute of Neurology was created at the University of Pennsylvania Medical School in 1937 to provide closer professional relations among clinical neurologists and those engaged primarily in neurophysiological research. It was conceived as an intellectually cohesive organization that could provide a focus for cooperative efforts among members of various departments in the hospital and the medical school. Det was the director and principal organizer. The future of this project seemed uncertain when he went to Cornell. Among the letters welcoming him back to Penn in March 1941 is one from Dr. Perry Pepper in which a problem connected with the Neurological Institute is eagerly turned over to Det months before he actually returned to the Johnson Foundation. This Neurological Institute, with original purposes intact, continues today—evidence of one more of Bronk's ideas that resulted in a viable organization for the advancement of research on the nervous system and promotion of procedures to make fundamental knowledge available for use in solving clinical problems.

The correspondence between Bronk and the Comptroller at Penn from 1939 to 1940 suggests that funding of research and salaries for all the members of the Johnson Foundation was becoming very uncertain at the time. In contrast, the balance sheet for 1942, after Det's return from Cornell, was much improved. One notes the new sources of support related to the military problems—National Research Council (NRC), National Defense Research Committee (NDRC), and Office of Scientific Research and Development (OSRD). Perhaps this financial situation in 1939 and 1940 was a factor in Det's decision to transfer to Cornell Medical College, a move that permitted him to hold his group together financially. The return to Penn, for intellectual and professional reasons noted above, may have been facilitated by this increasing emphasis on war-related research, which had begun for some members of Bronk's group while at Cornell Medical College. In February 1941 Bronk had received

a grant from the Division of Medical Sciences of the NRC in "support of your investigations in relation to the defense program." By April 1941, Bronk and Hartline were concerned with research on visual acuity in relation to the problems encountered by pilots flying at night. During the year at Cornell the research activities of some members of the staff were related to other military problems, particularly to cardiovascular and respiratory physiology during stress, as in submarines or high altitude flying. This trend accelerated after the return to the Johnson Foundation. Bronk became involved as a consultant in medical research related to military problems. A. N. Richards was head of the medical group (Committee on Medical Research) directing this national effort within the OSRD created by Vannevar Bush. Perhaps this was a major reason why he urged Bronk to return to the Johnson Foundation. Their previous friendship became an even closer association during the war years.

In a letter from Frank Jewett to Walter Miles in 1946, we learn a further explanation of why Bronk left Cornell Medical School and returned to the University of Pennsylvania in 1941. Bronk was sure that the United States would become involved in the war while President Day was of the opposite opinion at that time. Consequently, Day did not approve of Bronk's devoting his time and research efforts increasingly to war-related problems. At the University of Pennsylvania he was supported in his opinions, and his expanded efforts in war-related research were fully approved. His return to the Johnson Foundation merely transferred his base of operation because the research contracted through the NRC was continued and extended there.

Bronk's primary role in World War II was played out in Washington rather than in personal performance in the laboratory. He was effective in linking research scientists to the war effort through grants and contracts at the University of Pennsyl-

vania and elsewhere. He served the NRC as a Member-at-Large in the Division of Physical Sciences from July 1940 to June 1941. Then he received and accepted an appointment for three more years in the same division under the chairmanship of Dr. L. P. Eisenhart. However, Det was also a physiologist, and in September 1941 he became a member of the Committee on Aviation Medicine of the Division of Medical Sciences of the NRC under the Chairmanship of Dr. Lewis Weed. In April 1942 Weed asked Bronk to be chairman of a subcommittee of the Committee on Aviation Medicine (CAM) to advise the medical services of the Army and Navy Air Corps on problems related to oxygen and anoxia.

The war focused the attention of scientists upon practical problems defined by the military requirements. Primary concern with advanced study and basic research had to be put aside in favor of investigations and effective use of available knowledge for quick solutions adequate for military purposes. For Bronk this meant increasing involvement in aviation medicine insofar as the physiological stresses of flying created special medical problems requiring investigation. He also perceived that an educational effort was needed to permit flyers and their doctors to understand the physiological origins of these special aspects of aviation medicine. He conceived and directed the recruitment of a corps of physiologists for this purpose. General David H. W. Grant, the Air Surgeon, and his aide, Colonel Lloyd E. Griffis, backed his proposal, and Bronk was appointed Coordinator of Research in the Office of the Air Surgeon. For this project he was uniquely qualified by professional experience in physiology and by his flight training during World War I. He began recruiting young physiologists into the Air Force, enabling these physiologists to utilize their specialized talents to serve the military needs of the nation. These officers worked at all major flight training centers and at air bases elsewhere.

Some were engaged in research work within the military organizations.

Two major problems under investigation were the adverse effects of moderate deficiency of cerebral oxygen supply and the improvement of goggles utilizing infra-red radiation for making terrain visible to aviators landing on a dark field at night. Bronk was particularly interested in the physiological aspects of the former problem. His observations on the sensitivity of neurons to oxygen deprivation and his knowledge of the cardiovascular system fostered his interest in the delivery of oxygen to the brain. This interest was intensified by his involvement in physiological problems encountered by aviators flying at high altitudes or making pull-outs from steep dives during combat. He was elated when Philip W. Davies developed a form of oxygen-electrode suitable for measuring the concentration gradients near blood vessels on the surface of the exposed cortex of a cat. Now a direct measure of changes in the delivery of oxygen to the neurons in the brain was available. Bronk reported this development in the "Transactions of the American Neurological Association" in 1944 and in a penultimate research report (with P. W. Davies) in 1957.

In 1947, Richards, as Chairman of the Committee on Medical Research of the OSRD, wrote to all subcommittee chairmen a letter thanking each for his emergency services during the war. His letter to Det comments upon Det's effective, simultaneous leadership in the Johnson Foundation and in the CAM and as Coordinator of Research in the Air Surgeon's Office. (Note again Det's unusual flare for focusing his efforts on a common problem through several channels of management.) His contributions to the war effort received national and international recognition. In June 1948 he was awarded the insignia of an honorary Officer of the British Empire for "invaluable services to the Allied cause in medical research and development." The commendation for exceptional civilian service reads:

For exceptional service to the Army Air Force [AAF] in initiating and supervising a program of aviation physiological training which greatly increased the safety and efficiency of all flying personnel. Through his extraordinary administrative initiative and skill, he achieved the successful establishment and fulfillment of the AAF altitude and training program, conceived and established the AAF night vision training program, and contributed outstandingly to the national welfare through the advancement and application of the knowledge of aviation medicine.

During the war, Bronk was heavily involved with work in national organizations, starting with the NRC and culminating in his appointment as Coordinator of Research, Office of the Air Surgeon, Headquarters Army Air Forces. He was a Special Consultant to the Secretary of War. In 1942, he became Chief, Division of Aviation Medicine, Committee on Medical Research, OSRD. In 1945, the war work was over. Det was directing the Johnson Foundation as it converted to more usual research activities. In the postwar years the scientific enterprise continued as an integral part of many federal agencies, and Bronk was a prime mover in the efforts to define the role of science in national affairs. His experiences and associations during the war led to his appointment, in 1945, as Foreign Secretary of the National Academy of Sciences (NAS) and, in 1946, as Chairman of the NRC. In addition, he was a member of: Naval Research Advisory Board; Scientific Advisory Board, Army Air Forces; Commission on Educational Scientific and Cultural Cooperation, State Department. He was spending much time in Washington.

PRIORITY: PERSONAL RESEARCH OR SCIENCE FOR HUMAN WELFARE

Det served the NRC several years before he became a member of the NAS in 1939. His first official role was in 1936 as Representative of the American Physical Society in the Division of Physical Sciences. In 1937 he was on the Executive Committee of the NRC. From 1940 to 1945 his participation in NRC affairs

was greatly extended. He was active in the Division of Physical Sciences and the Division of Medical Sciences and was chairman of the Committee on Aviation Medicine. A major reorganization of the NRC occurred in 1946 when the Council of the Academy became responsible for appointing the Chairman of the NRC, making him subject to dismissal by that Council. Thus, the NRC was linked more firmly to the NAS through its Council, which was composed of elected members of the Academy. A letter from Frank Jewett appointed Bronk as Chairman of the NRC beginning July 1, 1946. He was thus presented with an opportunity to develop the postwar NRC, subject to the general approval of the Council of the Academy. In June 1946, Jewett reported, "In accepting the chairmanship as Dr. Harrison's successor, Dr. Bronk has relinquished a large part of his responsibilities at the University of Pennsylvania so as to be able to devote a major part of his time to administering the affairs of the Council [NRC]. The Council is thus assured of what is essentially full-time administration of its operation—something which the largely expanded work of the Council demands." Many of the peacetime versions of wartime problems handled by the OSRD were dealt with by expanding the committee structure of the NRC. Fortunately, the confusion of purpose represented by the proposal that the NAS–NRC should function as a national science foundation in administering support of basic research and advanced education of scientists had been put aside by 1946. Earlier (1945), Bronk had testified in favor of this proposal at Congressional hearings. Now he could, and did, proceed in the reorganization of the NRC, guided solely by the original chartered purposes, as reaffirmed by Jewett in a major report to the Academy in 1947. Newton Richards, as Vice-President for Medical Affairs, enabled Det to make the necessary arrangements with Penn so that he could become chairman and also continue as Director of the Johnson Research Foundation. Of great inter-

est is the fact that Richards became President of the NAS one year later. Again, he and Det were working together in promoting science at Penn and nationally through the NAS and the NRC.

Det took the chairmanship of the NRC in the belief that he could have great influence on the course of the imminent changes in national policy for science and its role in society. He declined a full-time appointment because biophysical research and the development of the Johnson Foundation continued to be a major interest. He believed the two activities to be mutually supportive, arguing that much of the work of the NRC had a scholarly scientific aspect, and that a link to national scientific affairs was important to the University. In accepting the chairmanship Det enjoyed the confidence of his predecessor, Ross G. Harrison, who expressed his satisfaction in leaving the NRC in such capable hands. As Chairman, Bronk was the instigator and prodder of many enterprises in the national interest. The participants were scientists and engineers confronted with a wide variety of national problems that required the mobilization of available knowledge and specific recommendations for further research. Some specific examples are: the Committee to Assess the Biological Effects of Atomic Radiation, the Committee on Sensory Devices, the Chemical-Biological Coordination Center, and the Highway Research Board. Of special interest to him were the expanding fellowship programs administered by the NRC and the creation of the American Institute for Biological Sciences. Available letters reveal that his speeches were effective in delineating the problems and motivating the necessary efforts. Bronk was a focus for coordinating and promoting the activities of those concerned with "human ecology." In one of his statements to Congress, Bronk described himself as "a biologist and a physicist who is concerned with the influence of modern technology on human welfare." A letter from Jewett in 1949 suggests that Det had successfully revitalized the NRC. Jewett writes:

Tonight before dinner I lay down on the sofa for a rest and picked up the first paper on the pile. It was the minutes of the Academy Fall Meeting. I went through it casually, old stuff—until I came to the end—your report of stewardship of the NRC. Then I got a shot of nitro-glycerine and a great uplift.

It was a grand story of achievement and one that should give you a feeling of satisfaction—I only hope you can find time to keep a guiding hand on NRC affairs even if you have to delegate more to others.

While reading it I confess to a small twinge of regret at not having had a hand in it. However, I solaced myself a bit with the thought that in an antediluvian age, "when all the girls were twenty-one", I did have a hand in persuading you to take command of the battered ship. You're a skillful navigator and I don't think you learned it all on Vineyard and Nantucket Sounds either. You have put the NRC where I've always hoped it would be—as the real "guts" of the Academy structure. The combination of the freedom afforded by the Academy charter and the virility of a dynamic Council is unbeatable and a great thing for science and for America.

During this same period Bronk, as Foreign Secretary of the NAS, was very active in helping to restore normal relations with scientists in postwar Europe.

Bronk was prominent among those who decided that administration of science in the postwar period was of greater importance for the advancement of science than the continuation of a personal research career. The transition was not abrupt and not without difficult decisions. In accepting appointment as Chairman of the NRC, Bronk wrote to Jewett, "I am so grateful for your sympathetic understanding of the reasons why I felt unable to accept the post on a full-time basis, due to my loyalties and obligations to the University of Pennsylvania and my strong desire to continue research." The personal circumstances for his insistence on continuing at the Johnson Foundation while Chairman of the NRC are enhanced by a letter from his wife, Helen, reminding him that, "direct contact with important research is your first and most important interest." After six other relevant points she concluded: "a quotation keeps going through my head—'What shall it profit a man if he gain

the whole world, if he loses his own soul?' Your soul is your research work." The last remark underlines Det's entire professional history after his 1927 choice of an academic career at Swarthmore and at Pennsylvania as opposed to engineering management. The documents and letters over twenty years reiterate his strong motivation to participate personally and directly in research. After accepting the Presidency of The Johns Hopkins University in 1949, and of the NAS in 1950, a gradual weakening of this basic premise occurred—as happens to so many competent scientists who are also able administrators. For a while he continued professional participation in research through a number of collaborators who were also interested in the biophysical aspects of a neuronal activity and trans-synaptic excitation. He always wanted to know what experiments were being planned, and he liked to contribute to discussions about possible interpretations of new data. At Hopkins and later at The Rockefeller University he maintained an office in the research buildings. The last research paper bearing his name (coauthors, P. Cranefield and F. Brink) appeared in 1957, about thirty-four years after his first. The title of the first paper was "The Structure of the Absorption Bands of Certain Organic Gases and Vapors in the Near Infra-Red," published in the *Physical Review*, and the last one was, "The Oxygen Uptake of the Peripheral Nerve of the Rat," published in the *Journal of Neurochemistry*. He was sixty years old; further contact with experimental research was so peripheral to the focus of his activities that he no longer felt personally involved. Over all these years, on appropriate occasions, Bronk recapitulated related aspects of his research interests and created a tentative synthesis of the accumulated observations. This series of papers constitutes a carefully organized account of that which he selected as most interesting and significant in his research and the related work of others. Among these résumés are his Harvey Lecture (1934) on "The Nervous Mechanism of Cardiovascular

Control," the Cold Spring Harbor Symposia talk (1936) on "The Activity of Nerve Cells," the S. Weir Mitchell Lecture (1938) on "Cellular Organization of Nervous Function," the Symposium on the Synapse lecture (1939) discussing "Synaptic Mechanisms in Sympathetic Ganglia," and a paper in a symposium on Chemistry and Medicine (1940) entitled "The Nervous Regulation of Visceral Processes." The final talk of this kind was his Croonian Lecture delivered in 1949 on "The Rhythmic Action and Respiration of Nerve Cells." (This paper, never prepared in final form for publication, exists as a series of notes and references to specific slides.)

His early research on the nervous control of the cardiovascular system has become incorporated in textbooks of physiology as a permanent contribution to physiological science. Largely for this research he was granted membership in the NAS in 1939. His achievements as a scientist were recognized abroad as well as in the United States. In 1948 he was elected a foreign member of the Royal Society of Great Britain. The *Philadelphia Inquirer* noted that only two other University of Pennsylvania scientists had that distinction, A. N. Richards and Benjamin Franklin. In 1953 he was elected a foreign member of the French National Academy of Science. In 1958 the Russian Academy made him a foreign member, citing his contribution to neurophysiology, biophysics, and aviation medicine.

Det Bronk developed as an inspired experimental scientist with broad interests in the scholarly enterprise. His talents for leadership were evident to older colleagues, and opportunities flowed toward him. He arrived on this scene at a time when academic leaders were expected to continue their creative scholarly work. He learned gradually that innovative leadership in activities supportive to the scientific enterprise precluded direct participation in the search for new knowledge. The mobilization of scientists for service in World War II fostered Det's transition from the laboratory to the administration of

scientific activities on a national scale. One source of his personal motivation toward this task is well expressed in a paragraph from testimony at a Congressional hearing in 1945.

> After a war in which we have been forced to destroy vast quantities of our natural resources, it is well to give thought to the future sources of national strength. Fortunately, our greatest natural resource is one that need have no limits. I refer to our knowledge of the physical universe, our knowledge of plant and animal life, knowledge of the workings of our own bodies in health and disease. Such knowledge is a resource that can be increased indefinitely for the common good. Unfortunately, it can be lost through indifference and neglect. Accordingly, thoughtful citizens should derive confidence from the determination of Congress to insure the vigorous development of scientific research, so as to increase our national welfare and to prepare ourselves for the unforeseen problems of the future.

In retrospect this personal history seems inevitable. Det was dedicated to the furtherance of science, but his interests extended into other areas of scholarship. As an inspired leader in advanced study and research he had a deep concern for all creative people. He admired and wanted to understand creative scholars generally. One of the recurring topics in his discourse and writing was the desirability of unifying knowledge. He simply liked the idea of eventual unity of all knowledge. This frequently expressed theme was sometimes restricted to the unity of scientific knowledge. He found great satisfaction in bringing together scientists in many disciplines to pool their knowledge in relation to a national problem. Even in the practical uses of science, as in the NRC, he liked to describe how the inspired insight of one person into the creative research of another could eventually lead to some unusual synthesis in still another mind. He liked to point out that this coordinated utilization of available scientific knowledge to solve a problem was evidence for the essential unity of all science. In the absence of unity in the logical structure of basic science he found evidence for an intrinsic unity in the interlocking physical, chemical, and

biological process characterizing many natural systems. In this idea he found strong personal motivation for his work as chairman of the NRC.

The American Institute of Biological Sciences (AIBS) and the American Geological Institute (AGI) were created by scientists who were concerned with the fragmentation of their discipline into subspecialties. Bronk played a key role in the formation, in 1948, of the AGI, as described in *Geotimes* for October 1973. This Institute, fostered by the NRC through Det's efforts, provided the mechanism for promoting the development of earth sciences as a unified body of knowledge. Somewhat earlier, 1947, Bronk had a similiar pivotal role in creating the AIBS. He described these events in *BioScience* (1972):

> The schism between the zoological and botanical sciences is difficult to recall now that molecular biology comprises both, and "biology" has been broadened to "the life sciences" which include the behavioral sciences, too. In these times when life scientists are much concerned with the quality of life and the environment, there is no longer need to justify our organization that embraces all the biological sciences and their social adjuncts. The hopes of Butler and Cleland and Steinbach, of Chambers and Fenn and Griggs and their colleagues, have been fulfilled. The AIBS is thus a heritage from them to those who believe that knowledge cannot be contained within boundaries.

A striking characteristic of Bronk's total bibliography is the extensive overlapping periods of writing on (1) experimental investigations, (2) the nature of the scientific enterprise, (3) the role of science in society and national affairs, and (4) the imporance of higher education in our culture. His thinking on a wide variety of problems concomitantly is evident. In an interview published in the *Baltimore Sun* in 1949 he explained that relaxation for him was to shift his attention to a different concern or set of problems rather than to stop working. Thus, each day was divided into several periods, each devoted exclusively to a particular facet of his manifold interests. For relaxation he also went sailing or skiing. On such occasions he devoted total

attention to the immediate activities with exclusion of all other matters. He apparently had a well-developed ability to select and control the focus of his attention, including an assigned period before sleeping used for reading, usually history, biography, and literary commentaries like John L. Lowes' *The Road to Xanadu* (a favorite). Novels were avoided, according to his own statement.

IN SUPPORT OF RESEARCH AND THE SCHOLARLY LIFE

In 1948 the trustees of The Johns Hopkins University were seeking a successor to Isaiah Bowman. In Bronk's files there is a copy of a letter sent to Charles Garland, Chairman of the Board, by S. R. M. Reynolds, a staff member of the Carnegie Institute situated at Johns Hopkins, recommending Bronk for the post. There is also a letter from Garland to Dr. Reynolds stating that his was the first letter to be received by the presidential search committee urging consideration of Det. Garland indicated that the Board's deliberations rapidly focused upon Bronk and his credentials. These letters are of special interest because Sam Reynolds was the Research Assistant who, in 1928, kept Det informed of events at Penn and Swarthmore during the latter's sojourn with Adrian in England. One can only surmise how important the letter was to the trustees as they considered potential successors to Bowman. In *Time* magazine for August 1948 Det's appointment as President of Johns Hopkins University was announced with the comment, "When Johns Hopkins asked M.I.T.'s Karl Compton to submit a list of candidates, he sent back one name—Bronk's. Largely on Compton's say-so the University scarcely considered its one-hundred-odd other candidates."

When Det was offered the Presidency of The Johns Hopkins University his role as an educator and a scholar received appropriate recognition. He saw an opportunity to make explicit some of his ideas about an ideal graduate school. As usual, his

acceptance of this appointment was predicated upon further development of biophysics through the establishment of a department with research laboratories on the Homewood Campus and in the Medical School. He took five members of the Johnson Foundation with him, those most closely associated with his main interest in neurophysiological research. He thus reaffirmed his strong belief that biophysics was to develop on a par with biochemistry, both being fundamental to our understanding of the living state of matter. In addition to these specific interests he fostered implementation of his ideas for the proper conditions under which all scholars might live and work. He believed that students should be given the opportunity to advance in their scholarly activities in accordance with their individual capabilities. He created the "Hopkins plan" which permitted undergraduates to engage in advanced study without regard to their academic classification as undergraduates. This plan enabled persons to earn advanced degrees based upon demonstrated competence without the necessity of first completing the requirements for a B.S. or an M.A. In short, for the gifted and highly motivated student there was to be no distinction between college and graduate school; both were simultaneously available to him for developing his scholarly abilities.

In 1949 such ideas created a flurry of reappraisal of academic goals, purpose, and methods among concerned faculty at The Hopkins. The Bronk plan was reformulated by a committee of the faculty. The circulated document was vigorously analyzed and criticized by several faculty members. The final plan was a distillate of Det's proposal and the joint thinking of the faculty whose cooperation was needed. The idea of emphasis on scholarship in all student activities at all levels was endorsed, but the possibility for "erasing the difference between graduates and undergraduates" was provided only for the exceptionally able student. Others proceeded as usual. The key purposes of Bronk's plan were: development of the individual man according to his

individual needs and encouragement to think independently, to engage in original work, and to expand his intellectual capabilities to their full potential. In 1950, at the annual convention of the Middle States Association of Colleges and Secondary Schools, Bronk proposed abolishing the distinction between undergraduate and graduate education. He proposed advancement based on learning and judged by high standards of accomplishment in advanced study and creative enterprises leading to the doctorate in six years. At Hopkins Det worked closely with the faculty committee to develop his plan for advancing students in accordance with their scholarly accomplishments rather than their exam grades and course credits. Later, at The Rockefeller University, he utilized fully the experience derived from discussions of these ideas among the more diversified faculty at Johns Hopkins University.

The role of the scholar in national affairs was never far from Det's thoughts in considering the purposes of a university. In a speech at the Applied Physics Laboratory he spoke of the important role of Johns Hopkins University in providing an intellectual home for scholars serving government. He emphasized mutual benefit to the university and to the governmental agencies in which the scholars served the country.

In his presidential message to the freshman class he wrote,

> Our nation has assumed heavy responsibilities for the material welfare of peoples in many parts of the world. But the people of the world desire of us more than food and more than shelter. They look to us as a nation to prove the power of free men to create for themselves and others a more satisfying life by preserving the rights of individuals to work for common purposes and to resolve differences of opinion by free discussion. The faculties and administration of The Hopkins have no higher mission than to fit you to assume your responsibilities for such individual action. By discharging that responsibility you will make your greatest contribution to the preservation of our strong democracy.

And how are they to do this? He continued, "We live in challenging times that offer great opportunities for service and

satisfaction to those who have courage and trained minds. The Hopkins is traditionally devoted to exploration of the frontiers of knowledge. In this environment you will have unique opportunities to acquire the spirit of research which will enable you to play a leading role in a swiftly-changing civilization."

Among the many letters of congratulation in 1948 were those that expressed opposite views of two related subjects: (1) Det's intention to continue some research, and (2) the continuation of his chairmanship of the NRC. With regard to the first intention many expressed approval, saying that a president should be an active scholar. Others intimated that this was desirable but could not be done. On the second subject, some expressed hope that he would continue, but others implied that he would need to give up the chairmanship. The letters came from high school classmates, physics students taught by Det at Michigan, and many, many former associates in Penn, Cornell, the NRC, the Office of Naval Research, etc. A letter from Isaiah Bowman, in 1948, was especially gracious in saying that he was delighted to have a successor who would open up a new era for Hopkins: "I believe you will find the Presidency a most satisfactory career, but I place opposite that an equally strong belief that your maintenance of interest in biophysics represents a wise decision." In contrast, Frank Jewett wrote to Det in 1948 (in a postscript): "Are you still so adamant about keeping your hand in on actual research work in the laboratory that you wouldn't consider a really top line administrative position connected with research if it wandered your way?"

Thus, like other scientists and educators directly involved in the rapidly expanding national scientific enterprises, Bronk continued his academic career *pari passu*. He devoted much of his attention to the administration of Johns Hopkins. He perceived that a creative effort by faculty and administration was necessary to rejuvenate a dedication to advanced study that had become distorted by their earlier war efforts. From 1948 to 1953, he led the faculty and students to renewed adherence to the scholarly

purposes of an ideal university. In his speeches during this time phrases recur such as "breadth in education," "fostering of curiosity," "freedom for self-determination," and "a university is a community of scholars." His special concern for science was reflected often. In 1949 he wrote, "I believe universities must be preserved as the home of science because in them it is possible to integrate learning. It is only in the universities that we can train true scientists." He repeatedly emphasized the need for individual intellectual freedom as essential to progress of scientific thought.

His strong intention to continue personal research work was completely abandoned sometime after he became President of Johns Hopkins University. The necessity of this drastic change of priorities becomes evident when the range of his self-imposed administrative responsibilities is contemplated. Like Ira Remsen in earlier times, he was President of Johns Hopkins and of the NAS simultaneously. In addition, he was a member of the Board administering the newly created National Science Foundation. As the recently elected president of the American Association for the Advancement of Science, he committed himself to its affairs for 1952. In 1951 he was appointed by President Truman to serve on the Science Advisory Committee of the Office of Defense Mobilization. He served on the National Advisory Committee for Aeronautics from 1948 to 1958. From 1950 to 1970 he was a member of the Board of Trustees and the Committee on Scientific Policy of the Sloan Kettering Institute. He had also become a member of the Board of Scientific Directors of The Rockefeller Institute in 1946 and, in 1951, was chairman of its committee to prescribe a future policy and recommend a new director for the Institute.

IN SERVICE TO SCIENCE AND THE NATION

The general approval of Bronk's service in the NRC was expressed by his election as President of the NAS at the annual meeting of the Academy in 1950. Bronk, nominated from the

floor by the Section for Chemistry, was placed in opposition to Dr. James B. Conant, the choice of the Presidential Nominating Committee. A ballot was taken and Bronk received a majority vote. He refused to serve because he had personally urged Conant to accept the nomination. Conant was not present but graciously requested, when Vannevar Bush informed him by phone, that the election of Bronk be made unanimous. The occurrence was taken by many scientists as a signal of approval of the prevailing NRC–NAS procedures for relating science to national needs.

Det's predilection for pursuing his goals through simultaneous control of several channels of management was evident to his associates in Washington. He was encouraged in this approach by some (as in Jewett's 1949 letter). In contrast, Richards admonished him, in a letter written in 1950, to resign as Chairman of the NRC before taking up the duties of President of the Academy:

> Ever since your election to the presidency of the Academy, I have been hoping that you would undertake to find ways of divesting yourself of much of the active work of the Research Council. . . .
>
> Our conversation yesterday makes me fear that your thoughts are not going in that direction. If I am wrong I hope you'll show me that I am. Agreed that a closer drawing together of Academy and Research Council is desirable and that your experience with the Council, coupled with your opportunities as president of the Academy fit you uniquely to design such closer union, I cannot see how it is possible for one person, even you, with prime responsibility to a University, to do the active work of leadership of both the Academy and Research Council. . . .
>
> Your intense desire to be useful, your extraordinary capacity to see opportunities for usefulness and your knowledge of your own ability to improve them leads you to accept such a multiplicity of them that some must inevitably suffer—and so indeed must you. . . .
>
> Affectionately yours, Newton

This advice prevailed, and Douglas Whitaker became Chairman of the NRC in September 1950. After nine months of successful service he was succeeded by William Rubey who served for

several years, during which time Det continued as President of the NAS.

When Det Bronk became President of the Academy in 1950 he began a central role in the national development of science that was to continue for twelve years. Indeed, "very little of a high-policy nature affecting science happened around Washington without showing the influence of Detlev W. Bronk." This sentence in a recent letter from Dr. S. Douglas Cornell (now Assistant to the President, NAS) summarizes what I have been told by many others directly involved in such matters at that time. No scientist took the ideas in the charter of the NAS more seriously than did Bronk. He devoted a large part of his life to reinterpreting their meaning in the postwar years. During these crucial years the basic policies that now define the place of science in our national culture were formed. New federal institutions concerned with science were created: Atomic Energy Commission, National Science Foundation, National Aeronautics and Space Administration, President's Science Advisory Committee, and Office of Science and Technology—and a science advisor to the President of the United States appeared on the scene. These events required an increased effort by the Academy, initially, to help define the scope and purpose of each new federal agency for science, and thereafter, to prepare itself for the wider range of scientific advisory service requested by these new agencies. Det had been well prepared for leadership of the Academy. As Chairman of the NRC from 1946 to 1950 he had learned how to mobilize and facilitate the efforts of scientists in various disciplines for the purpose of utilization of scientific knowledge in solving national problems. Furthermore, he had been Foreign Secretary of the Academy since 1945 and therefore experienced in promoting official participation of our national scientific societies in international scientific affairs. The range of his services and initiatives as President of the NAS are too extensive to review here.

A letter sent to me (January 1978) by Dr. Cornell reveals how he and John S. Coleman (now Executive Officer, NAS) recall Det's creative efforts to enhance the role of the Academy in the development and utilization of scientific knowledge for the welfare of our nation:

Det saw the NAS/NRC also as a place where the health of basic science must be faithfully tended, and its role as the foundation of the whole technological enterprise must be emphasized. Not only must the case be constantly and powerfully made for ample financial support of basic research, but here lay an extraordinary opportunity to foster gatherings of scientists where the "state of the frontier" in various fields could be discussed and ideas could be exchanged. He took part himself in many such meetings. And he found other occasions for preaching the gospel. When his beloved sailboat was destroyed by a hurricane that took a capricious and unpredicted course, he reacted by seeking ways to interest more physicists, chemists, and mathematicians in the basic problems that underlie the science of meteorology. On the science/society frontier, he enjoyed nothing more than talking to a group of highway engineers, challenging them to take some time away from problems of materials and design in order to think in the broadest way about the future role of highways in relation to the welfare of a nation and its people. He hoped that each major unit of the NRC would gather a small group of creative thinkers in its field who could ponder the broader horizons and the deeper potentialities of their common enterprise.

His courage and vision were manifested in very practical ways. As the activities of NRC grew under his leadership, the Council of the NAS was often concerned about over-extension. But he had no doubts. The potential service of NAS/NRC to science and the nation was limitless. He had to work to persuade a cautious Council to lease the first "outside" space for our activities, a tiny building two blocks from 2101 Constitution Avenue. By the end of his administration, there was "outside" space in eight different buildings, vastly exceeding the "inside" space. At the same time, Det was keenly conscious of the symbolic importance of a suitably impressive "house" of the NAS/NRC, and he tended that as well. He believed that man's spirit is ennobled by noble architecture and noble symbolism. The Supreme Court housed in the Empire State Building would not do. So he always had close to his heart the enlargement of the Academy's own "house", an enlargement that had been envisioned for the future in the original plans of Bertram Goodhue when he designed the building at 2101 Constitution Avenue in the 1920's. Det learned that the directors of the Equitable Life Assurance Society of North America were considering

a "gift to the nation" in celebration of the 50th anniversary of the founding of that Society. They invited him to discuss with them the kind of gift that would be most suitable. What more natural than that he should emphasize the intimate relationship between their interests and the furtherance of the life sciences, and what more natural than that they should then conclude that no more appropriate gift could be made to the nation than funds to add a "life sciences wing" to house the headquarters of the Academy's activities in that field? Heartened by this success, but never narrowly interested in just one area of science, he later spearheaded the campaign that raised funds from many sources for the balancing "physical sciences wing."

After World War II (1945) Vannevar Bush proposed, in a report requested earlier by President Roosevelt, the establishment of a national science foundation. The necessary legislation required congressional hearings, with scientists as the principal participants in formulating the bills and testifying before Congress. During the war, mobilization and cooperation among scientists in support of the national goals revealed the potential value of continuing the support of science as a national asset. However, in peacetime the long-range national goals did not provide the same unity of thought and purpose. Congress and the Administration tended to regard the scientific enterprise as a national resource that should be directed and controlled by legal procedures. The scientists and educators, so unified during the war effort, now revealed in legislative hearings extensive differences of opinion. This public revelation of individual freedom of thought, characterizing all university faculties, was not conducive to generating legislation that formalized the support and the direction of scientific research. Repeated efforts failed to establish a national science foundation. In the interim, the short-term, mission-oriented investigations, previously funded and coordinated by OSRD, were administered by various government agencies, Office of Naval Research (ONR), and NRC. The principal problem was that many scientists sought legislation that would insulate the scientific enterprise from political manipulation, whereas the Federal Administration sought con-

trol through the appointment of the managing board and the director.

Bronk, too, was engaged in testifying before Congressional committees concerned with this legislation. His testimony in 1945 on Bill S-1297 reiterated two principles that he believed essential for the long-range development of science as a national asset. He spoke in favor of "A Division of Basic or Natural Science for encouragement of research of a purely exploratory nature; uninhibited by the necessity of solving useful problems." Later he said, "I urge that means be found for giving many scientists of proven or potential competence the freedom to direct the course of their own investigations." During this period Det continuously exchanged letters with many other scientists involved directly with this portentous change in the relation of the Federal Government to the scientific enterprise They were very conscious that the form of the legislation would influence the direction of scientific development in the country for the foreseeable future. During the next five years they shifted tactics and made compromises, hoping to insulate the directorship from political control. However, President Truman insisted that the managing board and the director be appointed by the President of the United States. The advent of the Korean War provided a strong incentive for establishing a national science foundation to coordinate federal support for science in universities and other research institutions. Finally, in 1950, Truman signed the Bill establishing the National Science Foundation (NSF), which provided that the President appoint a board and a director.

The value of Bronk's advice in this creative enterprise was recognized when Truman appointed him a member of the first National Science Board in 1950. The Board, in turn, elected him Chairman of its executive committee. Det served as a member for fourteen years, during which time its primary policies were being formulated. As President of The Johns Hopkins Uni-

versity he was well versed in the problems, opportunities, and social value of advanced study and basic research—a primary concern of the new NSF. James B. Conant, Lee A. DuBridge, and Bronk were strongly in favor of initial emphasis by the NSF upon support of basic research and of fellowships to encourage competent students to choose a career in science. They, and many others, retained a direct role in academia while serving science from a strong position in Washington. For this reason the advancement of science in the nation was firmly linked to the advancement of science in our universities. There was strong support for the idea that basic science flourishes best in the free intellectual atmosphere of the university. The early policies of the NSF reflect this view.

Bronk was indisputably in the vanguard of those who guided the flourishing of the scientific enterprise in America following World War II. The political and social climate was favorable because of the effective service of scientists to the nation during the war. These years were marked by events that changed the national perception of the role of science in our society, as well as the rate of acquisition of new knowledge and of its application. The structure of these changes was a direct result of the actions of many scientists who donated a large part of their talent and attention to the promotion of science as a national resource. In 1955, the Board elected Bronk as Chairman, a vote of confidence that was made explicit in a letter from Lloyd Berkner. "This action of the Board will meet the unanimous approval of the scientific community, since we have all learned to have enormous confidence in your great wisdom and sound judgment as the leader of American science." Det continued as Chairman of the National Science Board for nine years.

I have never witnessed Det Bronk in action at a substantive meeting of the National Science Board, the Council of the Academy, or the Board of Trustees of any of the universities that he served. The following remarks by W. O. Baker are

commensurate with my expectations based upon discussion with Det spread over many years and my recent reading of some part of his extensive files of correspondence on such matters:

> We need hardly say that the experience of the trustees [of The Rockefeller University] during Det's tenure was no less demanding than that of the students. Led by Chairman David Rockefeller, who fully matched Det's zeal for frontiersmanship and excellence, we became progressively informed on examples of how to make the institution respond to relentless, but always cheerful and expectant, demands for progress. Whether it was for approval of a seductive call to another illustrious scholar for the faculty, for the Tower Building Committee to house new work, or for the Kiley landscaping to delight the eye, Det never let a trustee languish.
>
> But of course, that had always been his way. For instance, his founding and initiating role in the National Science Board, after his appointment by President Truman as a Charter Member, was good preparation for his chairmanship from 1955 to 1964. The period through the 1960's saw the greatest growth of the National Science Foundation and its profound influence in the national community of research and education. The many weekend meetings, orchestrated by Det Bronk, in which the Centers of Excellence programs, new curricular supports, national research institutions from the Antarctic to the Rockies, and many other activities were conceived and pursued, represent an historic phase of Federal science and education. His relation with Congressman Albert Thomas, the crucial chairman of the Appropriations Subcommittee of the House of Representatives, was a particular delight to behold. They shared a zest for life and people which established lasting rapport. Those of us who attended the annual hearings in the period, when the budget and role of the Foundation were growing steadily, were charmed by the solid and confident exchanges between the master politician from Texas and the politic master from nearly everything else, including the National Science Board.*

Det has recorded his personal recollection of these events in "The National Science Foundation: Origins, Hopes, and Aspirations" (*Science,* 188[1975]: 409–414).

Again, it is interesting to note Det's style of achieving common goals through many overlapping channels of management. During the period from 1950 to 1962 he was president of a university, chairman of the Board of NSF, and president of NAS.

* *Recollections of Detlev W. Bronk by Colleagues and Friends, February 18, 1976.* (N.Y.: The Rockefeller University Press.)

Indeed, he also had direct administrative control of NRC by acting as unofficial chairman from 1954 until 1959, at which time the Council formalized the arrangement. By this act the NAS–NRC affairs became more firmly linked by making the President of the Academy function as the administrator of NRC affairs. This change of administrative responsibility was fostered by Bronk, an arrangement opposed by Richards and favored by Jewett at an earlier time. It was a major administrative change that proved useful and has persisted to the present.

The NAS is responsible for implementing the participation of our national scientific societies in international scientific affairs. It administers our national cooperation with the International Council of Scientific Unions in a wide range of disciplines. Det was highly motivated to promote such activities through his experience as Foreign Secretary of the Academy (1945–1950) and his strong belief in the universal character of significant scientific advances. Among the major projects of this kind during his presidency of the NAS was the International Geophysical Year (IGY)—1957–1958—which required four years of preparation. President Eisenhower was particularly interested in this undertaking and decided to institute the Vanguard satellite program as part of the participation by the United States. Then came Sputnik and the dramatic announcement by Lloyd Berkner of its launching—at a party for organizers of the IGY held in the Russian Embassy. This and related events are recalled by Bronk (aided by William T. Golden's diary) in "Science Advice in the White House. The Genesis of the President's Science Advisers and the National Science Foundation" (*Science,* 186[1974]: 116–121). It fell to Bronk as President of the NAS, to make a proper response to the Russian Academy of Science. It was a congratulatory statement emphasizing the universal quality of scientific accomplishments. Later, President Eisenhower spoke to the nation in the same vein, after an interesting consultation with Bronk on the role of science in national

affairs. Bronk has traced a direct relation between these events and Eisenhower's decision, in 1957, to appoint a science adviser to the President, a proposal suggested by William Golden in 1950 and promoted by many over the intervening seven years. After the war there developed an ever increasing need for advice and counsel on scientific aspects of defense, reaching deep into foreign policy in relation to arms control and test-ban treaties. These concerns led to the formation of the Science Advisory Committee (SAC) within the Office of Defense Mobilization in 1951. Several years later, in accordance with the 1950 proposal for President Truman, SAC was conveniently transformed into the President's Science Advisory Committee, or PSAC, advising the President directly on scientific aspects of national policy. Simultaneously, also as proposed in 1950, the Office of Science Adviser to the President was created. These actions were precipitated by Sputnik much as the Korean War catalyzed the formation of the NSF. Thus, in 1957, the role of science in government was enhanced by Eisenhower's strong support, and science in the service of the nation achieved political, in addition to educational and technical, dimensions. Bronk was a charter member of PSAC and, appropriately, chairman of its subcommittee for foreign relations.

As the role of science in national policy increased, the requests by the Federal Administration for advice from NAS changed. In January 1958, Secretary of Commerce, Sinclair Weeks, asked Bronk to form a committee of the NAS to evaluate all scientific programs within the Department of Commerce. This unusual request exemplified the character of the new need for advice on scientific activities within the Federal Government and, according to Bronk, was one precursor to the formation of a new kind of standing committee within the NAS, distinct from the committees of the NRC. Similar requests for advice from the President's Science Adviser and from PSAC promoted this development. In May 1961 Bronk wrote to George B. Kistiakowsky

a letter that initiated the formation of a "Committee on Government Relations." He stated that the purpose of Committee was

> to assist the President and the Council of the Academy in responding to requests for studies and evaluations of scientific needs of the country, including long-range planning of major facilities, coming from the Executive Office of the President (President's Science Advisory Committee and Federal Council for Science and Technology) and especially from Congressional Committees. It will also undertake such studies on its own initiative for transmittal to the above Government organizations. It will not be concerned with advisory activities for individual executive agencies such as those of various NRC committees.

Kistiakowsky, motivated by his experience as Science Adviser to Eisenhower, had perceived the need of such a standing committee in the Academy. He had urged its formation in discussions with Bronk. The committee described above was the precursor to the Committee on Science and Public Policy (COSPUP), established in 1962, that evolved under the dedicated leadership of Kistiakowsky into one of the most effective advisory instruments in the Academy.

FREEDOM FOR INQUIRY

Det Bronk was a staunch patriot who believed that the mobilization of scientific knowledge for the benefit of the nation was a duty for every scientist. In turn, he considered the support of basic science a proper function of a Federal Government concerned with the long-range welfare of the nation and its people. He foresaw that restraints on freedom of inquiry would surely arise as the scientific enterprise became increasingly recognized as a national resource for solving social problems related to defense, health, food, and technology. He knew that freedom of inquiry and dissent were essential in the search for new knowledge and he understood clearly that science must be free of politics and of nationalism. Among the ten listed objectives of his administration at The Hopkins (Annual Report, 1953) one

can read: "Defend the right of scholars to investigate, debate and question conventional concepts and to seek new knowledge which [sometimes] fosters insecurity of established ways of thought and life." He also knew that acquisiton and synthesis of basic scientific knowledge depended upon supporting the advanced study and research of a gifted few among our citizens. He believed that this could be adequately achieved only with federal financial support, and, in turn, he recognized that in a democracy such selective support required widespread understanding among the people of the origins and proper uses of science. To this end he spoke and wrote about these matters often after 1945, when his role in Washington began to assume a broader scope than obtained during the war.

One might suppose that his administrative experiences in Washington during World War II generated such views. This surmise would be wrong because in a paper on "The Social Obligations of the Scholar" in 1934 he wrote, "The scholar is not excepted. He will neither escape the questioning of society in rapid flux nor fail to benefit by an analysis of his social relations." Then he added, "How are we to secure from society conditions which will make possible the existence of the scholar?" Twenty years later, after much practical experience, he wrote,

> Progress requires courage. If we are to fulfill our rightful role in the furtherance of science, we need abundant courage. For this we are fitted by tradition and by the nature of our calling, for we are discoverers and teachers of new knowledge which is usually challenged and disputed. And so, there is no place in science for timid men and women who are unwilling to defend their necessary freedom for inquiry and free unprejudiced discussion. The furtherance of science requires courage to withstand the pressure of reactionary forces.*

To an impressive degree Det Bronk practiced what he preached

* "The Role of Scientists in the Furtherance of Science," *Science,* 119(1954): 223–227.

as numerous problems arose from the federal support of science in universities.

After World War II much of the research, as well as the training, of young scientists was done in the universities but with funds derived from federal taxes. Specific policies, defining the role of government in higher education and preventing infringement of the principle of academic freedom through politically motivated interference, were needed. During these same eventful years prominent scientists were confronted with another aspect of this problem arising from their increasing influence in national affairs, especially national defense. Some members of Congress concerned with un-American activities suspected the loyalty and integrity of some scientists. Progress in developing a productive national science policy was slowed by public reaction to such accusations. Not only were the careers of individual scientists disrupted, but unwise resolution of these problems also jeopardized federal support of basic science. One of the most difficult and unpleasant problems for scientists was how to deal with a prevalent Congressional attitude that all scientists supported by federal funds must have complete security clearance through the FBI, even graduate students holding fellowships from federal sources. All parties agreed that federal support of science was essential for defense and the general welfare of the country. The issue was the specter of political intervention into higher education through centralized control of research and advanced study. One proposed compromise was a special loyalty oath, but this was objectionable to many scholars. The Joint Congressional Committee on Atomic Energy brought the matter into focus first (1948) when they discovered that an alleged communist sympathizer had been granted a fellowship by the Atomic Energy Commission (AEC) to study advanced physics.

Bronk was frequently a negotiator in these matters, problems which threatened the federal support of science generally. As

Chairman of the NRC he was directly involved in the AEC fellowship program because recipients were selected "solely on merit" by a committee of the NRC. The Joint Congressional Committee on Atomic Energy was opposed to granting AEC fellowships solely on scientific merit. They were adamant that government funds must not be used to support the studies of persons who advocated "overthrow of the government by violence and subversion." Bronk clearly perceived that resolution of this problem required finesse to protect the freedom of inquiry by scholars in universities and to insure continuation of student aid from federal sources.

In 1949, a meeting of scientists was convened by the American Association for the Advancement of Science to consider legislation establishing a National Science Foundation which was marred by an amendment requiring loyalty oaths for scientists receiving federal funds for research. As Chairman of the NRC Bronk reported that: (1) the NRC opposes "clearance" procedures being required of scientists working in unclassified areas and (2) it continues to administer federal non-military fellowships that carry security restrictions by the law providing the funds. He stated that some Congressmen wanted security clearance procedures for all students with federal fellowships. He said the NRC position was weakened because individual scientists and scientific societies did not take a firm public position on the matter.

Later, in 1952, he was again involved in problems arising from NSF grants to "communistic" scientists, at a time when he was on the Board. Finally, he helped to construct a generally acceptable policy on the matter when he persuaded Sherman Adams, President Eisenhower's adviser, to request that a committee of the NAS be formed to study the problem and make suitable recommendations. The need for advice in forming federal policy in this matter is contained in Adams' letter to Bronk (January 11, 1955) with the explanation that, "calling

upon the Academy in this way is in keeping with its Congressional charter to advise the Government in the formulation of policy to the end that the scientific resources of our country may be fully and effectively utilized." As President of the NAS Det appointed the committee with Julius Stratton as Chairman.

The committee recommended that scientists involved in unclassified research and advanced study need not be cleared. In April 1956, a letter from Sherman Adams indicated that the executive departments and agencies of the Federal Government would endorse the recommendations of the NAS committee on security procedures. A letter to Det from Stratton states, "On the whole, I feel that the great contribution of the Academy in this matter—and a very large part of the credit goes to you personally—is to have persuaded Governor Adams to take public administrative action in the matter." Bronk's persistent efforts in these affairs are also noted in a letter from D. E. Lillienthal, April 1956. He comments on the official action by Adams and continues, "This reminded me, of course, of the first time this precise question arose; it was under the AEC's unclassified basic research fellowship program. With exemplary forthrightness, you made a case against this mischievous doctrine of FBI investigations in non-secret research. Although I took quite a beating at the time for doing what I thought the AEC Chairman should to defeat that move, I felt that we were right: I hope that now sanity is going to be restored." The acceptance of this principle by President Eisenhower as federal policy settled the matter for most scientists receiving federal support for unclassified research, including students. The strong interest of Eisenhower in promoting science to achieve national goals provided the right circumstances for a rational solution to the problem. However, the Congressional Committees continued their watchdog responsibilities and incorporated in relevant laws the specific requirement that Communists were not to receive federal money for research or for advanced study.

The problem of granting fellowships to avowed Communists rose again in 1960 when the House Committee on Un-American Activities charged that the NSF had done just that. Bronk, as Chairman of the Board, was again involved, although Alan T. Waterman, as Director, was held responsible. The case reached the Supreme Court in 1963, but in the interim the NSF revoked the fellowship in accordance with the laws under which NSF operated. Such events were rare, and this aspect of the law has seldom been invoked. Indeed, Waterman claimed initially that there were no legal grounds for revocation until the Congressional Committee convinced him otherwise. The loyalty problem for graduate students continued at least ten years after the AEC episode. In more general terms the problems were related to procedures for insuring the freedom of universities from political influence while maintaining federal support of advanced study and basic research. Each new case required new policies depending on contemporary views of the role of the Federal Government in higher education. Now, the problems revolve around equal rights legislation as a potential conflict with selection of scholars "solely on merit."

Thus, the security issue became a distinct instance of federal intervention into university affairs, forcing faculties to adopt relevant policies. Bronk was confronted with this aspect of the problem as President of The Johns Hopkins University. In March 1950, Senator Joseph McCarthy accused Owen Lattimore of being an active Communist. He stated that Lattimore was associated with organizations listed as subversive and was simultaneously an adviser in the State Department. At the time, Lattimore was director of the Walter Hines Page School of International Relations at The Hopkins. Bronk was confident that Lattimore would testify and clear himself and stated this to the press, without consultation with Lattimore who was on a mission in Afghanistan for the United Nations. Bronk asked Senator Tydings to arrange a full hearing for Lattimore. On the

occasion he stated to the press, "I have seen no evidence that Lattimore is a pro-communist, but I have made no investigation. If national security is involved, of course, I feel anyone—even my own father or mother—should be investigated." When Lattimore testified, he was less than a cooperative witness and subsequently was charged with perjury. The Board of Trustees and some alumni were critical of Lattimore for his uncooperative behavior before the Senate Committee on Internal Security. Bronk decided to give him a leave of absence with full pay until the perjury charges were resolved. His action was supported by the Board and the Academic Council of The Johns Hopkins University. In 1953, the Walter Hines Page School of International Studies was discontinued and Lattimore assumed the title of Lecturer which he held until 1962.

The federal support of science within agencies of the government also invites interference from politicians who do not understand the objective character of good science. A typical instance was the dismissal in 1953 of A. V. Astin, the head of the National Bureau of Standards, because of a Bureau report that certain battery additives tested there did not improve performance of storage batteries. The Secretary of Commerce, Sinclair Weeks, considered the report an interference with free enterprise in marketing a product. Backed by the NAS, Bronk interceded to have Astin reinstated until a committee of scientists of the NAS could review the scientific evidence and evaluate the methods of testing used by the Bureau. At the time he was also a member of the Board of Advisers for the Bureau. It is interesting to note that Bronk handled his intervention in the Astin dismissal through reasoned discussion and that he and Secretary Weeks cooperated successfully for five more years until Weeks resigned in November 1958 (see page 54).

During this period, as President of both Johns Hopkins and NAS, Det spoke at commencements in all parts of the country. His themes were chosen to interpret the vital role of scientists and

other scholars in a democracy. He stated frequently that these are difficult times requiring the use of reason and restraint of emotional reactions in the solution of our problems. He reaffirmed the necessity in a democracy of personal freedom and self-determination. He spoke often of the necessity of freedom of inquiry, as in scientific research. In this way he strove to make clear the problems faced by scholars in universities as they sought financial aid from governmental sources. Concomitantly, he formulated and organized his own thoughts on the relations between the scientific enterprise in universities and social goals of a democratic society. As President of the NAS he focused upon problems facing scientists, but as President of Johns Hopkins he was concerned with the similar problems of all scholars in universities. In 1950 he stated, "Precious values of democracy are best preserved if universities receive major support from the private sector—free of political forces of distortion." In a speech dedicating the New York Academy of Science building, he decried "secrecy in science" as the antithesis of sound investigations of natural phenomena and asked for reaffirmation of "the individual's right to know as a basic human right."

Det spoke often of the proper conditions for promoting creative scholarly advancements. Among these were careful selection of creative people and protection of their rights as thinkers who might disturb the status quo. In concert with many others, he tried to develop policies that would insulate the scholarly enterprise from military, political, or commercial control and exploitation. For over fifteen years, 1948 to 1962, he had dealt with many specific instances of such interference. He was guided in his actions by personal principles but learned the political realities that derived directly from federal support of advanced study and research. This experience led him and others to emphasize the importance of retaining as much private support of universities as possible—to insure that freedom of thought and inquiry would be encouraged and defended against centralized political control.

A COMMUNITY OF SCHOLARS WHO ARE SCIENTISTS

During some part of 1953 Det Bronk was President of The Johns Hopkins University, The Rockefeller Institute for Medical Research, the National Academy of Sciences, and the American Association for the Advancement of Science and also Chairman of the Board of the National Science Foundation. This was the year in which he made the transition from Hopkins to The Rockefeller Institute and was President of both for several months. Indeed, immediately after this event he became a member of the Board of Trustees at Hopkins in order to continue as adviser to that institution. The procedure and purposes of this arrangement are reminiscent of his continued role at Swarthmore College after he became Director of the Johnson Foundation and Professor of Biophysics at the University of Pennsylvania in 1929. He did relinquish one responsibility when he resigned as Editor of the *Journal of Cellular and Comparative Physiology* (JCCP) in 1953, a post he had held since 1939.

In his last Annual Report as President of Hopkins (1953) he listed ten items of academic policy he had hoped to develop when accepting the position in 1948. Two of these are particularly representative of his concept of the ideal university.

> (1) I believed that research, as the basis for thought and as prelude to action, was essential to modern life. The Hopkins seemed to be the ideal community of scholars for furthering such objectives with little emphasis on pedestrian instruction or on distinctions between faculty, graduate and undergraduate students.
>
> (2) Foster the unity of knowledge and reduce the significance of departmental barriers. The growth of knowledge and the increase of information regarding man and nature encourages specialization. But understanding requires comprehension of many related fields of learning. Unless creative scholars and students learn in universities which stress the unity of knowledge and scholarly endeavor, universities fail to provide the intellectual leadership sorely needed in our complex civilization.

From 1949 to 1951 Bronk and the Hopkins faculty worked to implement these ideas, and in 1951, as a member of the Board

of Scientific Directors of The Rockefeller Institute, he became chairman of a subcommittee that was to nominate a successor for the director and to propose new policies and programs for the further development of that institution. At Hopkins the faculty had begun to de-emphasize the prevailing distinctions between graduate and undergraduate education. In addition, steps had been taken to encourage wide-ranging interdisciplinary study by reducing formal departmental requirements. Unfortunately, the majority of undergraduate students were not sufficiently prepared or not interested in proceeding rapidly into advanced study and research. For many disciplines a high degree of specialization is necessary and must be provided in training undergraduates. These considerations preclude establishing most universities as "communities of scholars devoted exclusively to wide-ranging advanced study and research." As Det continued his discussions of advanced education with the faculty at Hopkins and, simultaneously, his efforts on the committee considering the future development of The Rockefeller Institute, the idea of a graduate university of science emerged. This basic concept was in his final report to the Board of Trustees of the Institute submitted in March 1953, after he had accepted their offer to succeed Herbert Gasser.

In September 1953 when Bronk became President of the Rockefeller Institute for Medical Research, he was at last in a position to develop a unique institution devoted exclusively to the sciences, including the history and philosophy of science. He hoped to create a graduate university within which the young scientists learned from the more experienced, and all were there because of an intense dedication to increasing understanding through advanced study and research. Det was fully aware of the exceptional opportunity thus presented to him and proceeded enthusiastically to build his ideal university, making effective use of the existing faculty who favored his general proposals and putting no constraints on those who preferred to

remain aloof from the enterprise. The Rockefeller Institute for Medical Research was composed of autonomous laboratories devoted exclusively to experimental investigations of medical, biological, and biochemical problems. The faculty had much experience in training postdoctoral fellows in research. Det perceived that his major tasks were to increase the range of intellectual pursuits by new appointments to the faculty and to provide for graduate education. Among the recommendations adopted by the Board of Trustees in June 1953 was a plan to initiate a program in advanced study and research in science for a small group of carefully selected students who were candidates for the degree of Doctor of Philosophy. In October 1954 he and John Lockwood (Secretary and Associate Counsel) reported to the Trustees their preliminary discussions with the Board of Regents of the State of New York. In January 1955 the Rockefeller Institute for Medical Research was incorporated under the Board of Regents with the right to grant the advanced degrees of Doctor of Philosophy and Doctor of Medical Science, as well as certain honorary degrees. In September 1955, ten graduate fellows began their studies as candidates for the Ph.D. The Rockefeller Institute had become a graduate university in fact, though not in name. Much later, in 1965, the Institute became officially The Rockefeller University. The continuity of purpose in Det's thinking about higher education in the sciences is clearly evident, starting at The Hopkins in 1949 and culminating in the first convocation for the granting of degrees at The Rockefeller Institute in 1959. At the Institute he was now immersed in one of the most imaginative enterprises of his administrative career. In this creative effort he was helped and encouraged by the strong support and good advice of David Rockefeller, Chairman of the Board of Trustees.

Det had a great appreciation for the special role in society of creative scholars, and now he had a rare opportunity to bring such people together at the new Graduate School and Research

Center. He invited many scholars for short visits, choosing those in areas of research not strongly represented at The Rockefeller Institute. Simultaneously, he initiated his plans for an enlarged permanent faculty. Of course, biophysics was introduced in 1953 when he accepted the presidency. Then came Paul Weiss, Edward Tatum, and Fritz Lipmann. He was elated when Samuel Goudsmit advised him that George Uhlenbeck, Theodore Berlin, and Marc Kac might be interested. Thus, the faculty in biology was expanded and a faculty in mathematics and physics created. Det wisely focused his attention on individual scientists and carefully avoided constructing any group that might function as a conventional academic department. The next appointment was Carl Pfaffmann who proceeded to help him bring in talented people concerned with a variety of basic investigations in the behavioral sciences. The final extension of the scope of scholarly inquiry within The Rockefeller University was marked by the arrival of logicians and philosophers. As a prelude to this innovation, he had earlier (1961) appointed Ludwig Edelstein Professor, and had stated to the Board of Trustees, "It is only of incidental significance that he is a distinguished historian of biology and medicine. It is of deep significance that he is a great humanist; as a community of scientists we have suffered too long from lack of association with scholars such as he who is versed in the origins of modern science and the influence of science on the ideas and habits of man." The intellectual range of this enlarged faculty represented Det's view of the range of interests that a scholarly scientist should have in good measure.

His greatest concern was the selection of students with a scholarly potential that was commensurate with that of an exceptionally competent faculty, all of whom were engaged in research. For many years he talked with every prospective student invited to the campus for interview. He befriended all who were admitted and encouraged them in their efforts as long as he perceived a continued sincere endeavor to succeed. He scorned only those few who, in any manner, deliberately misused their

opportunities for full-time study and research. Det's description of the graduate program, in the Catalogue, was an expression of his vision of an ideal graduate university. The following excerpts from the Catalogue for 1967–1968 are, in effect, a résumé of his ideas about education that can be traced in published speeches as they evolved over a lifetime of service to universities.

> The purpose of this University is to further natural science and its application for the improvement of human welfare.
>
> The University is not an aggregate of departments dealing with specialized fields of science. It is a community of scientific scholars who are free to follow their interests in any field of scholarship.
>
> The students are few, and the faculty are many. This enables close association between the two, they live and work as junior and senior colleagues.
>
> Students must be capable of self-directed study. Although many courses are offered, teaching is done primarily in seminars, in tutorial conferences, and in faculty research laboratories. There is thus considerable freedom for the active process of independent learning.

He created a seminar for new students in which "the student deals with the significance and relation of ideas. At the outset of his career he is thus encouraged to develop a broad foundation of competence in many fields of science and to recognize the relations of his special field of interest to other areas of science. He is persuaded to broaden his concepts and become an independent thinker rather than a mere helper in a restricted part of another's highly organized program of research."

Det knew that only a few truly exceptional students could make effective use of such opportunities but believed these explicit idealized statements in the Catalogue would attract only able students who also had the courage to face the implied challenge. They must be exceptionally intelligent, he liked to say, but in addition they need self-assurance, self-discipline, and a great urge to learn through advanced study and research.*

* A more detailed review of these events is in my essay, "Detlev Bronk and the Development of the Graduate Education Program." In: *Institute to University, a Seventy-fifth Anniversary Colloquium, June 8, 1976* (N.Y.: The Rockefeller University Press).

I believe that most of the 125 students who received their diplomas from Det's hand in Caspary Auditorium would agree with the last paragraph in the memorial talk by Johns Hopkins III (an alumnus):

> It seems to me that a memorial service should do more than honor the dead. It should elicit new reflection and new dedication from the living. I think Det would have wanted to tell all of us who are associated with research and teaching to work a little harder, to put a little more faith in the student, and to make sure that The Rockefeller or any other university, and the enterprise of basic science, are passed on to the next generation in better and more effective condition than we found them. Perhaps, most of all, he would want to reaffirm his belief that, in this or any other endeavor, human relations and human dignity must be paramount.

MONUMENTS

A plaque in front of the Detlev Wulf Bronk Laboratory on the campus of The Rockefeller University describes him as Scientist, Educator, Humanist. One could well have added Patriot because Det Bronk's activities were strongly motivated by his urge to further the scientific enterprise for the welfare of the nation. Indeed, he believed the advancement of science to be in the public interest, materially and philosophically. With this description in mind the first outline of this biographical memoir was in three distinct sections. It was to be an account of his scientific research, followed by his role as teacher and university president, and terminated by an analysis of his concern with the relations of science to the welfare of the nation. This intention was somewhat strengthened by Det's description (1970) of his productive professional life in these words, "After fifty years as an engineer, biologist, and servant of universities and government, I still have faith in science and reason as sure means for creating an ever better quality of life." Of these fifty years he considered thirty spent "on the frontiers between science, technology, and public affairs. . . ." The other twenty were devoted to research and the development of biophysics as

a unified field of science. Then I systematically read through his published papers, other than research reports, and changed the plan. Despite his wide-ranging activities, there was evident a continuity of principle and purpose that unified his efforts. Furthermore, his manifold active roles were never end-to-end but extensively overlapping in time and intent. He obviously moved toward his larger goals by concomitant channels of influence achieved through simultaneous service in related institutions. For example, his views of the proper relations between universities and the Federal Government were represented simultaneously in the councils at Johns Hopkins University, the National Academy of Sciences, the National Science Foundation, and the President's Science Advisory Committee. Furthermore, as late as 1949 he concerned himself with experiments and their interpretation in a Croonian Lecture to the Royal Society of London at a time when he was Chairman of the NRC, President of The Johns Hopkins University, as well as Editor of JCCP. Clearly, his was an integrated life that cannot be partitioned readily into distinct segments. This memoir is written with the latter idea in mind and with an effort to exhibit that, for Det Bronk, "thought is a prelude to action." Because he usually preached what he practiced, I consider the following paragraph from a speech at a high school graduation, late in his life, to reveal his personal experience.

> Life is a wonderful journey through a beautiful world—it is filled with glorious adventures, and the only danger ahead is that we spend our time on the trifles and miss the rich experiences. I therefore challenge you to stop now and decide what you hope to get from the years to come and how you are going to live in order to realize those values which you consider most important. It is imperative that you make these decisions soon for the habits and attitudes toward life which you form or drift into during the next four or five years will largely dominate you throughout life.

I believe this philosophy explains the care with which Det critically evaluated his own motivations, talents, and opportuni-

ties during 1924 to 1926. His decision in favor of teaching and research was immensely strengthened by the subsequent stimulating year of research with Adrian and Hill. Through them he decided to emphasize research and advanced study as contrasted with college teaching. He found a unique opportunity for a career in research as Professor of Biophysics and Director of the Johnson Research Foundation in the University of Pennsylvania.

When Bronk left Philadelphia in 1948 he kept his home in Sycamore Mills, continued an active role in the American Philosophical Society, and participated in the affairs of the University of Pennsylvania as a member of its Board of Trustees. Nevertheless, the move to Baltimore terminated one of the most satisfying periods of his life. As noted by Frederick Seitz in a memorial talk at the National Academy, "His links to the University of Pennsylvania were clearly of a very special nature, encompassing as they did almost his entire professional lifetime, as well as his greatest period of self-discovery and subsequent fulfillment. Moreover, the Philadelphia community is so constituted that he could occupy a somewhat Franklinesque position —knowing and being known by almost every distinguished citizen."*

The various "institutions" derived from Det's creative ideas for the advancement of science have had a marked viability. The Johnson Foundation for Medical Physics (1929) was developed with the idea that research on basic biological problems would best serve the purposes implied in the name. That continues to be the policy now. The Institute of Neurology at Penn (1937) was conceived to unify knowledge of the nervous system, as studied in the laboratory and in the clinic. It continues with its purpose intact. The Hopkins Plan (1949) for permitting tal-

* The story of Det's Philadelphia years will be told with enthusiasm and appreciation in a biographical memoir prepared for the American Philosophical Society by Britton Chance.

ented undergraduates to pursue advanced studies and to progress to the Ph.D. in accordance with their accomplishments has served many gifted young scholars and continues to do so. The Rockefeller University was conceived in 1953 as an ideal "community of scholars" and a unique graduate university for students of science. It continues, with some attenuation in scope, as a graduate university emphasizing the life sciences and related physical sciences. Det Bronk was a dedicated builder of institutions and an enthusiastic builder of buildings as well. His efforts range from modest additions to his first home in Ann Arbor to noble additions to the NAS. He participated directly in creating the campus for the new Rockefeller University, including lawns, flower beds, pools, new administration buildings, dormitories, and two large towers for research laboratories.

A resolution by the Council of the NAS expressed full appreciation of the effectiveness of Det's forty years of continuous service to science and the nation through his work in the NRC and the Academy. He was acclaimed as the founder of the American Institute of Biological Sciences in a memorial in *BioScience*. His effective service to the National Science Foundation was eloquently recognized in a tribute adopted by their Board. One paragraph in this tribute encapsulates his personality well:

"Detlev Bronk was truly a giant among men. He combined wit with wisdom, loved life, enjoyed people, and had interests of a universal scope. He was an avid skier and sailor and loved flying and mountain climbing. He gave equally of advice and concern whether to a young student or to a President of the United States. The world has lost an outstanding citizen and public servant, but will be forever enriched by the achievements and memories of a truly unique individual."*

* From "Tribute to Detlev Wulf Bronk adopted by the National Science Board at its 178th meeting, January 15–16, 1976."

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