NATIONAL ACADEMY OF SCIENCES

WILLIS RODNEY WHITNEY

1868—1958

A Biographical Memoir by

GUY SUITS

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Willis R. Whitney

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WILLIS RODNEY WHITNEY, who died on January 9, 1958, once compared scientific research to a bridge being constructed by a builder who was fascinated by the construction problems involved. *Basic research,* he suggested, is such a bridge built wherever it strikes the builder's fancy—wherever the construction problems seem to him to be most challenging. *Applied research,* on the other hand, is a bridge built where people are waiting to get across the river. The challenge to the builder's ingenuity and skill, Whitney pointed out, can be as great in one case as the other.

The metaphor could be applied to Whitney's own career. There surely was never a builder more stimulated by the problems of his craft. As the "father of basic research in industry," Whitney was living proof of the fact that the essential qualities that mark the great builders are the same wherever the "bridges" may happen to be built.

In one sense, the whole endeavor that we know as modern industrial research—with its heavy emphasis on basic science—is a bridge that was largely built by Whitney at a time when there was precious little demand for it. The people at the water's edge, by and large, could hardly see the river, much less any necessity for crossing it. To Whitney, however, the need was clear.

When the opportunity presented itself, Whitney was teaching theoretical chemistry at the Massachusetts Institute of Technology. He had been born on August 22, 1868, at Jamestown, N.Y., the son of a furniture manufacturer, and had first looked into the world of science through a neighbor's microscope while he was in high school. He had gone to the Massachusetts Institute of Technology intending to major in biology, but after some consideration he decided that he was more interested in chemistry. In 1890 he received his bachelor of science degree in this subject, after which he served as an instructor for four years. In 1896 he received his doctorate in chemistry from the University of Leipzig, and before returning to the United States he added six months' study at the Sorbonne.

He then returned to the faculty of M.I.T. where he soon established a reputation by his work in electrochemistry, proposing the now universally accepted electrochemical theory of corrosion. At this time, working with Professor A. A. Noyes, he also contributed to the development of the modern theory of solution. Academic life, with its combination of research and teaching, was so congenial to Whitney that he once declared that he would rather teach than be president. It was to this thirty-two-year-old teacher and experimenter that the General Electric Company turned in 1900 in search of a man who could establish and direct the first laboratory in American industry to be devoted primarily to basic research.

The proposal was not one calculated to win instant acceptance. There was a long-standing prejudice in academic circles against industrial scientific work. The whole project, since it was an experiment, had an element of risk in it. In addition, Whitney had his doubts as to whether there would be enough challenging problems in the General Electric Company to hold his interest for a long period of time. In order to resolve these difficulties, it was agreed that Whitney would begin the project on a part-time basis, spending half of his time at M.I.T. and the remainder with General Electric. Under this arrangement Whitney came to Schenectady, N.Y., in 1900 and set up shop, working with the great Dr. Charles Steinmetz in an old barn behind Steinmetz's home, where they shared an assistant. A short time later the barn burned down and the new laboratory was moved to one of the buildings in the General Electric plant. After three years Whitney was ready to put an end to the part-time schedule and devote all his time and energy to directing the work of the growing laboratory staff.

As Whitney remarked later, his decision to make research in industry his career was prompted by "a desire to take part in more extensive research than could be accomplished by my personal efforts alone. I would have been glad to have been one of a large group of cooperators in colloid research [in academic life] but the greater rate of possible accomplishment in industry decided the case for me."

The difference between scientists working alone and in concert was discussed at greater length by Whitney in a speech delivered at the fiftieth anniversary of the granting of M.I.T.'s charter.

"The mathematics of cooperation of men and tools is interesting," said Whitney. "Separated men trying their individual experiments contribute in proportion to their numbers and their work may be called mathematically additive. The effect of a single piece of apparatus given to one man is also additive only, but when a group of men are cooperating, as distinct from merely operating, their work raises with some higher power of the number than the first power. It approaches the square for two men and the cube for three. Two men cooperating with two different pieces of apparatus, say a special furnace and a pyrometer or a hydraulic press and new chemical substances, are more powerful than their arithmetical sum. These facts doubtless assist as assets of a research laboratory."

Aware as Whitney was of the benefits that were to be gained from men working together, he was just as aware that the essential ingredient in any major scientific achievement must be the exceptional individual. Whitney was notably successful in attracting such talent to the Research Laboratory at General Electric. Such men as Langmuir, Coolidge, Hull, and Dushman, among the many who joined his staff, need no introduction.

In 1946, when Whitney was being presented with the Industrial Research Institute Medal award, Irving Langmuir spoke on "Whitney, the Man and Leader." In the course of his remarks he described the manner in which he came to join the laboratory's staff.

"The way men were found for the laboratory is rather interesting. It was the custom to have a colloquium at the laboratory each Saturday afternoon. Generally a speaker was invited to spend the day at the laboratory, which brought the laboratory men into contact with a great many well-known scientists. Also at times it was the policy to invite young men to come to the laboratory who later might join the staff. I had been teaching qualitative and quantitative analysis at Stevens Institute for three years, giving lectures and taking charge of the laboratory work. Although I had gone to Stevens with the intention of devoting my life to scientific research, I had found no opportunity to get started—there was no time for any research work. During a meeting of the Electrochemical Society in Schenectady in the fall of 1908, the members were shown through the laboratory, and I was asked to lead one of the future colloquia. After the colloquium, arrangements were made for me to spend the summer vacation at the laboratory.

"To me that summer vacation was a wonderful eye opener. The first day I asked Dr. Whitney what I should do. He had not even thought about it and suggested that I spend a few days getting acquainted with every man in the laboratory—talking with each and watching what he was doing. Two things I saw particularly interested me: First, the techniques used in making good vacuum were far better than any I had seen in Germany or had heard about in any university; and second, I was curious about the tungsten filaments which could be heated to over 3,000 degrees, as compared with platinum that would stand only much lower temperatures. Here was a possibility of getting familiar with very-high-temperature phenomena. So the work I did for my three months' vacation was along those lines. At no time was pressure brought to bear on me, even to steer me along certain lines. Every day Dr. Whitney was with me long enough to find out what I was doing and on each day he would make interesting observations and stimulating suggestions. He usually came in and said, 'Well, having fun today?' Of course I was having fun. That was his spirit. He was having fun talking to me and I was having fun listening to him, but the main thing we were interested in was what we were finding from day to day."

Some members of the staff came to the laboratory with the same mental reservations that Whitney himself had had when contemplating the change from the academic to the industrial scene. It is an interesting comment on the nature of the laboratory that Whitney had established, and on Whitney's own genius for administration, that these men soon lost their initial hesitancy and began to participate wholeheartedly in the unique experiment.

Dr. Whitney wrote at one time that when Dr. Coolidge had joined the laboratory staff he had experienced this sense of what might be called divided loyalties.

"He [Coolidge] joined our research corps on the condition that half of his time should be devoted to research on the electrical conductivity of aqueous solutions at high temperatures and pressures, a subject upon which he had already done excellent work with A. A. Noyes," wrote Whitney. "For a while he devoted himself religiously to perfecting his resistance bomb, but ultimately presented it to the Institute of Technology, because he wanted to devote all his time to other research. What Dr. Coolidge might have done with the resistance of electrolytes is unknown, but what he has accomplished by the application of extensive efforts and with many assistants to a forced research on ductile tungsten is well known. In practically every city, village, and residence in the world where electric wiring has found its way, the work of Dr. Coolidge has helped contribute the lamp."

Whitney's success in attracting men of Coolidge's caliber was of course due in large part to his policy of allowing them as much freedom as possible. After Langmuir had been hired in 1909, and had spent several years on one line of investigation or another that had caught his interest, he one day remarked to Whitney, "I'm having a lot of fun, but I really don't know what good this is to the General Electric Company."

"Well," Whitney replied, "that's not your worry, that's mine. As long as you are doing something, finding out about high vacuum and tungsten filaments, and things that are related to work the Company is doing, why, we want to see that work go on." Whitney assured Langmuir that somebody would make out a budget for the work, and that he need worry about it no longer.

This policy of freedom for the investigator was, of course, not appropriate for all members of the staff in the same degree, as Whitney and his colleagues realized, but it did insure that, for the exceptional talent who required and could make the most of freedom, freedom would be available. Both Whitney and Langmuir were fond of relating this policy to "serendipity": the habitual experience of making happy or interesting discoveries, unexpectedly or by accident. Langmuir once said that, in Whitney's case, he would prefer to define it as "the art of profiting from unexpected occurrences."

"When you do things in that way you get unexpected results," Langmuir observed. "Then you do something else and you get unexpected results in another line, and you do that on a third line and then all of a sudden you see that one of these lines has something to do with the other. Then you make a discovery that you never could have made by going on a direct road.

"Many of the things that have happened in the laboratory have happened in ways it would have been impossible to foresee, but not impossible to plan for in a sense. I do not think Dr. Whitney deliberately plans his serendipity but he is built that way; he has the art—an instinctive way of preparing himself by his curiosity and by his interest in people and in all kinds of things and in nature, so that the things he learns react on one another and thereby accomplish things that would be impossible to foresee and plan."

Whitney's interest in providing his staff with the maximum amount of freedom included not only a willingness to allow them to devote themselves to problems of their own choice, in the expectation of "happy or interesting discoveries," but also a desire to spare them the administrative formalities that so often accumulate in business—and, for that matter, in government and academic life.

"When I first came to our laboratory," Langmuir said once, "there was practically no organization. We never had any conferences on our work, that is, formal conferences. No reports were written. For years I never wrote a report on anything. And right up to today I have never yet attended a conference in the laboratory that had anything to do with expenses or budgeting. I do not know anything about how much my work has cost and I do not care to know.

"I have no executive responsibilities. Dr. Whitney took all that off the shoulders of any man who did not like that kind of thing. There are some men that do like it and they do it well. Others do not like it and can do something else better. He did the dirty work and would smooth things out so that we would not have to worry about it."

Whitney's disregard for managerial formality sometimes produced amusing results. Once he was approached by a member of the staff who complained to him that several days before he had requested through the proper channels that his desk be moved and the job had not yet been done. Whitney agreed with the man that this was indeed an unfortunate situation and suggested that they both go down to the man's office to study the problem further. When they got there, Whitney moved the desk himself.

Whitney's devotion to the principle of freedom of inquiry, like his impatience with time-consuming administrative details, was not based simply on a desire to provide his staff with a congenial atmosphere. It was, rather, based on his conviction that research unhampered by the exigencies of day-to-day crises was the surest path to major benefits for the sponsoring corporation. Whitney was convinced that, while relatively small gains could be achieved by attacking small problems, the real breakthroughs in science would come from the large-scale—and relatively unspecific—approach to the boundaries of man's ignorance.

"Necessity is not the mother of invention," he wrote. "Knowledge and experiment are its parents. It sometimes happens that successful search is made for unknown materials to fill well-recognized and predetermined requirements. It more often happens that the acquirement of knowledge of the previously unknown properties of a material suggests its trial for some new use. These facts strongly indicate the value of knowledge of properties of materials and indicate a way for research."

"The regularity with which we conclude that further advances in a particular field are impossible seems equaled only by the regularity with which events prove that we are of too limited vision," he wrote at another time. "And it always seems to be those who have the fullest opportunity to know who are the most limited in view. What, then, is the trouble? I think that one answer should be: we do not realize sufficiently that the unknown is absolutely infinite, and that *new* knowledge is always being produced."

To Whitney, the production of new knowledge was synonymous with experimentation. "I happen to be a kind of monkey," he once said. "I have a monkeylike curiosity that makes me want to feel, smell, and taste things which arouse my curiosity, then to take them apart. It was born in me. Not everybody is like that, but a scientific researchist should be.

"Any fool can show me an experiment is useless. I want a man who will try it and get something out of it."

The stories of Whitney's love for experimenting are legion. At one time he received a letter asking if insects could live in a vacuum. Whitney took the letter to one of the members of his staff and asked the man if he cared to run an experiment on the subject. The man replied that there was no point in it, since it was well established that life could not exist without a supply of oxygen. Whitney, who was an inveterate student of wild life, replied that on his farm he had seen turtles bury themselves in mud each fall, and, although the mud was covered with ice and snow for months, emerge again in the spring. The man exclaimed, "Oh, you mean hibernation!" Whitney answered, "I don't know what I mean, but I want to know if bugs can live in a vacuum."

He proceeded down the hall and broached the subject to another member of the staff. Faced with the same lack of enthusiasm for pursuing the matter further, Whitney tried another illustration. "I've been told that you can freeze a goldfish solidly in a cake of ice, where he certainly can't get much oxygen, and can keep him there for a month or two. But if you thaw him out carefully he seems none the worse for his experience." The second scientist replied, "Oh, you mean suspended animation." Whitney once again explained that his interest was not in the terms but in finding an answer to the question.

Finally Whitney returned to his own laboratory and set to work. He placed a fly and a cockroach in a bell jar and removed the air. The two insects promptly keeled over. After approximately two hours, however, when he gradually admitted air again, the cockroach waved its feelers and staggered to its feet. Before long, both the cockroach and the fly were back in action.

Occurrences that other men would have noted only with the most casual interest became for Whitney exciting opportunities to experiment. Once he became disturbed by a scientist's seemingly endless pursuit of irrelevant details in the course of an experiment, and criticized this as being as pointless as grabbing beans out of a pot, recording the numbers, and then analyzing the results. Later that day, after he had gone home, his simile began to intrigue him, and he asked himself whether it would really be pointless to count beans gathered in such a random manner. Another man might well have dismissed this as an idle fancy, but to Whitney an opportunity to conduct an experiment was not to be overlooked. Accordingly, he set a pot of beans beside his bed, and for several days each night before retiring he would take as many beans as he could grasp in one hand and make a note of how many were in the handful. After several days had passed he was intrigued to find that the results were not as unrewarding as he had expected. He found that each handful contained more beans than the one before, indicating that with practice he was learning to grasp more and more beans.

"This might be called research in morphology, the science of animal structure," he mused. "My hand was becoming webbed . . . so I said to myself: never label a real experiment useless, it may reveal something unthought of but worth knowing."

The Research Laboratory under Whitney addressed itself vigorously to the problem of producing new knowledge, whether "basic" or "applied," and it did so with notable success. During the time Whitney headed General Electric research, a great many important scientific and practical achievements were attained. Fundamental studies of vacuum phenomena and incandescent solids provided important foundation stones for improved electric lighting and for the important new field of electronics. The same basic science made possible Coolidge's development of the modern x-ray tube, and much later, Langmuir's concept of atomic hydrogen welding. Whitney himself developed high-frequency heating for therapy, embodied in the device known as the Inductotherm, and was very active in the laboratory-wide submarine detection project of the First World War that led to the famous "C"-tube detector. It can be truthfully said that the many important accomplishments of Whitney and his associates in industrial scientific research have had a profound and beneficial effect on the lives of nearly all civilized people.

Whitney was the director of the laboratory from its founding in 1900 until 1932. During the last four years of this period he also served as vice-president in charge of research for the entire company. In 1932 he retired from directorship of the laboratory and was named an honorary vice-president of the company.

For many years Whitney served as a trustee of the Albany Medical College and the Dudley Observatory in Albany. He was a life member of the Corporation of the Massachusetts Institute of Technology, and he was also on the U.S. Naval Consulting Board established during the First World War. He was a member of the National Academy of Sciences (elected in 1917), and he was also a member of the National Research Council, American Chemical Society (he once served as president of that body), the American Electrochemical Society (its president in 1912), American Institute of Mining and Metallurgical Engineers, American Institute of Electrical Engineers, American Society for the Advancement of Science, American Academy of Arts and Sciences, American Physical Society, the Franklin Institute, American Philosophical Society, British Institute of Metals, and the French Legion of Honor.

Many colleges and universities awarded honorary degrees to Dr. Whitney, including the University of Pittsburgh, Union College, Syracuse University, University of Michigan, University of Rochester, and Lehigh University.

Other honors bestowed on Dr. Whitney both here and abroad include: the Willard Gibbs Medal, Chandler Medal, Perkin Medal, Franklin Medal, Edison Medal, decoration of Chevalier of the Legion of Honor (France), gold medal of the National Institute of Social Sciences for having contributed toward the betterment of man, 1943 John Fritz Medal, distinguished service gold key of the American Congress of Physical Therapy, the Public Welfare Gold Medal (in memory of Marcellus Hartley), and the medal of the Industrial Research Institute.

The roll call of the honors that were given him is impressive, but Willis Whitney himself knew that the greatest prize that he could attain was the feeling that he had contributed to man's understanding of the world around him.

"Our immediate interests are after all of but small moment," he once told a biographer. "It is what we do for the future, what we add to the sum of man's knowledge, that counts most. As someone has said, 'The individual withers and the world is more and more.' Man dies at 70, 80, or 90, or at some earlier age, but through his power of physical reproduction, and with the means that he has to transmit the results of effort to those who come after him, he may be said to be immortal."

KEY TO ABBREVIATIONS

Am. Mag. = American Magazine
Am. Phil. Soc. Yearbook = American Philosophical Society Yearbook
Ann. Am. Acad. Pol. Soc. Sci. = Annals of the American Academy of Political and Social Science
Arch. Phys. Therapy, X-ray, Radium = Archives of Physical Therapy, X-ray, Radium with International Abstract
Chem. Engr. = Chemical Engineering
Elec. News = Electrical News (Toronto)
Elec. World = Electrical World
Electrochem. Soc. Trans. = Electrochemical Society Transactions
Engrs. & Eng. = Engineers and Engineering
Gen. Elec. Rev. = General Electric Review
Ind. Eng. Chem. = Industrial and Engineering Chemistry
J. Am. Chem. Soc. = Journal of the American Chemical Society
J. Franklin Inst. = Journal of the Franklin Institute
J. Ind. Eng. Chem. = Journal of Industrial and Engineering Chemistry
J. Phys. Chem. = Journal of Physical Chemistry
Mech. Eng. = Mechanical Engineering
Met. Chem. Eng. = Metallurgical and Chemical Engineering
Mining Eng. World = Mining and Engineering World
Nat. Acad. Sci. Biogr. Mem. = National Academy of Sciences Biographical Memoirs
N.E.L.A. Bull. = National Electric Lamp Association Bulletin
Proc. Am. Inst. Elec. Engrs. = Proceedings of the American Institute of Electrical Engineers
Proc Am. Phil. Soc. = Proceedings of the American Philosophical Society
Sci. Mo. = Scientific Monthly
Trans. Am. Electrochem. Soc. = Transactions of the American Electrochemical Society
Trans. Am. Inst. Elec. Engrs. = Transactions of the American Institute of Electrical Engineers
Z. physik. Chem. = Zeitschrift für physikalische Chemie

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