Chapter Seven

Physics Graduate Program
George Winchester (1921-1946)

Transformation of Rutgers University

In the years after World War I, the transformation of Rutgers College into a state university moved ahead. The first deans of agriculture and of engineering had been appointed in 1914, and the New Jersey College for Women had been established in 1918. In the following years, the Trustees formally established the College of Agriculture in 1921, and the School of Education in 1922. An attempt to develop an overall plan of organization for the schools and colleges was undertaken by a faculty committee in 1921.

Following discussion at several faculty meetings, the faculty committee submitted a report to the Trustees in 1922. That report proposed a university made up of colleges of arts and sciences, engineering, agriculture, and a college for women, together with a school of physical and biological science, a school of education, and a graduate school. According to the proposal of the faculty committee, there would be departments within schools and colleges, but there would be university departments. As an example, the committee suggested that there should be a single department of mathematics within the College of Arts and Sciences that would serve students in all the schools and colleges. The Trustees accepted the faculty's recommendations, with some modifications. They rejected the proposal for a school of physical and biological sciences and a graduate school. The proposal for university departments would be a recurring theme in discussions about university organization for more than fifty years.[1]

In recognition of this reorganization, the Trustees, in 1924, adopted the title of Rutgers University for all of its colleges, schools, and

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[1]McCormick, *Rutgers: A Bicentennial History*, 174, 178; Demarest, *A History of Rutgers College*, 518; *Rutgers College Catalogue*, 1934..

departments. The reorganization of the University was completed in 1925 when the College of Arts and Sciences was established, replacing the Classical School of the old Rutgers College. Thus, for a time, the name "Rutgers College" appeared only in the corporate title of the institution. The Scientific School was replaced by the College of Engineering and the College of Agriculture. The College of Arts and Sciences consisted of all the departments that were not administered by other Colleges or academic divisions, except the Department of Military Science and Tactics. Walter Marvin, previously Dean of the Faculty, became Dean of the new College of Arts and Sciences.[2]

As Rutgers College was being transformed into Rutgers University, President Demarest submitted his resignation, effective in June 1924. He had become frustrated with the movement of Rutgers from its dual role as a public and private institution to a more truly public institution. During Demarest's period of service there had been a phenomenal growth in the size of the College, and there was a gradual recognition of the importance of research and graduate instruction for the faculty. By the time Demarest resigned in 1924, the faculty had grown to 41 professors, 24 associate professors, 22 assistant professors, and 55 instructors and assistants. While he was President, the undergraduate enrollment had grown from 243 men to 734 men and 419 women, and the graduate student enrollment had grown from 3 to 43 students.[3]

Demarest was followed by John Martin Thomas, who was named President of Rutgers in 1925. After serving as pastor of a Presbyterian Church in East Orange, Thomas had been President of Middlebury College, and then President of Pennsylvania State College. In his inaugural address, Thomas committed himself to fully establishing Rutgers as the State University of New Jersey. Aware of the difficulties he faced, he argued: "That a college socially selective in its clientele, scornful of vocational curriculum, insistent above all on the maintaining of tradition, cannot serve the purposes of a state institution may be freely admitted. That a university responsive to the needs of a great industrial commonwealth may lose some of the amenities of a strictly private

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[2]McCormick, *Rutgers: A Bicentennial History*, 179, 180.
[3]Ibid., 195; *Rutgers College Catalogues*.

institution must be frankly faced." It would turn out that Thomas was largely unsuccessful in fulfilling his goals.[4]

Thomas attempted to increase the level of funding from the State, but it appeared that doing so would require that the University truly become the State University of New Jersey with greater control by the State. President Thomas was prepared to agree to State representatives on the Board of Trustees and to the designation of the University as a State Institution, but the Board of Trustees did not agree.[5]

This position of the Board of Trustees led to a deterioration in the relations between the University and the State. In 1929 the State phased out the state scholarships, repealed the title of State University of New Jersey, which had been approved in 1917 for the Scientific School, and created a state board of regents with a responsibility for higher education in New Jersey. Additional funding to Rutgers was withheld until the status of Rutgers could be clarified. In 1930 the Board of Regents and President Thomas presented to the Board of Trustees a proposal in which Rutgers would be a college of liberal arts, and all other units would be taken over by the State. The Board of Trustees rejected this proposal. Unable to convince the Trustees to take the steps that would transform Rutgers into a state university, and thereby obtain additional state support, President Thomas resigned in 1930.[6]

By 1928 N.J.C. had expanded to the point where the graduating class was larger than that at the men's colleges. Originally, faculty members from the men's colleges provided most of the teaching at the College for Women. However, after 1927 a separate College faculty provided most of the teaching at N.J.C. In 1926 half of the instructors at N.J.C. were faculty members from the College of Arts and Sciences, but by 1930, all but 14 of the 102 faculty members taught exclusively for the College for Women. Separate departments were organized at N.J.C., and the N.J.C. faculty began to assume responsibility for the conduct of the College. In the two decades after 1930, there was little growth in the numbers of students or in the physical facilities at N.J.C.[7]

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[4]McCormick, *Rutgers: A Bicentennial History*, 141, 196-198.
[5]Ibid., 202.
[6]Ibid., 203-207.
[7]Ibid., 207-212.

George Winchester (1921-1946)

When President Thomas left Rutgers in 1930, Philip Milledoler Brett served as Acting President until Robert Clarkson Clothier became President in March 1932. Clothier had graduated from Princeton University, and been Headmaster of Haverford School, and Dean of Men at the University of Pittsburgh. His educational philosophy included a concern for the whole character of the student. He was not inclined to push Rutgers to become a state university, knowing that the Board of Trustees had rejected President Thomas's proposals for a stronger liaison with the State. In a statement to the Board, President Clothier said: "I cannot bring myself to accept the idea of Rutgers turning its back on the tradition of the last 150 years and accepting the status of a state university with all the educational perils and threat to educational ideals which it involves." Until 1940, Clothier pursued his objective to have Rutgers remain a private college.[8]

When Clothier became President, the Board of Regents was still responsible for the relations between the University and the State, and those relations were not very good. While continuing to try to develop plans for a state university, the Regents were critical of the contractual relationship between the State and Rutgers. The Board did not recommend capital appropriations, and the annual appropriations to Rutgers were cut in 1932 and again in 1933. Finally, in 1934, the state appropriation to Rutgers began to increase again, and, in 1937, the state scholarship program was renewed.[9]

The adverse relations with the State and the effects of the depression had a negative effect on the University. Between 1930 and 1940 the number of students in the College of Arts and Sciences and at N.J.C. remained about the same, while the College of Agriculture increased by 25%, and the School of Education, the School of Chemistry, and the Department of Ceramics more than doubled. Because of the austere financial conditions, faculty salaries were reduced in 1932 and 1933, and were not significantly raised for a decade. Most faculty members were frozen in ranks. The faculty remained fairly stable, with few faculty resigning or retiring, and very few new faculty members hired. Tenure for faculty members had not been explicitly recognized, and, in theory, appointments

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[8]McCormick, *Rutgers: A Bicentennial History*, 224-227.
[9]Ibid., 227-230.

were made on a yearly basis. President Clothier was critical of the idea of tenure for faculty members. There was not yet any real pension system for faculty members.[10]

On the positive side, research gradually became important at the University. In 1934 President Clothier stated: "Scholarly research, as well as instruction, is an essential function of the University." Some research was carried out in ceramics, chemistry, engineering, and biology, and by individual faculty members in non-scientific disciplines. A small group of faculty members formed the Bureau of Biological Research in 1936. President Clothier advocated greater research opportunities, and in 1943 allocated $35,000 for this purpose. The Research Council was established in 1944, providing grants to faculty members in support of their research efforts.[11]

World War II had a major impact on the University. In September 1939, the Civil Pilot Training Program began to operate at Rutgers, and in January 1941 the College of Engineering began the Engineering Defense Training. In May 1942, the Army and Navy instituted their reserve programs, which allowed students to continue their education. In September 1942, the upper classes had lost one-fourth of their students, but the freshman class was the largest in history. In the spring of 1943 student withdrawals increased significantly, until, by May, there were fewer than 800 civilian undergraduates in the men's colleges, about half the number at the beginning of the academic year. The decrease continued during the next two years, reaching a low point of 516 in 1944-45.[12]

In March 1943, the Army Special Training Program (A.S.T.P.) was announced, and Rutgers was selected as a pilot school. Several hundred trainees, selected from Army enlisted personnel, came to campus and received basic and advanced training in civil, mechanical, electrical, and sanitary engineering, or advanced training in foreign language studies. Subsequently, premedical and predental programs were added. By the fall of 1943, over 1,300 A.S.T.P. students were in residence. The total enrollment of the men's colleges was 1,855, the largest in history. Then, the pending invasion of Europe caused the withdrawal of most of the

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[10]McCormick, *Rutgers: A Bicentennial History*, 230-243.

[11]Ibid., 241, 242.

[12]Ibid., 255, 256.

trainees from the University. The program did not officially end until December 1945. However, after April 1944, it operated at a very low level, except in the College of Engineering.[13]

In August 1943, the Army Specialized Training Reserve Program was inaugurated. The first A.S.T.R.P. students arrived in January 1944. By early 1945, there were over 400 of these students enrolled in classes in English, history, geography, mathematics, and science. This program continued until March 1946. As a result of the decrease in enrollment and special programs, the men's colleges went on a schedule of four twelve-week terms in April 1943. The regular curricula were largely replaced by two standardized curricula for entering students. New students could begin their study at any of the four terms, and beginning in January 1943, diplomas were awarded to graduates whenever they completed their course requirements.[14]

During World War II, the Rutgers President and Trustees took steps to have the whole institution become the State University of New Jersey. By 1939 the relations between Rutgers and the Regents had begun to improve as the Regents recognized the important contributions Rutgers was making to higher education in New Jersey. President Clothier decided that his early vision of a richly endowed Rutgers in control of its own destiny was not realistic, and came to support a stronger relationship between the State and Rutgers. By 1942 the Regents dropped their discussion of a separate University of New Jersey, and came to recommend capital funds for buildings at Rutgers. At Rutgers there was a growing recognition of the need to strengthen the partnership with the State, rather than to secure huge new endowments.[15]

The efforts to forge a partnership between Rutgers and the State came to fruition in March and April 1945, when the State Legislature and the Rutgers Board of Trustees agreed on a new role for the University. The units of Rutgers were collectively designated as the "State University of New Jersey to be utilized as an instrumentality of the State for providing public higher education and thereby to increase the efficiency of the public school system of the State." Four state officials became ex

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[13]McCormick, *Rutgers: A Bicentennial History*, 256.

[14]Ibid., 257.

[15]Ibid., 251-263.

officio members of the Board of Trustees, along with five public Trustees, appointed by the governor for five-year terms. However, the public appointees represented a minority on the Board of Trustees, and the Board maintained its autonomy to a substantial degree. Nevertheless, this new structure strengthened the position of Rutgers as an instrumentality of the state, and provided for increased public support, while providing that Rutgers would be free of control by a state agency. This formal establishment of all units of Rutgers as the State University of New Jersey appeared to provide a culmination of the transformation of Rutgers from a small private college to a state university, a process that began in 1864 when the Rutgers Scientific School was designated as the land-grant college for New Jersey. However, discussions about the status of Rutgers would continue and lead to a further change in 1956.[16]

At the same time that the University was forging a new relationship with the State, there was an internal review of the faculty personnel procedures. In 1945 the Trustees approved a new set of procedures, which were incorporated in the University statutes. The system of appointing heads with absolute authority was replaced by an arrangement for a chairman to be nominated by the members of a department, serve for a limited term, and consult with colleagues on matters affecting the department. Divisions were set up which provided coordination among departments in different colleges offering instruction in the same field. Terms of appointment for faculty members were codified. Instructors were to hold annual appointments, for a maximum of four years. Assistant professors were appointed for three-year terms, and if in exceptional circumstances they were to continue in that rank for more than six years, they would enjoy indefinite tenure. Scholarly activity, teaching effectiveness, research accomplishments, competence, experience, and general usefulness to the University were set down as the criteria for promotion.[17]

After graduate study had been formally established at Rutgers in 1876, few advanced degrees were awarded until 1912, when new regulations were adopted. Thereafter, there was a slow increase in the number of advanced degrees awarded, initially in the College of Agriculture, then in the biological departments, and finally in the social

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[16]McCormick, *Rutgers: A Bicentennial History*, 263-265.
[17]Ibid., 269.

and humanity disciplines. A total of 51 advanced degrees were awarded in 1930, in addition to those in education. In 1932, the Graduate Faculty was created, composed of those professors who offered graduate courses. It was given responsibility for graduate instruction leading to the degrees of Master of Arts, Master of Science, and Doctor of Philosophy.[18]

College of Arts and Sciences Curriculum

The Rutgers College curriculum, with its system of group requirements, combined with majors, minors and electives, installed in 1917 in the liberal arts courses, was scarcely changed until 1926. Greek was dropped as a major after 1919 and economics was added in 1922. After 1919 only one classical language (Greek or Latin) was required for the A.B. degree. The course, Evidences of Christianity, was last offered in 1916-17, but was replaced by a course in Bible and ethics, which was required of all juniors in the liberal arts courses until 1926. The course in Hebrew was dropped in 1920.[19]

In the technical curricula, English composition was increased to 6 semester hours, and there was a reduction in the foreign language requirement. The number of students enrolled in the technical curricula decreased between 1920 and 1925, although the total number of students in the men's colleges increased from 641 to 753.[20]

In 1926, after the establishment of the College of Arts and Sciences, the group and major requirements were maintained, and groups of courses were recommended for economics, business administration, pre-legal, pre-theological, pre-medical, journalism, chemistry, and sanitary science. In 1929, the group and major requirements were abolished, and all students entering the College of Arts and Sciences were required to choose between the following eleven curricula:

Curricula leading to A.B. degree:

- Language and Literature
- History and Political Science
- Economics
- Pre-Legal

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[18]McCormick, *Rutgers: A Bicentennial History*, 239, 240.

[19]Ibid., 186, 187.

[20]Ibid., 187.

- Pre-Theological

Curriculum leading to Litt.B. degree:

- Journalism

Curricula leading to B.Sc. degree:

- Mathematics and Natural Science
- Pre-Medical and Biological Science
- Business Administration
- Chemistry
- Sanitary Science

In their first two years, the students would pursue a general course of study, with English, mathematics, science, foreign languages, and social science, although the course was not identical for students in the various programs. In the final two years the students would usually take two courses in their major fields, two related minors, and an elective. Classics was no longer a required subject.[21]

Between 1943 and 1945 there was a review of the curricula with a concern about strengthening the liberal education of all students. In July 1945 the Faculty of Arts and Sciences adopted general education requirements that required every candidate for the bachelor's degree to take two full-year courses in each of the following three areas: humanities, social sciences, and mathematics and science. Each full-year course was required to be in a different department. The College for Women also adopted this requirement, which lasted for twenty years.[22]

Physics and Astronomy

After serving as Chairman of the Rutgers College Physics Department for three years, Otis Gage left the Department in 1920 for a position at the Corning Glass Works. Following the departure of Gage, the physics instruction at Rutgers College was carried out for a year (1920-21) by the two associate professors, Frank Pratt and Frank Ferguson, and by an instructor in electrical engineering, Paul Creager.[23]

The following year, 1921-22, George Winchester joined the Physics Department as Professor of Physics and Chairman of the

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[21]*Rutgers College Catalogues.*

[22]McCormick, *Rutgers: A Bicentennial History*, 267, 268.

[23]*American Men and Women of Science*, 1927 edition; *Rutgers College Catalogues*.

Department. Winchester grew up in Illinois, left school at the age of 15, and managed the family's farm. He studied on his own, passed the State Normal School examination at 17, and began teaching in a one-room school. In a few years he became principal of the high school in Chillicothe, Ill. He then decided to be a physicist, and entered the University of Chicago in 1899. He received a B.S. degree there in 1903 and became an assistant to Albert Michelson. He earned his Ph.D. degree from Chicago in 1907.[24]

Figure 19 George Winchester

After receiving his Ph.D., Winchester spent a year (1906-07) at the University of Washington at Seattle as Acting Professor and Head of the Department, and then was appointed Professor of Physics and Head of the Physics Department at Washington and Jefferson College in Washington, Pa. His tenure at Jefferson College ended with a dispute about academic standards, in spite of the fact that he had been successful in raising money for a quality physics laboratory at the College, and he had personally contributed more money than most Trustees. It seems that he had flunked some of the College's leading athletes. In March 1918 he was granted "a leave of absence for the duration of the war, or so long as he remains in the

[24]*New York Times*, February 16, 1960; *American Men and Women of Science*, 1938 edition.

service of the allies." After the armistice he went to work with the French Admiralty, advising the College of his intention to return on July 1, 1919. Meanwhile, the athletic alumni managed to get the Board of Trustees to summarily drop Winchester from the faculty, and appoint his successor. The American Association of University Professors intervened, Winchester was reinstated, and his leave was continued at full pay until July 1919 when he resigned.[25]

During World War I Winchester was a scientific liaison officer in the Army Signal corps. In France he conducted experiments in the front-line trenches, and developed the Army's first infrared signaling apparatus. In an effort to show that his device could be used in airplanes, he received his pilot's wings in the aviation section of the Signal Corps, and flew missions in the forward areas, using his device to signal to colleagues in the trenches. He retired from the Army Reserve as a major.[26]

In July 1919 Winchester became head of the Engineering Laboratory of Research at the Standard Oil Company in Elizabeth, New Jersey. He found this field of research too limited and decided to return to a university setting. In 1921 he accepted the appointment to head the Physics Department at Rutgers. His areas of research and interest included electron theory, fatigue of metals under the influence of ultraviolet light, surface tension, and photoelectricity. Although his research at Rutgers did not lead to major publications, he presented a number of papers on the physics that he was doing at meetings of the American Physical Society. Although not a particularly productive researcher himself, he began the movement of the Physics Department towards research with the recruitment of Robert Atkinson in 1929 and Frank Dunnington in 1937.[27]

When Winchester arrived at Rutgers in 1921, Ferguson moved on to full-time teaching at N.J.C., and Winchester was assisted in teaching at Rutgers College by Pratt, Creager, and Instructor Pierre Van Dyck, the adopted son of Francis Cuyler Van Dyck. Between 1921 and 1923, Winchester and Pratt taught the physics courses at Rutgers College, with assistance from an instructor in physics or electrical engineering.

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[25]Sinclair, *The Goose-Step*, 376.; *New York Times*, February 16, 1960.

[26]*New York Times*, February 16, 1960.

[27]*American Men and Women of Science*, 1933 edition.

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After four years at N.J.C., Frank Ferguson left in 1923 for a professorship at the Connecticut Agriculture College, later the University of Connecticut. When Ferguson left N.J.C., Frank Pratt began teaching there, and David Porter joined Winchester and Pratt in teaching in the Rutgers College Physics Department. Porter had received the A.B. degree from Pittsburgh in 1913, and his areas of research interest included the determination of the velocity of sound in liquids with ultrasonic waves. Porter came to Rutgers as an instructor, and became an assistant professor in 1933. In the later years he shouldered the responsibility for the introductory physics laboratories.[28]

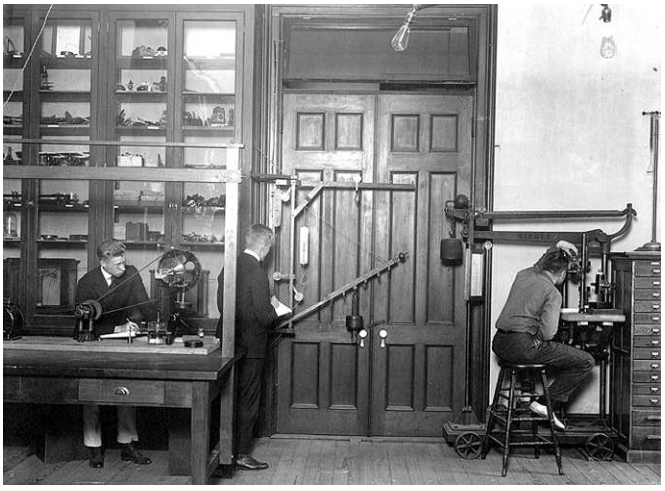

Figure 20 Instructional Physics Laboratory in Geology Hall

In the following year, 1924, the Physics Department expanded again when Alec Lloyd Greenlees became the fourth full-time faculty member in the Physics Department. Greenlees received his Ph.D. from the California Institute of Technology in 1925. In his dissertation he studied the ionization of argon by alpha-particles. He joined the Department as an instructor and proceeded through the ranks to become Professor in 1941. Although he was a very active member of the Department, teaching a

[28]*American Men and Women of Science*, 1944 edition; *Rutgers College Catalogues*.

variety of undergraduate and graduate courses, he does not appear to have had any research publications while he was at Rutgers.[29]

When Winchester came to Rutgers, the Physics Department was housed in Geology Hall. Winchester's office was in the dingy basement with a bare cement floor, which was damp in the summer and cold in the winter. The physics laboratory was simple, and there were scarcely any funds for equipment. With careful use of what little money there was, Winchester was able to add a few pieces of apparatus each year, but he experienced considerable difficulty in building up the Physics Laboratory.[30]

Figure 21 Van Dyck Hall

Concerned about the cramped conditions for the Physics Department in Geology Hall, Winchester pressed to obtain the funds for a new building. In October 1921, a special faculty committee was appointed to prepare a master plan of the physical requirements of the University. The plan assumed that within 25 years there would be at least 2,350 students in the men's colleges, and called for a number of new buildings,

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[29]*American Men and Women of Science*, 1944, 1960 editions; *Rutgers College Catalogues.*

[30]*College of Arts and Sciences Faculty Minutes*, June 3, 1946; *Rutgers College Catalogues.*

including a new building for physics. Because of the lack of funds, little progress was made in implementing this plan, except for a new physics building and a new ceramics building.[31]

In 1925 the State Legislature provided the funds for a new physics building, which was built in 1925-26 and named in honor of Francis Cuyler Van Dyck. It was located on the College Avenue Campus, opposite the Chemistry Building, which had been built in 1911. Winchester worked with the architects and gave careful attention to the many details involved in the design of the new building. The building that resulted served the Physics Department for many years. In later years the History Department made the building its home.[32]

As the Physics Department moved into a splendid new building, it also changed from the Rutgers College Physics Department to the College of Arts and Sciences Physics Department, following the creation of the College of Arts and Sciences in 1925. In 1927 Frank Pratt left the College of Arts and Sciences to teach full-time at N.J.C., and Winchester, Porter, and Greenlees continued to teach the physics courses at the College of Arts and Sciences, with the help of two physics graduate assistants.[33]

At the New Jersey College for Women, Wilfred Jackson joined Frank Pratt in the Physics Department in 1928. Jackson was a native of Canada. He graduated from Dalhousie University at Halifax, Nova Scotia, and he received the Ph.D. from Princeton in 1927. He taught for a year at Kings College in Dalhousie, before coming to N.J.C. in 1928 as Assistant Professor. In 1946, upon the retirement of Frank Pratt, Jackson become Professor and Chairman of the Physics Department at N.J.C. In 1949-1950 he was Chief Scientist in the New York Branch of the Office of Naval Research, while on leave from N.J.C.[34]

Also assisting with the physics instruction at N.J.C. were Graduate Assistants Dorothy Dodd (1928-30), Gladys Francis (1928-30), and Margaret Blackford (1931-33). In addition, Dodd was an Instructor (1930-31), and Katherine Van Horn was an Instructor (1941-43) and Assistant Professor (1943-46). Dodd had an A.B. from Wellesley, Francis an A.B.

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[31]McCormick, *Rutgers: A Bicentennial History*, 185.
[32]*College of Arts and Sciences Faculty Minutes.*
[33]*Rutgers College Catalogues.*
[34]*Physics Today*, May 1959, p. 64; *Rutgers College Catalogues.*

from N.J.C., Blackford a B.Sc. from N.J.C., and Van Horn an A.M. from Wellesley.[35]

In order to advance the physics graduate program, George Winchester reached out to Germany to recruit a truly outstanding physicist, Robert d'Escourt Atkinson. Atkinson is undoubtedly one of greatest physicists who served in the Department. This recruitment of Robert Atkinson was a major step in the development of physics at Rutgers. At the time, physics in the United States was in something of a backwater, while Germany was the center of physics and the forefront of the most exciting developments in physics.

Robert Atkinson was born in 1898 in North Wales. He was taught at home by his parents until he was ten years old. His family moved to Manchester and he attended the Manchester Grammar School. In 1916 he won an open scholarship in classics to Hertford College, Oxford. Before going to Oxford he joined the army in 1917 and saw service in Italy. After the army he went to Oxford and graduated in 1922. Before his graduation he published his first paper in which he worked out the equilibrium conditions for TiO gas in cool stars.[36]

After graduation, Atkinson remained at Oxford for four years as a research fellow at Hertford College and a demonstrator in the Clarendon Laboratory. During this period he published papers on thermodynamics and atmospheric physics. While a Research Fellow at Oxford, he published a paper on the theory of the aurora.[37]

Atkinson left Oxford in 1926 when he was awarded a Rockefeller Fellowship to study under James Franck at Göttingen. While at Göttingen, Atkinson published a paper on the emission of light from hydrogen atoms and a paper on the energy exchange process between molecules and free electrons in gases.[38] He received his Ph.D. in 1928 for a dissertation on the recombination of positive ions and free electrons.[39]

After receiving his Ph.D., Atkinson was appointed Assistant at the Technische Hochschule in Berlin, where he published a paper on the

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[35]*New Jersey College for Women Catalogues*.

[36]*Mon. Not. R. Astr. Soc.*, v. 82, p. 396, 1922; *Q. J. R. Astr. Soc.*, v. 25, p. 100, 1989.

[37]*Proc. Roy. Soc.*, v. 106, p. 429, 1924.

[38]*Proc. Roy. Soc.*, v. 116, p. 81, 1927, and v. 119, p. 335, 1928.

[39]*Zeits. f. Phys.*, v. 51, p. 188, 1928.

excitation of neon by electron impact.[40] He stayed in Berlin for a year (1928-29), collaborating with Fritz Houtermans, on a momentous paper, which proposed that thermonuclear fusion in stellar interiors was the source of energy generation and of nuclear synthesis of the elements. Houtermans had also earned his Ph.D. under James Franck at Göttingen and gone on to the Technische Hochschule.[41] While at Göttingen, Houtermans met George Gamov, who had just published his famous paper on alpha-particle decay.[42] Houtermans insisted that Gamow's theory should be developed with greater mathematical precision,[43] and Gamov and Houtermans published a paper with some refinements of Gamow's theory of alpha decay.[44] At the same time, Gamow published a paper giving the quantum mechanics for the inverse process in which an alpha-particle would penetrate a nuclear barrier from the outside.[45]

Houtermans was aware of Gamow's paper on alpha-particle penetration of a nuclear barrier. It was clear that the rates for such a nuclear fusion were negligible at the energies available in the laboratory at the time, but Atkinson was familiar with Arthur Eddington's estimates of the interior temperature of stars. The result was the fruitful collaboration between Atkinson and Houtermans, which produced the important paper positing the role of nuclear reactions as the source of stellar energy and nuclear synthesis.[46]

In that paper, Atkinson and Houtermans suggested that a heavy nucleus in a star caught and absorbed four protons and two electrons and produced a helium nucleus, which was subsequently emitted from the nucleus. The author's paper was originally entitled "How Can One Cook Helium Nuclei in a Potential Pot?" The editors of *Zeitschrift für Physik* changed the title of the paper to "On the Question of the Possibility of the Synthesis of Elements in Stars."[47] Although inaccurate in some details,

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[40]*Proc. Roy. Soc*., v. 122, p. 430, 1929.
[41]*Physics Today*, July 1992, p. 29.
[42]*Zeits. f. Phys.*, v. 51, p. 210, 1928.
[43]*Astr. Soc. Pac.*, v. 129, 35, 1997.
[44]*Zeits. f. Phys.*, v. 52, p. 496, 1928.
[45]Ibid., v. 52, p. 510, 1928.
[46]Ibid., v. 54, p. 656, 1929.
[47]*Physics Today*, July 1992, p. 29.

the process of the successive capture of four protons followed by the successive emission of an α particle was the essential ingredient of the C-N cycle later proposed by Bethe and von Weizsäcker.

Because the neutron had not yet been discovered, Atkinson and Houtermans assumed that following the proton capture, gamma emission would be governed by the dipole radiation formula, overestimating the probability of the process by a factor of 10,000. Also, because of the state of nuclear physics theory, they assumed that the probability of a nucleus striking the nucleus would be the order of magnitude of the geometric cross section, rather than the de Broglie wave length of the incident thermal protons at the solar temperature of 20 million degrees. This error caused them to underestimate the probability of the collision by a factor of 10,000. Ironically, these two errors canceled out and the rate of energy production calculated for the solar interior was essentially correct.[48]

The correct formula for the rate of the thermonuclear reaction, using the correct collision cross section and the quadrupole emission formula, was published in 1938 by Gamow and Teller.[49] In their paper, Gamow and Teller credited Atkinson and Houtermans as the first to suggest that at the high temperatures in stellar interiors, there was a considerable probability for the penetration of protons through the potential barriers of light nuclei.

In 1939 Hans Bethe published his famous paper on the energy production in stars, identifying the C-N cycle as important in the energy production in ordinary stars.[50] In this paper Bethe identified Atkinson and Houtermans as the first to calculate the probability of a nuclear reaction in a gas with a Maxwellian velocity distribution. Bethe received the Nobel Prize in 1967, primarily for this paper on stellar energy. In his Nobel Lecture Bethe again referred to Atkinson and Houtermans, who concluded in 1929 "that at the high temperatures in the interior of a star, the nuclei in the star could penetrate other nuclei and cause nuclear reactions, releasing energy."[51]

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[48]Gamow, *My World Line*, 70-71.

[49]G. Gamow and E. Teller, *Phys. Rev.* v. 53, p. 608, 1938.

[50]*Phys. Rev.*, v. 55, p. 434, 1939.

[51]"Energy Production in Stars," Nobel Lecture, in Bethe, *Selected Works of Hans A Bethe*, p. 380.

Atkinson came to the Physics Department at Rutgers in 1929 as Assistant Professor, and was made Associate Professor in 1931. At Rutgers, Atkinson further developed this theory in two major papers on "Atomic Synthesis and Stellar Energy" published in the *Astrophysical Journal* in 1931, and a third one in 1936.[52] The Royal Astronomical Society recognized the importance of the 1931 pioneering papers in awarding its Eddington Medal to Atkinson in 1960.[53] Atkinson made a number of other important contributions to astrophysics, including a prediction of the life of bright stars, an estimate of the time-scale of the universe, and a description of the energy process in white dwarfs.[54]

Atkinson taught undergraduate and graduate physics courses at Rutgers, and he took over the astronomy courses when Professor Breazeale retired in 1932. Atkinson was described by his student, George Downsbrough, as a brilliant man, but one who was not especially tolerant of people. He was clearly the most active researcher in the department at the time.[55]

Following the appointment of Atkinson, there were four faculty members in the Physics Department until 1934, when Samuel Anderson joined the Department. Anderson received his Ph.D. from Illinois in 1912, and taught at Albany College (Oregon), Occidental College, and Washington (Seattle). He worked at the Signal Corps Laboratories at Fort Monmouth while teaching at Rutgers. He had a variety of research interests including photoelectric cells, tungsten arc characteristics, and x-ray radiography of light metal alloys. Anderson joined Winchester, Atkinson, Greenlees and Porter in the Department. He was initially appointed as Lecturer, and later as Instructor. He remained in the Department until 1940.[56]

In 1937 Atkinson left the Department after eight years. H. N. Russell attempted to recruit Atkinson to come to Princeton University, but Atkinson turned down the proposed appointment and returned to England as Chief Assistant at the Royal Observatory, in Greenwich. During World

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[52]*Astro. Jour*., v. 73, p. 250 and 309, 1931, and v. 84, p. 73, 1936.

[53]*Q. Jl. Roy. Astr. Soc.*, v. 1, p. 26, 1960.

[54]*Q. Jl. Roy. Astr. Soc.*, v. 25, p. 100, 1984.

[55]Downsbrough Interview; *Rutgers College Catalogues.*

[56]*American Men and Women of Science*, 1944 edition; *Rutgers College Catalogues*.

War II, Atkinson worked on demagnetizing ships and assisted in the application of photogrammetry to ballistics. He returned to Greenwich in 1946 and assisted in moving the Royal Observatory to its new site at Herstmonceaux Castle, Sussex. During this period his research focused on instruments and techniques for precision astronomy. He retired from the Observatory in 1964, and went to the University of Indiana at Bloomington, Indiana, where he was Visiting and Adjunct Professor until he retired in 1979. He died in 1982.[57]

When Atkinson left Rutgers, he was replaced in the Department by Frank Dunnington, who was appointed as Assistant Professor. Dunnington was born in Colorado Springs, Colorado, and graduated in electrical engineering at the University of California, Berkeley, in 1929. He received his Ph.D. in Physics from Berkeley in 1932, working with Ernest Lawrence.[58]

After receiving his Ph.D., Dunnington spent five years at the California Institute of Technology, measuring the value of *e/m* with high precision using a method suggested by Lawrence shortly after inventing the cyclotron. The experiment consisted of measuring the time it takes an electron to move through some measured fraction of one revolution in a magnetic field. In this work, published in the *Physical Review*[59] in 1937, Dunnington went to extraordinary lengths to assure that he would not know the final value of the measurement until all of the experimental work was completed. The precise value of the angle of revolution in the magnetic field was not measured until after the experiment had been completed and the paper written for publication.

Years later, Nobel Laureate Luis Alvarez described in his memoirs the great effort that Dunnington had taken to remove bias in the calculation of his results.[60] At the time, many results of measurements of fundamental constants had tended to cluster near currently "popular" values. Richard Weidner described how, in later years, Alvarez had brought Dunnington's work to the attention of Stanford's William

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[57]*Physics Today*, May 1983, p. 81, 82.
[58]*American Men and Women of Science*, 1972 edition.
[59]*Phys. Rev.*, v. 52, p. 475, 1937.
[60]Alvarez, *Alvarez, Adventures of a Physicist*, 18.

Fairbanks.[61] Fairbanks was reporting on the results of measurements of fractional electron charges. Dunnington was encouraged to go back to his research notebooks, and reported no evidence for such fractional charges.[62]

Franklin Miller also joined the Physics Department in 1937, appointed as Instructor. Miller had received his Ph.D. from Chicago in 1939. His areas of research were X-ray diffraction, theory of double crystal spectrometer, radioactive tracer problems in biology, and discontinuities in expansion coefficients. At Rutgers, Miller took over the descriptive astronomy course that Atkinson had been teaching. The following year, 1938, Nelson Fuson joined the Department as Instructor. He had received his Ph.D. from Michigan in 1938. In 1938 there were seven faculty members in the Physics Department, who were assisted by four graduate students in teaching the physics courses.[63]

In January 1941 Dunnington went to work on the development of radar at the Massachusetts Institute of Technology Radiation Laboratory. William Rense, a member of the faculty of Miami University of Ohio, came to Rutgers for a semester as Visiting Assistant Professor of Physics, taking over Dunnington's classes. While at the Radiation Laboratory, Dunnington was head of a group that developed modulators for a wide variety of radar transmitters, ranging from small models used in bombers to a unit for a very large ground installation.[64]

During World War II, several individuals taught in the Department for a year or two. One of these faculty members was Harry Lewis Dember, who was another truly distinguished physicist. Dember was an authority in the field of photoconductivity and photoelectricity. He was born in Germany in 1882, and spent most of his life there. He was a faculty member at the Polytechnium in Dresden. During World War I he was head of a research project at the Canary Islands studying atmospheric optics and electricity.

After the war Dember returned to Dresden where he carried out experiments on the photoelectric effect. He made a new determination of the Avogadro constant using light scattering. He is better remembered for

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[61]Interview with Richard Weidner.

[62]*Physics Today*, May 1984, p. 104.

[63]*American Men and Women of Science*, 1995 edition; *Rutgers College Catalogues*.

[64]*Physics Today*, May 1984, p. 104.

the *Dember effect*, a semiconductor photoeffect. He was recognized as an expert in the field and made a determination of the long-wavelength limit of the photoelectric effect. Being of Jewish origin, he lost his position at Dresden in 1933. He escaped to Turkey and spent some years in Istanbul. He then came to the United States, followed by his son Alexis, who worked as an assistant to Robert Millikan at the California Institute of Technology. Harry Dember came to Rutgers in 1941 as Lecturer and then Visiting Professor of Physics. He taught in the Physics Department at Rutgers until his death in 1943 at the age of 61. He was visiting at the home of Lloyd Greenlees in Highland Park when he had a heart attack and died.[65]

In addition to Dember, Roy Kennedy and Lawrence Loveridge taught in the Department for a year, and Elmer Eisner taught in the Department for three years. There were a number of others who taught physics briefly in the Army Specialized Training Reserve Program (1944-45). Eisner received his Ph.D. from Johns Hopkins in 1944, and was Assistant Physicist at the National Bureau of Standards before coming to Rutgers as Assistant Professor. His early area of research was the analysis of nuclear scattering.[66]

Undergraduate Curriculum in Physics and Astronomy

When Winchester joined the Department, there were only undergraduate physics courses, which included general physics, applied physics, electricity and magnetism, electrical instruments, light, heat, and a general laboratory course. Winchester added courses in kinetic theory and elementary thermodynamics, light, and electron theory and radioactivity. This sequence of physics courses was changed again in 1923 with the listing of courses in physical optics and spectroscopy, and separate courses in electron theory, and radioactivity. In 1927-28 the undergraduate course in thermodynamics specifically mentioned *quantum theory* for the first time in connection with black body radiation.

In addition to the physics courses at the College of Arts and Sciences, there were also two courses in astronomy that were taught by

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[65]*New Brunswick Home News*, March 23, 1943; *Progress in Surface Science*, v. 49, p. 107, 1995; *Rutgers College Catalogues*.

[66]*American Men and Women of Science*, 1955 edition; *Rutgers College Catalogues*.

William Breazeale of the Mathematics Department. One of these was a course in descriptive astronomy, and the other was a course in theoretical and practical astronomy that included observatory work. Between 1927 and 1931 Breazeale also taught astronomy at N.J.C. But when Breazeale retired, there was a hiatus in astronomy instruction at N.J.C. until 1950.[67]

Graduate Program in Physics

In addition to expanding the undergraduate physics course offerings, Winchester initiated the listing of physics graduate courses. In 1921-22, Physics 291, 292, a course previously listed for seniors, was listed as a course designed for "graduate students who are prepared to do advanced work in the field selected." In 1924-25 the eight advanced undergraduate courses were listed for "Undergraduates and Graduates", and the single graduate course was listed as a course "for students who are prepared to do laboratory work of an advanced grade on a problem developed from the work in courses 705-712."[68]

The graduate course offering in physics was expanded in 1929-30 when six graduate courses were added to the advanced laboratory course. The six new courses, listed as mathematical physics and theoretical physics, covered an assortment of problems in advanced dynamics, but specifically mentioned *quantum mechanics* for the first time. The following year (1930-31), these six graduate courses were replaced by the following sequence of 12 graduate courses:

209 X-rays and Crystal Structures (Greenlees)
210 Higher Dynamics (Greenlees)
211 Atomic Energy Levels (Atkinson)
212 Spectroscopy (Atkinson)
213 Conduction of Electricity through Gases (Winchester)
214 Photoelectricity (Winchester)
215 Quantum Theory [Black Body Radiation] (Winchester)
216 Thermodynamics (Winchester)
217, 218 Electromagnetic Theory (Greenlees)
219 Analytical Theory of Sound (Atkinson)
220 Wave Mechanics (Atkinson).

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[67] *Rutgers College Catalogues.*
[68] Ibid..

Thus it appears that wave mechanics was taught by 1930 if not before. This sequence of graduate courses remained intact until 1940 when the one-semester course in wave mechanics was replaced by a two-semester course in quantum mechanics. The following year (1940-41) a course in relativity was listed for the first time.[69]

The graduate students came to the program slowly in the 1920's and then in large numbers in the 1930's. Pierre Van Dyck, adopted son of Francis Cuyler Van Dyck, was a graduate student in mathematics and physics (1922-23), after graduating from Rutgers in 1919. He did not receive an advanced degree.[70]

Rufus King Reber was the third physics graduate student at Rutgers, the first to receive an advanced degree . Reber came to the Department in 1927 after graduating from Juniata College, and he held a graduate assistantship for two years. He wrote a master's thesis on measurements of the variation of the surface tension of oils with temperature, research that he carried out with George Winchester.[71] After receiving the M.Sc. degree in 1929, Reber stayed on at Rutgers for a year as an instructor. From Rutgers, he went to Yale, where he received the Ph.D. in 1933. At Yale he carried out research with L. W. McKeehan on the effects of atomic hydrogen on the magnetic properties of iron. After receiving his Ph.D., Reber taught mathematics at the City College of New York, where he studied the magnetic susceptibilities of liquids and vapors. In 1942 he joined the Navy Department's Bureau of Ships, where he became an internationally recognized authority on mines and countermeasures. He received several major Navy awards for this work, and he retired from the Bureau of Ships in 1965. Following his retirement he served as a consultant to the United States Navy Mine Defense Laboratory. He died in 1972 at the age of 69.[72]

Following Reber, the number of graduate students in the Physics Department increased substantially. In 1929-30 there were three graduate students, and in 1930-31 there were eight. Between 1930 and 1940 the

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[69]*Rutgers College Catalogues*..

[70]Ibid.

[71]Reber, “Surface Tension of Oils”, M.Sc. Thesis, Rutgers, 1929.

[72]*Physics Today*, October 1972, p. 57; *American Men and Women of Science*, 1949 edition.

number of graduate students fluctuated between four and ten, including three or four graduate assistants. There was a significant decrease in the number of graduate students during World War II, and a substantial increase after the War.[73]

Following the first M.Sc. degree earned by Rufus Reber in 1929, there were a number of M.Sc.'s earned by graduate students in the 1930's. There were three in 1931, and additional M.Sc.'s in 1934, 1936, 1937, 1939, and 1941. One of the three M.Sc.'s in 1931 was awarded to Gladys Francis, the first woman to receive an advanced degree in physics at Rutgers. She had graduated from N.J.C. in 1928, and was an Assistant in Physics at N.J.C. for three years. Frank Pratt at N.J.C. was her thesis advisor. She wrote an M.Sc. thesis on the variations of the rigidity modulus with changes in applied stress for a variety of materials, including copper, steel, and quartz.[74] The other two 1931 M.Sc. degrees were awarded to Truly Hardy and Oscar Seidman, who had been graduate assistants from 1929 to 1931. Hardy looked for, and was unable to find, a variation of the photo-electric sensitivity in a single crystal of iron with a change in the plane of polarization of the incident photons.[75] Atkinson and Greenlees advised him on his research Seidman studied the atomic heat of nickel at low temperatures.[76] Atkinson was his advisor.

The graduate program in physics came to fruition with the awarding of Ph.D. degrees. The first Rutgers physics Ph.D. was awarded to Donald Hill in 1935. His thesis was "The Principal Expansion Coefficient of Single Crystals of Mercury,"[77] work carried out under the direction of George Winchester. While working for his Ph.D., he and George Winchester designed and built apparatus for liquefying oxygen gas. After leaving Rutgers, Hill taught for eight years at Scranton-Keystone Junior College, Elizabethtown College, and the Philadelphia College

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[73]*Rutgers College Catalogues*.

[74]Francis, "Variations of the Rigidity Modulus", M.Sc. Thesis, Rutgers, 1931.

[75]Hardy, "The Possibilities of a Variation of the Photo-electric Sensitivity", M.Sc. Thesis, Rutgers, 1931.

[76]Seidman, "Atomic Heat of Nickel at Low Temperatures," M.Sc. Thesis, Rutgers, 1931.

[77]Hill, "The Principal Expansion Coefficients of Single Crystals of Mercury," Ph.D. thesis, Rutgers, 1935.

of Pharmacy, and then worked in electronics at Boonton Radio and General Dynamics.

The second Rutgers physics Ph.D. was awarded to George Downsbrough in 1936 for work on the damping of torsional oscillations in quartz fibers, work carried out under the direction of Robert Atkinson. Downsbrough came to Rutgers in 1927 as an undergraduate. After graduating from Rutgers, he became a graduate assistant in the Physics Department from 1931-1936, earning his M.S. degree in 1933. The 1930s were hard times. Downsbrough initially had an assistantship for $900. Because of the financial difficulties resulting from the depression, the assistantship was cut in half and he was given a room. Downsbrough initially started work on a project to measure the angular momentum of circular polarized light, a subject on which Atkinson published a paper in 1935.[78] Unfortunately, someone at Princeton beat Downsbrough to the experiment, and he settled for measuring the damping of the torsional oscillations of the quartz fiber that he had constructed for the experiment. After leaving Rutgers, Downsbrough worked in electronics at Johns Manville, Navy Ordinance Bureau, Boonton Radio, American Standard, and Singer Manufacturing. In his later years Downsbrough became associated with Penn. State University.[79]

In 1939 George Buc received a Ph.D. for his thesis, "Ultraviolet Absorption Spectra of three Related Olefines," research carried out with guidance from George Winchester and Lloyd Greenlees. After leaving Rutgers, Buc taught for a year at Bergen Junior College, and then worked for American Cyanamid, Tide Water Oil, Fisher Scientific, and Farrington Electronics.[80]

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[78]*Phys Rev.* v. 47, p. 623, 1935.

[79]Interview with George Downsbrough; *American Men and Women of Science*, 1965 edition; Downsbrough, "The Damping of torsional Oscillations in Quartz Fibers," Ph.D. thesis, 1936.

[80]*American Men and Women of Science*, 1965 edition; Buc, "Ultraviolet Absorption Spectra of Three Related Olefines," Ph.D. Thesis, 1939.