and his collaborators, showed that the immediate intravenous injection of a combination of sodium nitrite and sodium thiosulphate was effective in saving animals subcutaneously injected with sodium cyanide. Consideration of Chen's experiments shows that his advocated therapy would be more effective in oral poisoning where the poison is absorbed gradually than in that due to inhalation of cyanide where absorption occurs instantaneously and the maximal effect on the tissue oxidative systems has occurred by the time therapy is instituted. It was necessary for us to determine the extent to which such therapy was effective in inhalation poisoning.

The mechanism underlying the use of nitrites in cyanide poisoning is the formation of methemoglobin. There is considerable *in vitro* evidence to indicate that this pigment competes with the respiratory pigment, ferricytochromeoxidase, for cyanide ion. The question arose as to whether the deliberate production of methemoglobin in the blood might not constitute an effective prophylactic measure against cyanide and thus be employed, in addition to the gas mask, to safeguard the soldier. In this connection, it was necessary to investigate substances which could readily produce methemoglobinemia without any physiological effects other than that due to the methemoglobinemia itself. A compound which had previously been reported in the literature appeared to fulfil these requirements. Methemoglobinemia was induced in animals as well as in a considerable number of men. Various aspects of the induced methemoglobinemia were then studied: the blood chemistry, the oxygen dissociation characteristics of the blood, the work capacity, effect on dark adaptation and the effects on hematopoietic, renal and liver functions. Embarrassing and lethal levels of methemoglobinemia were ascertained in animals. Methods of treatment of various degrees of methemoglobinemia were investigated.

The application of these studies to clinical medicine is apparent. Methemoglobinemia may result from the administration of certain drugs or from the absorption of toxic materials used in industry. Cases of familial idiopathic methemoglobinemia have also been reported in the literature. The information which has been obtained in the course of the studies referred to above will be of considerable aid in the diagnosis, prognosis and treatment of such conditions.

The studies on cyanides have had other interesting implications. In 1918, Loevenhart, in the course of studying the property of sodium cyanide as a respiratory stimulant, observed that the administration of cyanide to a schizophrenic patient resulted in a brief return towards normal mental processes. So far as the author is aware, this observation did not find any subsequent application. For a number of years physiologists and biochemists have been studying the effect of cyanide on tissue metabolic reactions. It has been possible for us at the Medical Division to extend and elaborate these studies. Since the lethal action of cyanide depends upon a central nervous system effect, the metabolic reactions in brain tissue have claimed special attention. With these and studies on toxicity of cyanides as a background, attention was redirected to the possible use of cyanides in the treatment of certain types of schizophrenia. A program is now in progress at one of the neuropsychiatric centers in this country to study, by means of encephalographic and other newer techniques, the effect of cyanide on brain activity and, if feasible, to apply these results to the treatment of certain selected cases of schizophrenia.

In this paper it has been possible to sketch only briefly the contributions which research in chemical warfare has made to medicine. There have been other contributions which, for lack of time, it has not been possible to describe or mention. It is interesting to note that the story of these contributions is the story of fundamental research everywhere. The prime purpose of the research workers in chemical warfare was to determine the toxicity of certain chemical warfare agents and to devise therapy against their use. But, wherever possible, the approach used was fundamental, not empirical. It did not consist of haphazard, disconnected attempts to find substances which somehow might prove useful in therapy. Its methods were to initiate systematic investigations into the mechanisms of action of the chemical warfare agents, and to build therapeutic procedures upon the results of such investigations. It was this type of approach which, in spite of the urgencies of war, yielded practical returns in our treatment of gas casualties and contributed substantially to fundamental and clinical progress in medicine.

OBITUARY

ROBERT H. GODDARD

IN the passing on August 10, 1945, of Dr. Robert H. Goddard, American science and engineering lost one of its greatest pioneers—the creator of the modern science of jet propulsion and rocketry.

His investigations had covered almost every essential principle involved in both the theory and practice of jet propulsion, particularly as applied to high-power rockets. His work was mainly responsible for the immense progress of the subject in the last three decades, which has exceeded in importance the results previously attained in several centuries of early development.

His research and his inventive mind produced the first liquid-fuel rocket, the first smokeless-powder rocket, the first practical automatic steering device for rockets and innumerable other devices. He was one of the first to develop a general theory of rocket action, including the important "optimum velocity" principle, and to prove experimentally the efficiency of rocket propulsion in a vacuum.

Even more impressive than Dr. Goddard's technical skill, insight and ingenuity was his extraordinary perseverance, patience and courage. He carried on many of his investigations in the teeth of public skepticism and indifference, with limited financial resources and in spite of heartbreaking technical difficulties—a combination of obstacles which might have baffled and disheartened a less stout-hearted pioneer. Almost single-handed, Dr. Goddard developed rocketry from a vague dream to one of the most significant branches of modern engineering.

Goddard was born in Worcester, Mass., on October 5, 1882. His early schooling was obtained at Boston, where he lived with his family until he was sixteen. His college work was taken at Worcester, where he was graduated from the Worcester Polytechnic Institute in 1908.

Upon graduation, he obtained a position at Worcester Polytechnic Institute as an instructor in physics. He continued to be connected with the academic world until 1943, part of the time on leaves of absence. His teaching career was conventional, rising in the usual steps from instructor to assistant professor and finally to full professor at Clark University. During a small part of this period, in the 1912–1913 season, he served as research fellow at Princeton University. The rest of his academic career was passed in Worcester.

It was during his brief period at Princeton in 1912 that he made the initial computations which later were to form the basis of his first publication in the new field of rockets and jet propulsion: "A Method of Reaching Extreme Altitudes," which was issued seven years later, in 1919, by the Smithsonian Institution. In this Princeton period, when he was about thirty, the great excitement of discovery first began to come upon him, for his calculations clearly indicated that only a little fuel, relatively, would be required to lift a payload to really great heights by rocket power, provided the rocket were so constructed as to make use of the fuel effectively.

Upon returning to Clark, in 1914, he began to experiment, beginning with ship rockets, and continuing with rockets of various types manufactured by himself. By 1916 he had reached the limit of what he could do on his own resources. Inexperienced though he was in the ways of money-raising for scientific research, his earnestness and enthusiasm won respect and attention. When he presented his ideas on paper to the Smithsonian that year he promptly received a letter from Dr. Charles D. Walcott, then secretary of the institution, commending him on the report and inquiring how much money would be needed.

Goddard guessed it might ultimately require $10,000, but cautiously asked for $5,000. Between that day in 1916 and the appearance of his first paper in 1919, the experimental work actually required a total of $11,000, the whole sum of which was made available by the Smithsonian. This was the investment that launched modern rocketry and jet propulsion.

The rest of Goddard's published achievements are told, factually, in his Smithsonian report of 1919, and a subsequent paper published by the Smithsonian in 1936, entitled, "Liquid-Propellant Rocket Development." What is not disclosed in these reports—what can never be told adequately—is the labor, persistence, thought and heartbreak that went into these accomplishments, through which Goddard fathered so much of the research and development which led to the great expansion of jet propulsion in the Second World War.

Most of the early work which led to the publication of the 1919 report was done at or near Worcester. After the publication of that report, which dealt principally with the possibilities of powder or "dry fuel" rockets, he turned to research in liquid fuel rocket motors. On March 16, 1926, he shot the first liquid fuel rocket ever constructed, a strange-looking contrivance about ten feet tall, which was the ancestor of all the liquid fuel rockets constructed since, including, of course, the German V-2 rockets.

In 1929 his work attracted the attention of Colonel Charles A. Lindbergh, who communicated his interest to the late Daniel Guggenheim. From that time until his death, a great part of Goddard's research was underwritten by Daniel Guggenheim and later by the Daniel and Florence Guggenheim Foundation. This support made it possible to establish quarters on Mescalero Ranch, near Roswell, New Mexico, where experimental conditions were excellent. It was there that Goddard made the rapid strides in liquid fuel rocket development disclosed in his 1936 Smithsonian report.

After the entry of the United States into the first World War in 1917, Goddard volunteered his services, and undertook the task of exploring the military possibilities of rockets. He succeeded in developing a trajectory rocket which fired intermittently, the charges being injected into the combustion chamber by a method similar to that of the repeating rifle. He also developed several types of projectile rockets intended to be fired at tanks or other military objectives, from a launching tube held in the hands and steadied by two short legs, a device similar in many respects to the "bazooka" of World War II.

These weapons were demonstrated at the Aberdeen Proving Grounds on November 10, 1918, before representatives of the Signal Corps, the Air Corps, the Army Ordnance and others. The demonstrations went off quite successfully, but the Armistice next day put an end to the war and also to the experiments.

In the Second World War Goddard likewise offered his services, and was engaged in work on liquid fuel rocket research for the Navy at Annapolis throughout the conflict.

Goddard concluded his last report, in 1936, with these words: "The next step in the development of the liquid-propellant rocket is the reduction of weight to a minimum. Some progress along this line has already been made."

Part of this progress consisted of the development of ingenious, light-weight, simple fuel pumps for injecting the propellants rapidly into the liquid-fuel rocket motor. The physicist had expected to return to New Mexico as soon as possible after the war, to continue his work on high altitude rockets, and planned to set some altitude records which would have been spectacular indeed. His death, at the age of 62, brought this program to an untimely end. Nevertheless, Goddard lived to see the dream of his youth become reality. Jet propulsion, for the uses of war at least, matured in his lifetime from a fantastic notion into a billion-dollar industry. It gave promise, too, of achieving the objectives of peacetime research for which he had spent a lifetime of thought and effort.

Dr. Goddard had been a member of the American Rocket Society for many years, and a few months before his death was elected to the society's Board of Directors. He was universally beloved and respected, and especially so by his associates in research on rockets and jet propulsion. The Board of Directors of the American Rocket Society paid tribute to him in these words:

> The lifework of Dr. Goddard, both as a scientist and a man, will always remain a brilliant inspiration to all of those who are privileged to carry on his endeavors, and to every other bold explorer on the new frontiers of science. In time to come, his name will be set among the foremost of American technical pioneers.

G. EDWARD PENDRAY,
Secretary, American Rocket Society

RECENT DEATHS

DR. EUGENE COOK BINGHAM, professor of chemistry at Lafayette College, died on November 6 at the age of fifty-six years.

DR. RODNEY B. HARVEY, professor and head of the Section of Plant Physiology of the University of Minnesota, died on November 4 at the age of fifty-five years.

DR. RALPH HENRY SMITH, professor of entomology and entomologist in the Agricultural Experiment Station of the University of California at Los Angeles, died on September 22 at the age of fifty-seven years.

DR. CALVIN S. BROWN, professor of Romance languages at the University of Mississippi, well known for his work in geology and in archeology, died on September 10 at the age of seventy-nine years.

SCIENTIFIC EVENTS

THE SUMMER MEETING OF THE AMERICAN MATHEMATICAL SOCIETY

THE fifty-first summer meeting of the American Mathematical Society was held at the New Jersey College for Women of Rutgers University, New Brunswick, on September 15, 16 and 17. The Institute of Mathematical Statistics met on September 16. In accordance with the restrictions on conventions by the Office of Defense Transportation, the society has held no previous meetings in the east or midwest since the annual meeting on November 24–25, 1944, in Chicago. The attendance was about four hundred, including three hundred and twenty members of the society.

Three addresses were given: "Some New Viewpoints in Differential Geometry in the Large," by Professor S. S. Chern, of the National Tsing Hua University and the Institute for Advanced Study; "Topological Methods in Abstract Algebra," by Professor Samuel Eilenberg, of the University of Michigan; "Some Aspects of Ergodic Theory," by Professor Witold Hurewicz, of the University of North Carolina.

On Sunday afternoon a symposium was held on "Recent Developments in Numerical Methods," consisting of three addresses: "Interpolation, Smoothing and Curve Fitting," by Professor I. J. Schoenberg, of the University of Pennsylvania; "Laurent Expansions of Algebraic Functions," by Professor Hans Rademacher, of the University of Pennsylvania, and