Application of Biochemical Studies in Evaluating Drug Toxicity, Drug Research Board, National Academy of Sciences, National Research Council, Division of Medical Sciences. This committee is under the chairmanship of Dr. J. J. Burns and consists of representatives from universities, the National Institutes of Health, Food and Drug Administration, and the pharmaceutical industry.
5. In a letter to the research laboratories of the pharmaceutical industry, Dr. E. I. Goldenthal, acting deputy director, Office of New Drugs, Bureau of Medicine, FDA, recommended on 15 July 1968 that comparative studies of drug metabolism in animals and man be conducted early in the toxicologic evaluation and during preliminary stages of clinical investigations. Such data are not now required while the drug is under clinical investigation but are expected to be submitted, with the new drug application, to the FDA.
6. For examples of sex differences, see G. Zbinden, *Advan. Pharmacol.* **2**, 1 (1963). No clinical significance for such experimental observations has been established. Moreover, the presence of sex differences could be determined in a simple experiment and does certainly not require duplication of all toxicologic studies.
7. Other considerations for the appraisal of toxicologic findings in animals were reviewed in (*6*).
8. For example: exploratory research with chlorpromazine has uncovered a multiude of biologic effects with potential toxicologic implications, including inhibition of many enzymes, suppression of hormones, inhibition of mitochondrial respiration, S incorporation in sulfolipids, glucose uptake, glycolysis, K excretion, norepinephrine uptake and alcohol metabolism, acceleration of blood clotting and reduction of γ-aminobutyric acid, glutamic acid, aspartic acid, serine, and sialic acid content of the brain. Significance of such findings is reviewed by G. Zbinden, *J. New Drugs* **6**, 1 (1966).
9. E. I. Goldenthal, "Current views on safety evaluation of drugs," *FDA Papers* (U.S. Government Printing Office, Washington, D.C., 1968), p. 1; W. D'Aguanno, "Drug toxicity evaluation—preclinical aspects," paper presented at Symposium on Clinical Drug Evaluation, 17–19 May 1968, University of California Extension, Los Angeles, and the U.C.L.A. School of Medicine, Los Angeles, California.
10. A good example is the evaluation of physical and psychological drug dependence for which satisfactory experimental procedures have been developed. See: "Evaluation of dependence-producing drugs," *WHO Tech. Rep. Series No. 287* (Columbia Univ. Press, New York, 1964).
11. I thank Drs. J. J. Burns, E. I. Goldenthal, A. Hollaender, R. H. Levin, H. M. Peck, and M. Weiner for contributions and criticisms.

Theodore William Richards and the Atomic Weight Problem

He applied physical chemical principles to critical chemical problems.

Aaron J. Ihde

The birth year of Theodore William Richards, 1868, occurred during a momentous decade in the history of chemistry. At the beginning of the decade there was much skepticism among competent chemists regarding the usefulness to science of the atomic theory, and for very good reason. Although Dalton had introduced his theory 50 years earlier, some of the key questions connected with chemical atomism had never been satisfactorily resolved. At the end of the decade the power of the atomic theory was recognized and the periodic law based upon it was being established.

The decade began auspiciously with the Karlsruhe Congress in September 1860. Younger men in the field, particularly Kekulé and Wurtz, were responsible for calling the congress, which had as its objectives the formulation of an area of agreement among chemists regarding the nature of atoms and molecules and a consensus with respect to a mutually satisfactory atomic weight system. After 3 days of discussion the congress adjourned, with apparent lack of agreement. There had been a notable moment, whose significance was missed by the audience, when the young Italian chemist Stanislao Cannizzaro called attention to the value of Avogadro's hypothesis as an organizing device for the interpretation of chemical phenomena. While Cannizzaro's message was largely misunderstood, the pamphlet which he had prepared and which was passed out before the meeting adjourned was thoughtfully read by one young chemist, Julius Lothar Meyer, who saw that it pointed the way out of a half-century of chemical chaos. His *Die modernen Theorien der Chemie,* published in 1864, utilized as its basis Avogadro's hypothesis. The particular significance of the hypothesis lay in the fact that its application made possible the determination of molecular weights of gases and vapors, and thereby the derivation of molecular formulas of these substances. It further led to acceptance of the concept of diatomic molecules of hydrogen, oxygen, nitrogen, and the halogen gases and to a rational understanding of gaseous reactions. Of particular importance, it led to the stabilization of atomic weights into a consistent system. No longer would chemists use several different sets of atomic weight values (*1*).

A natural outgrowth of reliable molecular formulas was structural theory. Although Archibald Scott Couper had been groping toward structural formulas in his famous paper of 1858, it was not until after the Karlsruhe Congress that structural formulation began to develop fruitfully in the minds of Butlerov, Kekulé, and, to a lesser degree, Crum Brown, Frankland, Wurtz, Erlenmeyer, and Hofmann (see *2*). Before the decade was ended a viable theory of structural chemistry had been established, not only for the simple aliphatic compounds but for aromatics as well. As new and formidable demands were placed upon structural theory during the next decade in connection with the formulas of complex natural products and synthetic dyes, the theory would prove capable of meeting the challenges.

The decade of the 1860's also saw chemical knowledge being utilized by the developing dye industry. By 1868, students of Baeyer had been successful in duplicating the molecule of alizarin, the coloring matter present in an ancient dye, madder. The foundations laid in the 1860's were so sound that it was possible for knowledge of organic chemistry to explode during succeeding decades.

The 1860's were also notable in the

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nonorganic field. The spectroscope, developed by Kirchhoff and Bunsen just before the decade began, led to the discovery of five new elements during the decade (cesium, rubidium, thallium, indium, and, in the corona of the sun, helium).

Most notable in the theoretical field was the development of a system of classification of the elements. Classification schemes had been attempted ever since Döbereiner's introduction of the triad idea several decades earlier. Others who sought to develop a classification system were unsuccessful in a period before values for atomic weights were reliable. Once Cannizzaro pointed the way, the development of a successful classification scheme was possible. Béguyer de Chancourtois devised the telluric screw in 1862, and John Newlands had begun to develop the law of octaves by 1864. Lothar Meyer was also groping toward a classification scheme at about this time. It was not until 1869, however, that a definitive periodic arrangement was arrived at, by Dmitri Ivanovitch Mendeleev and, independently, by Lothar Meyer. With the available atomic weights and extensive knowledge of the properties of chemical elements it was possible to arrive at a law of periodicity.

By 1870 chemistry had taken on a new character, based on the power of structural theory and periodic classification. The next decades, up to World War I, would be a momentous period of development. Within two decades Richards would become a part of this activity.

Richards, the Man

Theodore William Richards was born on 31 January 1868 in Germantown, Pennsylvania, the son of William Trost Richards, a landscape and marine painter, and Anna Matlock Richards, a woman who achieved fame for her poetry. The son's education was the responsibility of his mother until he was 14, when he entered Haverford College as a sophomore. His early interests were divided between chemistry and astronomy. Upon graduation, Richards moved to Harvard in order to study chemistry under Josiah Parsons Cooke, one of the few American chemists who was winning recognition for his research activities. Richards received the A.B. degree *summa cum laude* in 1886 and the Ph.D. 2 years later. His doctoral dissertation, dealing with the combining weights of hydrogen and oxygen, was sufficiently promising to win him the Parker fellowship for a year of travel and study in Europe.

He spent the winter semester in Göttingen, where he studied analytical chemistry under P. E. Jannasch, working on the determination of sulfate in the presence of iron, and under Victor Meyer, making vapor density determinations. During the spring he visited various European laboratories where important research was being done. The experience was a valuable one, and in later years he repeatedly urged students who could spend a year abroad to spend half their time doing intensive research work in a single laboratory and the other half as peripatetic scholars visiting famous centers of chemical activity.

Upon returning to Harvard in the fall of 1889 he became an assistant in analytical chemistry. He was promoted to instructor in 1891 and to assistant professor in 1894. When Cooke died in that year it was necessary to provide for continuation of instruction in physical chemistry, and Richards was selected for the position. In order that he might become more fully qualified, the university sent him to spend a semester with Ostwald at Leipzig and another with Nernst at Göttingen. Upon returning to Harvard the next year he inaugurated his course in physical chemistry, bringing to it the latest ideas generated in the principal German centers of activity.

By 1901 Richards' reputation was sufficiently great to win him the offer of a professorship at the University of Göttingen. The offer was an exceedingly attractive one, since it provided an opportunity to take over a laboratory where vigorous research was being done. His teaching duties would be minimal, and he would have splendid opportunities for research. But Harvard persuaded him to remain, with the offer of a full professorship. In 1912, following the death of Loring Jackson, Richards was appointed to the Erving Professorship of Chemistry, which had been endowed in 1792. He held this position until his death.

Richards' life was in some respects an unspectacular one, devoted as it was to chemistry, to Harvard, and to his family. He had developed a quiet confidence as a result of close association with a talented father and mother. They traveled extensively and moved in artistic and scholarly circles where accomplishment was considered the expected thing. Young Richards had abundant opportunities and was able to make the most of them in a friendly and unpretentious manner.

In 1896 he married Miriam Stuart Thayer, the daughter of a professor in the Harvard Divinity School. Their daughter Grace Thayer became the wife of James B. Conant shortly after he completed work as a graduate student under Richards; Conant was later to become a distinguished chemist, president of Harvard, U.S. diplomat, and educational reformer. One of Richards' sons, William Theodore, studied chemistry, receiving the Ph.D. from Harvard in 1924. He served as instructor and assistant professor at Princeton, but his career was cut short by illness leading to his death in 1940. The third child, Greenough Thayer, became an architect.

Richards died, after a brief illness, on 2 April 1928 (*3*). At that time, three Harvard colleagues wrote (*4*):

> The distinguished and characteristic precision of Richards' experimental work was not merely dictated by the need of accuracy for the sake of trustworthy scientific results; it was inspired by his inner honesty and by his joy in perfect workmanship. The man's noble ideal of character and the artist in him conspired to bring to full fruition his vigorous and broadly developed mind. Of singular modesty and devoted to his very happy home, his friendliness and charm made his society highly prized, and he moved in a large circle, admired and beloved. His friendships ran through many countries, and his varied interests brought him into contact with a wide range of people. His colleagues recall with deep gratitude the unstinted help he knew how to give and his peculiar gift of instilling new courage at critical moments of baffling difficulty. His strength, never robust, was for years scrupulously conserved for his work, and he often longed for a greater physical power to carry into execution the plans of investigation which thronged his mind.
>
> Capable of strong feeling and strict judgment, he described the guiding principles of his life as "kindliness and common-sense"; we may add that these modest qualities were served by genius. The moral conditions of successful scientific work—"the overwhelming importance," as he put it, "of perfect sincerity and truth"—were never absent from his mind, and of them he was himself, in all ways, the very embodiment. Modest, lovable, competent in business, interested in games, possessing a trained knowledge of music and a critical appreciation of art, patient with obstacles, unsparing in painstaking labor, he gave himself to his carefully ordered tasks with joy of life and work and thought.

During this busy lifetime of 60 years Richard built a steady record of accomplishment. His work on atomic weights won him the Nobel Prize in chemistry for 1914, the first such award to an American chemist (the next Nobel award in chemistry to an American was in 1932). He was president of the American Chemical Society in 1912 and of the American Association for the Advancement of Science in 1917 (*5*).

He was a leader in introducing the new field of physical chemistry into the United States, and his laboratory at Harvard was a center which prepared a whole new generation of physical chemists. His influence on students and associates was profound. Sir Harold Hartley, in his Memorial Lecture to the Chemical Society, stated (*6*):

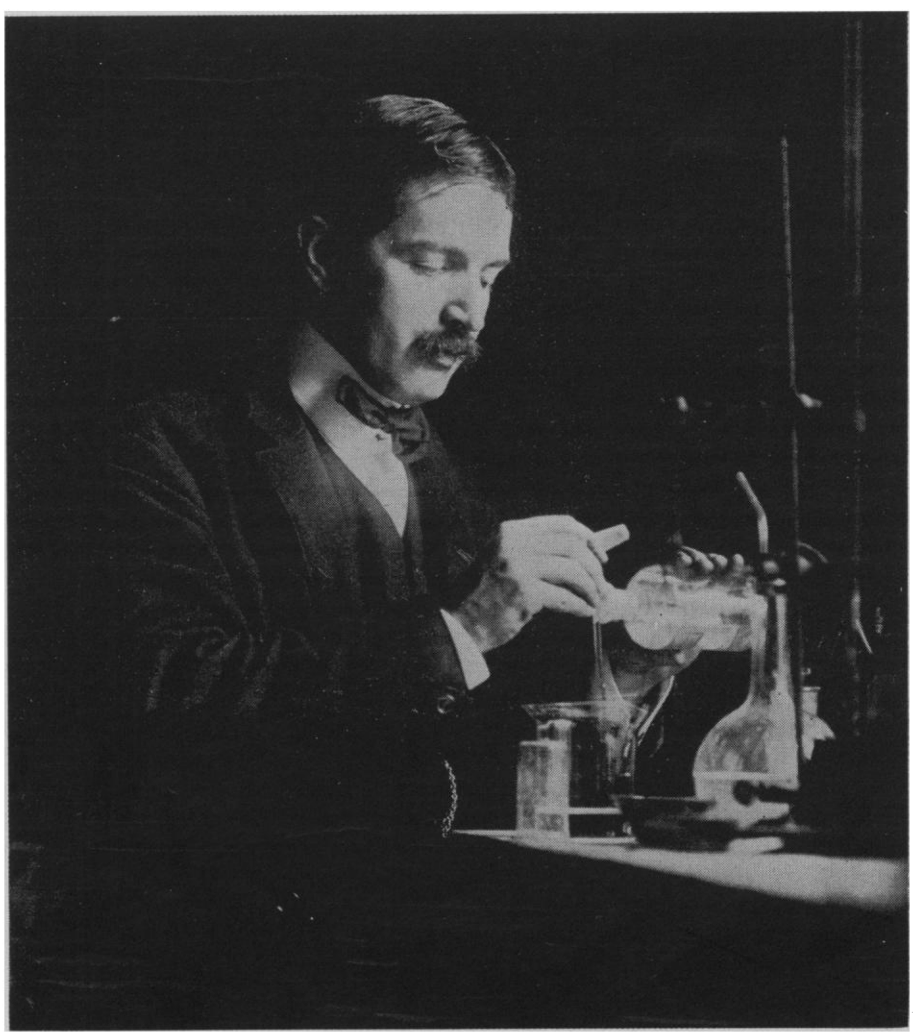
> Richards was by nature and temperament a great teacher and leader, with the keenest interest in the young men around him and the gift of imparting to them his own enthusiasm and his own standard of achievement. . . .Richards was an admirable lecturer with an exceptionally clear and pleasant voice that compelled attention. His simple logical way of presenting a subject seemed to rob it of its difficulties, and many a student owed to him his first real insight into the principles of chemistry. They learnt from him too the thrill of discovery, and his vividly sketched picture of the unsolved problems was to them "a challenge to join the ranks." Richards knew how to get the best out of young men. They felt his interest in them, and his innate kindness, which often took a practical form. They went to him with their troubles, they did their best to live up to his standards, and when he went round the laboratory a look of disappointment from him was more effective than anger or sarcasm. But with all his kindness Richards was a shrewd judge of men and of their work, and quick to detect any lapse from that uncompromising integrity which he looked for in an investigator. Anyone who tried to bluff him quickly became aware of a sterner side to his character.
>
> Richards was a most meticulous and inspiring director of research. He usually spent some time every day with each of his students, seeing the progress of their work, insisting upon the utmost purity of the substances they used, and if their results were not reproducible he would spare no pains to ascertain the source of trouble. Even the most persistent difficulties yielded to his skillful diagnosis, including the almost supernatural vagaries of a delicate galvanometer which he traced to the movements of a man in an adjoining room with a large bunch of keys in his pocket.

Among the young men who worked in his laboratory and went on to achieve independent fame in chemistry were Gregory Baxter, Arthur B. Lamb, Lawrence J. Henderson, George S. Forbes, James B. Conant, and Grinnell Jones, all subsequently associated with Harvard; G. N. Lewis (University of California); Otto Hönigschmidt (Munich); H. H. Willard (Michigan); J. H. Mathews, Farrington Daniels, and N. F. Hall (Wisconsin); E. H. Archibald (Vancouver); R. C. Wells (Washington); Frederick Barry (Columbia); H. Krepelka (Prague); and Roger Adams (Illinois).

Richards, the Chemist

Richards' principal impact on the science of chemistry was in the field of atomic weight determinations, in which he did his work for the Ph.D. under Cooke. Although he made important contributions to other areas of analytical and physical chemistry, it was to the rigorously accurate determination of atomic weights that he devoted his career. He stated on numerous occasions that his fundamental interest lay in the search for an understanding of fundamental relations in the universe (*7*). He felt that an accurate understanding of atomic weights was one of the principal objectives in this connection.

Although John Dalton tentatively listed some values for atomic weights in his notebooks in 1804, Dalton was not the kind of experimentalist to work out the fundamental problem connected with chemical atomism. While Dalton perceptively saw the value of an atomic theory, it was Jöns Jakob Berzelius who recognized the great importance that atoms could have in the development of chemistry and who recognized the need to determine atomic weights with great accuracy. The tables published by Berzelius in 1814, 1818, and 1826 were models of careful analytical work (*8*). However, Berzelius was not in a position to master some of the fundamental difficulties associated with the determination of atomic weights for certain elements, and his figures sometimes failed to take into account the proper relation between equivalent weights and atomic weights. Those chemists who believed in the atomic theory tended to use Berzelius' values, but other, equally good chemists were dissatisfied with the atomic theory and preferred to consider



T. W. Richards in the laboratory. [Courtesy of Mrs. James B. Conant]

Table 1. Atomic weights determined by Richards and his students.

Element	Publication date	Previous value	Richards' value	1930 value	1958 value
Hydrogen	1888	1.002	1.0082	1.0078	1.0080
Copper	1892	63.3	63.57	63.57	63.54
Barium	1893	137.0	137.37	137.36	137.36
Strontium	1894	87.5	87.62	87.63	87.63
Zinc	1895	65.0	65.37	65.38	65.38
Magnesium	1896	24.2	24.32	24.32	24.32
Cobalt	1899	59.1	58.97	58.94	58.94
Nickel	1899	58.5	58.68	58.69	58.71
Iron	1900	56.00	55.85	55.84	55.85
Uranium	1902	240.2	238.4	238.14	238.07
Rubidium	1903	85.5	85.42	85.44	85.48
Cesium	1928	132.9	132.81	132.81	132.91
Sodium	1905	23.05	22.995	22.997	22.991
Chlorine	1905	35.45	35.458	35.457	35.457
Bromine	1906	79.95	79.917	79.916	79.916
Potassium	1907	39.14	39.095	39.104	39.100
Nitrogen	1907	14.04	14.008	14.008	14.008
Sulfur	1907	32.06	32.07	32.06	32.066
Silver	1910	107.93	107.88	107.880	107.880
Lithium	1910	7.03	6.94	6.94	6.940
Calcium	1910	40.00	40.07	40.07	40.08
Lead (uranium)	1926		206.02	206.02	207.21*
Carbon	1915	12.0	12.005	12.000	12.011
Aluminum	1921	27.1	26.96	26.97	26.98
Gallium	1923	69.9	69.716	69.72	69.72

* Value for lead from nonradioactive sources.

numerical relationships in terms of equivalents.

In 1840, when Dumas recognized an inaccuracy in Berzelius' value for the atomic weight of carbon, questions began to be raised about the validity of Berzelius' other values. Dumas was influential in encouraging Jean Servais Stas to undertake an accurate redetermination of a number of atomic weights. Stas did his work carefully and painstakingly, and his values came to be widely accepted in the world of chemistry. Other chemists contributed atomic weight values for some elements, but Stas's values were basic, and even when he did not make the determination directly, other chemists' values were frequently recalculated relative to the Stas base. This was the state of chemistry when Richards came to Harvard as a student.

Cooke was interested in the newly developing field of physical chemistry and had a particular interest in atomic weights, having reported the atomic weight of antimony with a new degree of precision in 1873. He, like others at the time, was interested in the ratio of the atomic weights of hydrogen and oxygen. All chemists attracted to the hypothesis of Prout naturally wished for a value for this ratio of 1/16. The work of Dumas in 1842 had led to an apparently reliable value of 1/15.96. Cooke was skeptical of the value and suggested that Richards work on the problem. Richards passed a weighed quantity of hydrogen over copper oxide and weighed the water formed. He obtained a result which departed still farther from the ratio of 1/16 demanded by Prout's hypothesis. Richards' ratio was 1/15.869, or 1.0082/16.

His work on hydrogen led him to be suspicious of the then current value of 63.3 for the atomic weight of copper. Upon his return to Harvard he determined the atomic weight of copper by five different methods and arrived at a corrected value of 63.57. His work revealed errors in earlier studies, errors which could be perceived by applying physical chemical principles to the problem of preparing pure precipitates.

While he always showed the utmost respect for the work of Stas, Richards' familiarity with physical chemistry caused him to recognize inherent errors in Stas's techniques. Stas worked with large quantities (frequently several hundred grams of precipitate) in order to reduce weighing errors to a minimum. Richards saw that such an approach led to difficulties in the purification of materials. Precipitation from concentrated solutions led to adsorption of soluble salts. Drying under atmospheric conditions led to occlusion of oxygen and moisture. Richards introduced the practice of working with small quantities (seldom more than 20 grams of precipitate), and precipitating from dilute solutions. He introduced a weighing tube which made it possible to cool and weigh precipitates under anhydrous conditions. He developed the nephelometer to detect traces of unrecovered precipitates in his filtrates. Above all, he set for himself rigorous standards for the purification of materials. He was able to show, for example, that Stas's silver had contained impurities and that therefore Stas's value for the atomic weight of silver was inaccurate.

All in all, Richards and his students determined the atomic weights of 25 elements (see Table 1). Two of his former students, Gregory P. Baxter (*9*) at Harvard and Otto Hönigschmidt (*10*) at the University of Munich, were responsible, with the aid of their students, for many additional atomic weight determinations. Values for 55 of the then known elements were established in the laboratories of Richards, Baxter, and Hönigschmidt. Toward the end of Richards' life the mass spectrograph was coming into use for the identification of isotopes and the study of isotope distribution. Richards took a keen interest in the work of Aston and Dempster, despite the fact that it threatened to render his painstaking work obsolete (*11*).

He recognized early the significance of isotopes in connection with radioactive decay. Since lead was identified as the end product of the uranium decay series, and since mass loss occurred primarily through loss of alpha particles, he saw, as did several others, that uranium would hardly decay to ordinary lead of atomic weight 207.2. Kasimir Fajans sent Max Lembert to Harvard in 1913 with a sample of lead from a uranium source, and Richards and Lembert found an atomic weight of 206.6. Later results on very pure uranic lead gave a value of 206.08. The early results of Richards and Lembert were confirmed independently in the laboratory of Hönigschmidt and in that of Maurice Curie (*12*).

Of Richards' nearly 300 published papers (*13*), approximately half dealt with atomic weights. The remainder dealt with significant phases of physical chemistry. He (with G. N. Lewis) had an early interest in the electrochemistry and thermochemistry of amalgam cells. His ideas on the compressability of atoms began to develop in 1899, and the subject occupied his attention to the end of his life. By 1904 he had developed a method of determining compressabilities up to 500 atmospheres. The method was applied to 40 elements and to various compounds and showed compressability to be a periodic function of atomic weight and other physical properties. Richards' work on thermochemistry led to the development of the adiabatic calorimeter and to a new level of refinement in the study of heat phenomena.

His career may well be summed up as one which established a new standard of excellence for every task he undertook. Some of his concepts proved to be without lasting significance, and some of his contributions have been superseded by improved approaches. Nevertheless, he left a lasting mark on chemistry as a result of his care, his perseverance, his insights, and, particularly, his humaneness.

References and Notes

1. For the English text of Cannizzaro's pamphlet, see *Alembic Club* (Edinburgh) *Reprint No. 18* (1911). For details on the Karlsruhe Congress, see C. de Milt, *Chymia* **1**, 165 (1948) and A. J. Ihde, *J. Chem. Educ.* **38**, 83 (1961). For general background on the period, see ———, *Development of Modern Chemistry* (Harper and Row, New York, 1964), p. 222 ff.
2. O. T. Benfey, Ed., *Classics in the Theory of Chemical Combination* (Dover, New York, 1963); A. A. Baker, Jr., *Unsaturation in Organic Chemistry* (Houghton Mifflin, Boston, 1968).
3. The principal biographical sketches of T. W. Richards are: G. P. Baxter, *Science* **68**, 333 (1928); B. Harrow, *Eminent Chemists of Our Time* (Van Nostrand, New York, 1920), chap. 4; H. Hartley, *Mem. Lectures Chem. Soc.* **3**, 131 (1933); A. J. Ihde, in *Famous Chemists*, E. Farber, Ed. (Wiley, New York, 1961), chap. 58; *Nobel Lectures, Chemistry, 1901–1921* (Elsevier, Amsterdam, 1966), p. 293.
4. G. P. Baxter, J. H. Ropes, T. Lyman, *Harvard Univ. Gaz.* **24**, 56 (1928).
5. Many other awards, honorary degrees, and other distinctions were conferred upon him. For a complete listing, see *American Men of Science*, J. Cattell, Ed. (Science Press, New York, ed. 4, 1927).
6. H. Hartley, *Mem. Lectures Chem. Soc.* **3**, 160 (1933).
7. See, for example, Richards' Nobel prize address, in *Nobel Lectures, Chemistry, 1901–1921* (Elsevier, Amsterdam, 1966), p. 280; his Faraday lecture, *J. Chem. Soc.* **99**, 1201 (1911); and his Phi Beta Kappa oration, *Science* **44**, 37 (1916).
8. For a comparative tabulation of the Berzelius tables, see A. J. Ihde, *The Development of Modern Chemistry* (Harper and Row, New York, 1964), p. 142.
9. Baxter's laboratory was responsible for independent determinations of the atomic weights of the following elements: argon, arsenic, boron, bromine, helium, neon, phosphorus, silicon, chromium, manganese, iron, cobalt, nickel, germanium, cadmium, tin, iodine, lanthanum, neodymium, praseodymium, lead, and titanium.
10. Hönigschmidt's laboratory determined the atomic weights of the following elements: bismuth, beryllium, boron, chlorine, silicon, potassium, scandium, iron, bromine, silver, antimony, cerium, barium, dysprosium, hafnium, mercury, lead, radium, thorium, uranium, yttrium, and zirconium.
11. T. W. Richards, *Chem. Rev.* **1**, 1 (1924).
12. ———, *Science* **49**, 1 (1919).
13. Most of Richards' research papers were published in the *Journal of the American Chemical Society*, from 1890 to the end of his life. His principal addresses were published in *Science* and reprinted in the *Smithsonian Report*. From 1902 on, his research received extensive financial support from the Carnegie Institution.

NEWS AND COMMENT

Brussels: In Aftermath of Revolt, a Medical School Works at Reform

Brussels. Last spring, when the French student revolt spilled over into Belgium, the medical school of the University of Brussels was tradition-bound and administratively coagulated in the style of most European institutions of higher learning. Its affairs were effectively in the hands of some 40 all-powerful chairholding professors, who ran their fiefs with unassailable authority, were subject to no review, and were removable by nothing short of imprisonment, retirement, or death. Today, following a year of arduous effort at reform, the medical school—which has 1600 students spread over a 7-year undergraduate and professional program—is still a good distance from escaping its antique past. But the old ways are bending, if not cracking, and the prospect for significant change is fairly bright.

Here and elsewhere in European academic affairs, modernization is overdue by as much as half a century, and, even if accomplished, would probably do no more than bring the affected institutions to the conditions that prevailed at Berkeley, Ann Arbor, and Columbia before they went through *their* crises. But every upheaval must be measured from its own base line, and what is going on in many European universities today is indeed significant in terms of the normal pace of change.

At the Brussels medical school, the academic omnipotents—titled *professeurs ordinaires*, and not to be confused with *professeurs extraordinaires*, who are one notch below in rank, but a great way off in status and power—usually reigned from their positions as chiefs of the school's services, or departments. From these positions, each, if he so chose, exercised complete authority over staff appointments, the educational program, and research activities within his jurisdiction. The office was an august one, commanding a kind of deference that has rarely taken hold in American universities. As a Brussels teacher with extensive experience in the United States remarked, "It's really something to be a professor at Harvard or Berkeley, but still they call you by your first name. Here a professor is in a very elevated position."

Those positions, however, came within range of reform last May when the student uprisings in France inspired similar outbreaks in Belgium, and students and junior teaching staff members moved swiftly to exploit the situation in behalf of long-talked-of changes. Well represented in this movement were researchers who had spent some time in American laboratories, and who saw no reason why their own institution should remain bound up a stifling authoritarian system. "We are closely linked to the United States," one of these researchers explained. "We want to emulate the good things that we saw there." To which he added that, upon returning from a visit to a U.S. research center several years ago, he told his chief that he thought several changes in departmental affairs would be desirable. "He answered me, 'That's a very good idea. Go ahead and make them. But wait about 2 years before you start.' "

Revolutionary Aims

Although the student movement was revolutionary in its origins and objectives, its most immediate effect was to clear the way for those persons whose disaffections could most readily be treated by managerial or organizational changes. And that apparently is the way things worked out in the medical school last spring. With the university's central administration building occupied, and threats forthcoming that the medical school might be next, the ruling professors agreed to establish and delegate power to a Conseil Facultaire de Réforme that would include representatives of all ranks within the school—full professors, lower-ranking teachers,