its causes, deficiencies in vitamins and minerals in our foods have so far been ascertained as the chief reasons. A large number of vitamins necessary or of value in the human diet have been found. Their list runs through the full length of our alphabet if the fractional parts of those letters that the nutritionists have been obliged to "split" are taken into consideration. Improper selection of food-producing plants, modern methods of handling the crop and faulty preparation by cooking and other means has resulted in a diet of subnormal vitamin content for many people. Refining and processing of foods has devitaminized still further our modern products. Profit has been often the motivating force in present food technology, the dollar sign the guiding star, setting styles, fostering sales and creating eating "habits" for the use, in volume, of certain products.

Having become conscious of the present undesirable food situation, the factors involved are being studied diligently by nutritionists, chemists, plant breeders and food processors. Counter measures are being advocated and promulgated for the breeding of plants of higher vitamin content, for better handling and storage of food materials and for the enrichment or restoration of devitalized food products. The popularity of vitamin pills has reached an epidemic stage, sales being fostered through modern ads wildly by dealers.

In this excitement the scientists hope to create or at least wait for sanity in the attitude of the average man and emotional nutritionists towards vitamins. The instinct for a healthy diet has not been destroyed in most people, though social and economic forces undoubtedly have modified it. We trust that in the future the "common man" will be nourished more properly to the benefit of his gastro-intestinal flora, his health and serenity of his mind. In the meanwhile, let us have the fortitude to hope that "freedom from want" will eventually mean also freedom from unhealthy food. Good health is not only desired by every American citizen, he is also entitled to have it. If we believe that "science goes from strength to strength to dominate the lives of men," to use words by E. W. Sinnott,[14] let us not forget that, in its application, "science has the power to work us infinite good or ill. The mastery it gives of energy and material things may send our race careening to its doom unless we gain the wisdom and the sanity to control our course."

OBITUARY

THOMAS MIDGLEY, JR.

An Appreciation

IN the passing of Thomas Midgley, Jr., on November 2, the American Chemical Society lost its president and the long-time chairman of its board of directors, and the nation lost one of its most creative men. Also those of us who were fortunate enough to know him personally lost a friend who held the highest place in our affection and esteem. Although only fifty-five when he died, Midgley had crowded into his lifetime an immense amount of accomplishment, and the achievements he left behind are an important legacy to the world.

Among the several contributions of Midgley and his associates, these four are particularly noteworthy:

He discovered the chemical antiknock agents. Tetraethyl lead, the principal one of these, is added to most automobile gasoline and it is also an essential ingredient of all high-octane aviation gasoline, so vital to-day.

As bromine in large amount is a necessary complement to lead in gasoline, he conceived and demonstrated the possibility of extracting it from the ocean, although it is present there in concentration so minute as to be measured in parts per million.

He made an altogether new series of refrigerating gases, based upon the unpromising element, fluorine, which are at once nontoxic and noninflammable.

He conducted intensive researches on rubber which extended the knowledge of the chemistry of vulcanization and of the composition of natural and synthetic rubbers.

How it happened that Thomas Midgley, Jr., a man trained not in chemistry but in mechanical engineering, came to make all these important advances in chemistry, is one of the unusual stories in modern research.

Midgley was born in Beaver Falls, Pa., on May 18, 1889. He attended high school in Columbus, Ohio, and at Betts Academy, Stamford, Connecticut. Then in 1911 he graduated from Cornell University with the degree of mechanical engineer. Out of college, he was employed at the National Cash Register Company. There he served as a draftsman in Inventions Department Number Three, the same department which I myself had left only two years before to develop a system of battery ignition and the self-starter for automobiles. After about a year at the National Cash Register Company, he left there, first to do some research on tires, and then to be successively chief engineer and superintendent of the Midgley Tire and Rubber Company, of which his father, Thomas Midgley, Sr., was general manager. In 1916, Midgley, desiring to go into research, applied for a position in our Dayton Engineering Laboratories Company. And thus began an association between us which lasted for nearly thirty years.

[14] E. W. Sinnott, *Am. Scientist*, 32: 205, 1944.

The first thing he did for us was to finish up the development of a simple mechanical means of indicating the degree of charge of a storage battery. Next he made some improvements on mercury-cooled exhaust valves. Then at my suggestion he began his long and important research on knock, the noisy and destructive bugbear which stood as a barrier to getting higher powers and better efficiency out of the gasoline engine. It was by means of a Dobbie-McInnes manograph that he made his first approach to that problem. The manograph was one that I had obtained some time before with the hope of finding opportunity to study the problem of knock, which by that time had become a serious one in automobile engines, and which I had encountered again in the effort then being made to develop a farm-lighting set. By means of this instrument mounted on a Delco-Light engine, Midgley soon found that knock did not come from preignition, as was generally believed then, but that it was a violent pressure disturbance which occurred late in the combustion of the charge, and not until some time *after* ignition by the spark plug.

In trying to understand why that violent combustion disturbance occurred, we surmised that it might result from an uneven combustion coming from imperfect vaporization of the fuel. Working on this theory, Midgley dyed the fuel red. There having been no dyes handy, he got the color with iodine; and, to his astonishment, the knock disappeared. As this observation seemed too simple to be credible, he next tried some true dyes that were soluble in the fuel and found that they had no effect upon knock whatever. But in the experiments he had discovered that iodine, either of itself or combined in the form of the colorless compound, ethyl iodide, did stop the knock.

At this point came the first World War, and Midgley's attention was turned to an effort, pursued in cooperation with the Bureau of Mines, to produce a better—more nearly knock-free—aviation gasoline. The extensive investigation made then showed for the first time that the behavior of a fuel in respect to knock is controlled not by physical characteristics, such as gravity and volatility, as had been supposed, but by the chemical structure of its components. From the results of this investigation, it was decided that a mixture of cyclohexane and benzene would best combine a good degree of freedom from knock with the possibility of being produced in simple fashion, for that could be done by hydrogenating benzene. After overcoming several obstacles, one of which was the destructive effect of sulfur on the catalyst, this endeavor had reached a stage of progress at which it was just ready to be put to practical use when the Armistice came. But the product, a mixture of 70 parts cyclohexane and 30 parts benzene, represented the first synthetic high-octane aviation fuel.

Although neither the discovery that iodine is an antiknock agent nor the making of an improved fuel by hydrogenating benzene was ever put to practical use, they did have an important effect. And that was to change Midgley's interest and activity after the war from mechanical pursuits to the chemical endeavors in which he proved to be so versatile and creative. Having been blessed with initiative and drive, and being unhampered by precedent, he soon became one of the best informed among chemists, and one of the most productive as well. Fortunately, he had that measure of intelligent ignorance—ignorance that the thing undertaken could not be done—which is so often needed for success in pioneering research.

So, after the war, Midgley began his career in chemistry by taking up again the search for a chemical antiknock agent. This "fox hunt," as he called it, was pursued for three years more in an intensive manner before the discovery of tetraethyl lead was made, and then for about two years longer before the several problems of using lead in an engine were solved in a satisfactory manner. It was during this latter period that the work on getting bromine out of the ocean was done also. After spending some years more in commercializing the tetraethyl lead development, he went back to the research laboratory. And there in due time he made his contributions to refrigerants and to rubber, already mentioned.

Having been a many-sided person, Midgley did not limit his accomplishments to those named. He also developed the Midgley Optical Gas Engine Indicator and the extensively used bouncing-pin indicator. He was a pioneer in the investigation of engine flames by visual observation through a window, by spectroscopic means, and by measuring the radiant energy emitted. He discovered some of the earliest cracking catalysts. In the present war, he was a member of the National Inventors Council and head of one branch of chemical endeavor for the National Defense Research Committee. In the first World War also he had a large part in the development of the aerial torpedo, now called the "buzz bomb."

For his many contributions Midgley received an unusual number of honors and awards, some of which were these: The Nichols Medal of the New York Section, American Chemical Society, 1922; the Longstreth Medal of the Franklin Institute, 1925; the Perkin Medal of the Society of Chemical Industry, 1937; the Priestley Medal of the American Chemical Society, 1941; the Willard Gibbs Medal of the Chicago Section, American Chemical Society, 1942.

He was elected an honorary member of the National Academy of Sciences in 1942, and he received the honorary degree of doctor of science from the College of Wooster in 1936 and from the Ohio State University in 1944.

In the citation read by William Lloyd Evans when Midgley received the latter of the two degrees was the following:

The research work of Mr. Midgley has received wide recognition, as is evidenced by the great number of distinctions which have come to him from those groups best qualified to evaluate his contributions to human knowledge. Through experience, the layman will also testify his indebtedness to one who has contributed so greatly to more pleasant and efficient living. He has made science a liberator, and we rejoice with him in the satisfactions that must be his in seeing the fruits of his labor. Posterity will acknowledge their permanent value.

Some of the fruits of his labor are these: the millions of horsepower added to automobile engines, and particularly to aircraft engines in this war, by his discovery of the antiknock agent, tetraethyl lead, and by the impetus he gave to getting bromine out of the sea as a needed complement to lead in gasoline; the big boost given to refrigeration and air conditioning by his discovery of a non-inflammable and completely nontoxic refrigerant, as well as the unforeseen but fortunate dividend from that advance of the great usefulness of the same nontoxic gas for dispersing insect repellents in the atmosphere of the living quarters of our soldiers in tropical countries; and the employment given to thousands of people by the new industries which, through his discoveries, he did so much to bring into being.

Midgley had a large part in the business side of these endeavors too. He was vice-president of the Ethyl Corporation, and of Kinetic Chemicals, Inc. (freon). He was also a director of the Ethyl-Dow Chemical Company (bromine from the sea). Midgley was particularly effective in selling the products of research to people. Something of his ability in salesmanship or showmanship has been seen by those who have heard him present papers at scientific meetings. In giving his first paper on the antiknock agents, for instance, he made striking demonstrations of knock and of its removal by antiknock agents, both in a glass tube and in an engine. Also in reporting on his discovery of the fluorine-containing refrigerants he demonstrated both their nontoxic and their non-inflammable properties by breathing in some of the vapor and exhaling it softly to extinguish a burning candle.

Midgley was a firm believer in the value of scientific societies. He was a member of the American Association for the Advancement of Science, the American Chemical Society, the American Institute of Chemical Engineers, the Society of Automotive Engineers, the American Society for Testing Materials and the Society of Sigma Xi, as well as of several other organizations. He was particularly active in the American Chemical Society. He served on its committees, he took part in local section affairs, he became a member of the board of directors in 1930 and chairman of the board in 1934, and he was president of the society in 1944. Speaking in 1937 of Midgley's large service to the American Chemical Society, Robert E. Wilson said this: "Having served as fellow director and under his chairmanship during the past five years of heavy stress for professional societies as well as business organizations, I can testify that his work and judgment have been invaluable to that organization."

Midgley was, of course, a strong believer in research also. In a paper presented less than a month before his death he said, "I am of the opinion that, as time goes on, more and more research of the fundamental type will be necessary." And, as an insurance that there will be trained men to conduct such research, he advocated that "by ample fellowships both in size and number, it (industry) should encourage many young men to remain in educational work."

The period of Midgley's researches covered only twenty years. But into these twenty years he compressed an immense amount of activity. Even after an attack of poliomyelitis in 1940 had made him a semi-invalid, he continued his interest and activity in the field of research, as well as his large service as an executive officer of the American Chemical Society and of other organizations. And this was in entire keeping with the intensive and remarkably useful life he lived. As a closure for his presidential address, "Accent on Youth," presented before the American Chemical Society less than two months before he died, Midgley used an original poem, of which these were the last two lines:

Let this epitaph be graven on my tomb in simple style,
''This one did a lot of living in a mighty little while.''

CHARLES F. KETTERING
RESEARCH LABORATORIES DIVISION,
GENERAL MOTORS CORPORATION,
DETROIT

RECENT DEATHS

DR. JOHN MADISON FLETCHER, professor of psychology at Tulane University, died on December 12 at the age of seventy-one years.

DR. HOWARD ADAMS DOBELL, head of the department of mathematics at the State College for Teachers at Albany, N. Y., died on December 8 at the age of forty-eight years.