Stephen Moulton Babcock, man of science: a memorial to him in observance of the centenary of his birth. 1943

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Stephen Moulton BABCOCK

MAN OF SCIENCE

WISCONSIN ALUMNI RESEARCH
FOUNDATION · MADISON

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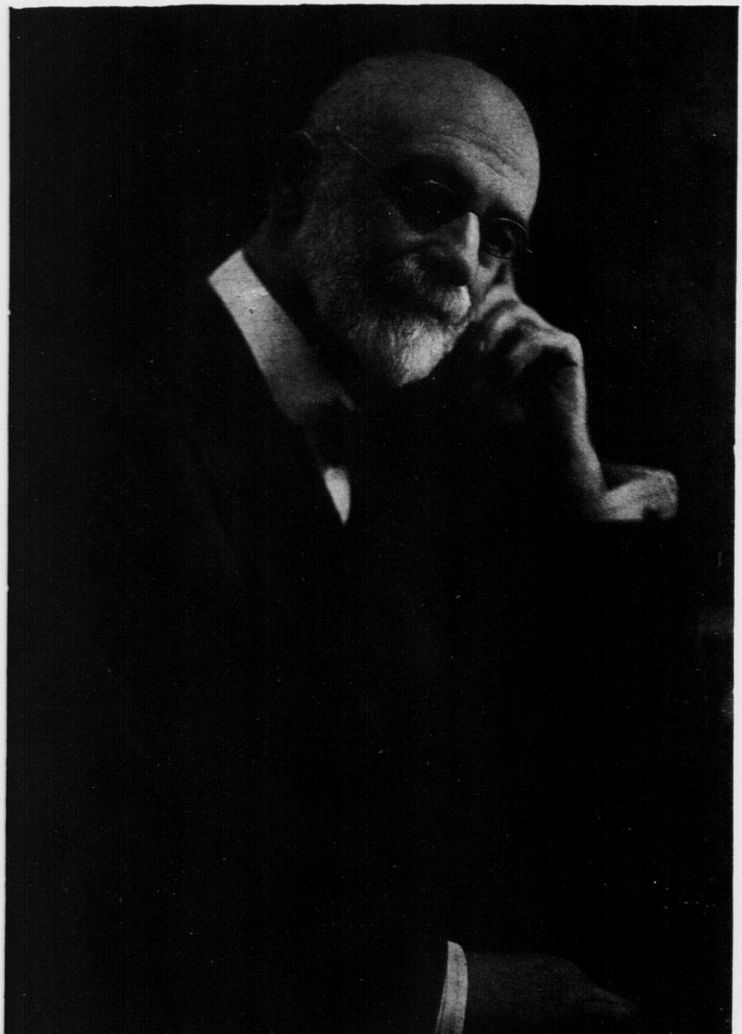

STEPHEN MOULTON BABCOCK

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A Memorial to Him
In Observance of the Centenary
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1943
THE WISCONSIN ALUMNI RESEARCH FOUNDATION

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The Man of Science

HARRY L. RUSSELL

DIRECTOR WISCONSIN ALUMNI RESEARCH FOUNDATION

SOME men are born inquisitors. They are always prying into things, trying to find out why and how the wheels go round, what makes the thing go. Where the insatiable impulse of boyhood persists into manhood you have the making of a scientific mind, for scientists are born, not made. If they are good scientists, they are continually asking questions, not necessarily of someone else but of the world about them. Even the stones will yield their secrets if the right question is asked in the right way.

As a boy Stephen Moulton Babcock had an inquisitive mind. Born in the country, he had early and constant associations with nature. After graduating from college he entered a technical institute hoping to become an engineer. When circumstances forced him to return to the farm, he did not lose his desire to learn more of science. Before long he accepted the opportunity to work on a part-time basis in the chemical laboratory of Professor G. C. Caldwell of Cornell University, meanwhile operating a small farm nearby.

Contact with this outstanding teacher inspired him to continue. He decided to go to Germany, which was then the Mecca of the American student. In the laboratory of the renowned

THE HOUSE NEAR BRIDGEWATER, NEW YORK, IN WHICH BABCOCK WAS BORN ON OCTOBER 22, 1843

Woehler of the University of Göttingen he found a congenial atmosphere, and there he completed the requirements for his doctorate, which he received in 1879.

Upon his return from Europe he was appointed instructor in chemistry at Cornell, but soon was called as chemist to the New York Agricultural Experiment Station at Geneva. In 1888 he came to Wisconsin. Forty-three years of his life span were spent at this university. Practically his entire productive life work was done at Wisconsin.

Dr. Babcock's educational life was spent mainly in the laboratory and not on the public platform. He was not a fluent speaker and he always tried to avoid making speeches when it was possible to do so. Yet when he did talk he was always most interesting.

Relied on Laboratory Results

Babcock lived in the right age to bring out the best that was in him. His pioneer spirit would let him spend little time in poring over the writing of others to classify knowledge that already existed. Moreover, he had little regard for self-constituted authority. Of statements made in books, he would often say, "This is probably good evidence that it has been borrowed from some other source." For too frequently, he feared, books masquerade in borrowed plumage. He knew that nature will not lie, but he was never quite sure that man might not have erred in making the record. The laboratory, not the library, was where Babcock sought the truth.

Yet no one knew better than he that science is built up line upon line, precept upon precept; that our knowledge advances as we build on the foundations laid by others. As Tennyson says:

> *. . . men may rise on stepping stones*
> *of their dead selves to higher things.*

And in spite of his attitude of eternal skepticism regarding the truth of the printed word, he believed firmly in scientific libraries. When he was selected by Dean W. A. Henry to join the staff of the Wisconsin Experiment Station, he was unable to begin work at the opening of the semester and asked that the pay check he was unwilling to accept for this period of absence be turned over to the agricultural library to purchase certain scientific journals. Four complete sets of German publications and a number of other volumes were thus added to the library. In Dr. Babcock's will half of his estate was given to the University for the purchase of books. The bookplate of the University's agricultural library commemorates his lifelong appreciation of the value of libraries as a tool in scientific progress.

Often Whittled His Own Equipment

Babcock was an improviser. Most men of science surround themselves with assistants who do much of the tedious check work involved in scientific study. Not so Babcock. He never had an assistant about him. Time after time, in the early days of the Experiment Station, Dean Henry would try to help him multiply his fingers through additional help, but it was of no avail. He would rather whittle out a piece of apparatus with his jack-knife than have the University mechanician build the apparatus in the shops.*

This method has its advantages as well as its disadvantages. It naturally limits the speed with which desired results can be accomplished. But the attempt to translate an idea into accomplishment is never an orderly, progressive process. In the act of building equipment there is time for new ideas to keep coming to the surface. One may start with a definite objective in mind, but the chances are that the original plan will be modified and improved upon. The Doctor often ended up with a materially different piece of testing equipment than he had originally contemplated.

Although he would not tolerate having a student assistant about, Babcock was a constant source of inspiration to other workers in the laboratory. Those of us who were fortunate enough to work where we could, now and then, catch a glimpse of the movement of his scientific mind, had indeed a rare privilege. It was as if an angel had touched our lips with a coal from off the altar. The Wisconsin Experiment Station has done a great work, and when all is said and done it is the spirit of Babcock that has been the pervasive power immanent through it all.

* I have seen many a piece of laboratory equipment that Babcock constructed in this way.

His Skepticism Started Vitamin Research

It was Babcock's refusal to adopt the then-prevalent notion that a completely balanced ration could be constructed on the basis of chemical analyses that later led, at Wisconsin, to the epoch-making discoveries in the field of vitamin research and the role of mineral elements in the nutrition of animals and man.

Though Babcock was a chemist, he was no such blind adherent to chemical methods that he lost sight of the fact that life is made up of something more than can be measured in a test tube. The accepted way of measuring the relative value of feeds was to determine the number of calories present in a given quantity of it. Expensive respiration calorimeters were set up to study, with infinite exactness, just how many calories were contained in the proteins, the carbohydrates, and the fats of specific foods. This was the status of animal and human nutrition studies when young Babcock, fresh from the laboratories of Germany, went to the Experiment Station at Geneva.

A Born Doubter

Being an ardent adherent to this prevailing school of chemical thought, Dr. E. L. Sturtevant, director of the Geneva station, set Babcock to work piling up more and more data of the conventional type. This involved analysis not only of the feed an animal consumed but also of the waste products it threw off.

Babcock, a born doubter, began to lose faith in the whole procedure. He found that if he left out of consideration the mineral ingredients in the feed the chemical analysis of the intake corresponded closely with that of the wastes. There was something wrong. Taking the two analyses to Sturtevant but not telling him which was which, the quizzical Babcock asked the director which would make the better ration. Sturtevant could see no essential difference. Babcock then told him that one was feed, the other manure.

To make matters worse, Babcock then suggested that he could make up from soft coal and similar materials a feed that would show the same chemical composition. Babcock had cracked open a new idea. After all, animal rations are something more than fuel for an engine. A cow's stomach is more than a test tube.

Man Cannot Live by Bread Alone!

Next he wondered what would happen if he fed animals a chemically balanced ration made wholly from a single kind of plant. But such a foolish experiment was at that time quite out of the question. No sane director would waste valuable cows on so foolish a procedure!

It was not until some years after Babcock came to Wisconsin that he borrowed a couple of cows from the animal husbandry department on which to try the "fool" idea that still lurked in his mind. It is doubtful whether he would have been able to surmount the stockman's prejudices had he not developed in the meantime the simple butterfat test that is universally associated with his name. This practical accomplishment softened the prejudices of other departments, even won tolerance from the Dean. Finally he induced the animal husbandry department to *loan* him a couple of cows. He was then able to start his pet experiment—feeding one cow on a completely balanced ration made from the corn plant, another on a ration equally nutritious according to chemical analyses but made wholly from oats.

In three months things began to happen. The corn-fed cow prospered and grew, but the "oat" cow pined away and died. The animal husbandman said, "I told you so; nobody could have expected anything different." The animal husbandry department put its foot down and gave the genial Doctor no more of its selected dairy stock. And that was the end of that.

Six years more rolled by, and the work of the Station grew in magnitude and importance. New blood, freshly trained young scientists, came to the Station. E. B. Hart and George Humphrey were starting their careers, the one in chemistry and the other in animal husbandry.

Babcock talked with these new men, still harping on the "crazy" idea that if the chemists were right, why couldn't one build a well-balanced ration from a single plant as well as from a mixture of a dozen? These young fellows were for trying it out, and Babcock backed their request to the Dean for a new herd of sixteen young calves reared from birth on a single ration diet. Lots of four were fed wholly from single-grain rations composed of oats, wheat, and corn, and on a mixture of all three.

Hidden Hunger Was at Work

At an early stage physiological differences began to show. The different groups reached maturity at widely varying periods. Even in the first year the animals on the mixed ration were much more normal than those on the "single" plant ration. But the experiment did not stop in a year. Fortunately it was carried forward long enough to reveal what might happen when the "single" ration cows went through the strain of reproduction.

The longer the experiment ran the more pronounced were the differences. The cows fed solely on wheat nutrients produced weak, undersized calves and maintained a low milk production. Those on the corn ration produced large vigorous calves and a high milk flow. The oat-fed group stood between the corn and the wheat lots. When animals that had matured on an exclusive corn ration were switched to wheat, death soon followed. But when a "wheat" cow was given corn, a marked improvement occurred.* Some unknown factor was at work producing what Paul de Kruif calls the "hidden hunger."

Then another link was forged into the complex when E. V. McCollum came to Wisconsin fresh from the laboratories of

* We now know that corn contains a vitamin lacking in wheat and oats.

Osborne and Mendel at Yale. He repeated a similar series of experiments, working with white rats because they are cheaper than calves and cows and more adaptable to laboratory operations. On carefully balanced *purified* chemical diets these rats grew for a time, then wasted away and died. However, a trace of butter (as little as one per cent) added to this synthetic ration restored them to normal. The results were wholly different when such vegetable fats as cottonseed and olive oil were added.

A new light appeared on the horizon. Here was a scientific basis for the essential difference between butter and oleomargarine. We now know that the special value of butter is vitamin A—the thing that McCollum called "fat-soluble A."

Classic in Nutrition Science

The University of Wisconsin is known throughout the entire scientific world for many discoveries that have been made within its walls, but no more fruitful researches have been undertaken, no richer returns have ever been made to the science of animal and human nutrition, than these "single grain" ration trials. They are considered classic in the field of biochemistry.

The pendulum of human thought has now swung strongly to a deeper study of the vitamin field. Deficiency troubles due to the lack of these accessory growth factors are adequately recognized. Fortified and enriched foods make up the field kit of the soldier and sailor; they improve eyesight, making possible more accurate night flying; keep him from contracting scurvy, that dreaded ship disease which was such a menace in the days of the windjammers; favor growth and stimulate a proper balance of the nervous system; and provide a more normal balance in manifold body functions.

This long series of epoch-making studies in nutrition stems from unorthodox Babcock, who many years ago had the courage to doubt the universally accepted chemical standards. Out of the long years of experiment the doubting Babcock started a train of new ideas, serving as a "torch bearer of science who lighted the way to truth."

Devises Butterfat Test

Although it is of no greater significance than some of his other work, the accomplishment for which Dr. Babcock is best known is his famous test for measuring accurately the intrinsic value of milk. This test was the outgrowth of necessity, as is so often the case with inventions.

So long as butter was made on the individual farm it did not matter much whether a test was applied to the milk or not. But with the development of the factory system, which naturally accompanied the introduction of the cream separator, it became a matter of financial importance to determine the value of milk of varying richness. Such breeds as the Jersey and Guernsey produced a milk much richer in butterfat than the Holstein. This latter breed, on the other hand, equalized the advantage by producing a much larger volume of milk. Manifestly if milks of such varying character were mixed and paid for by weight, it worked to the disadvantage of the farmer who brought milk of higher fat content. Then, too, the opportunity for fraud by skimming off a portion of the cream, or "watering" the milk, could not be detected by the factory operator. The temptation was too great for *every* patron to resist. The obvious result was great dissatisfaction, which endangered the whole system of co-operative or associated dairying.

Many Work upon the Problem

The problem of developing a quick and easily applied method of measuring butterfat content was an urgent one, and it engendered much activity among chemists and dairymen connected with agricultural experiment stations. In nearly all these tests the fat content of the milk was separated from the non-fat solids by the use of acids or alkalies that dissolve these other constituents. The melted butterfat was then separated by gravity or dissolved in ether or petroleum and measured in terms of percentage.

Some of these tests were put to commercial use. But while they gave fairly accurate results for whole milk or cream, they were not satisfactory when applied to such factory by-products as skimmilk or buttermilk. Dairying was at that time becoming so important in Wisconsin, and its future success was so obviously dependent upon an accurate and easily applied test, that Dean Henry urged Dr. Babcock to develop a test that could be used by the ordinary factory operator.

Babcock succeeded in devising several methods that worked fairly well. But since they were not of universal application, he rejected them one by one until only a single test was left. With this he continued his studies and finally succeeded in producing results that were apparently satisfactory. Hundreds of tests, on both mixed and individual milk samples gave an accurate register of the butterfat content as could be achieved by complicated quantitative chemical analyses. But in testing the fat production of each cow in the University herd, Babcock found one cow—Sylvia, a grade Jersey—whose milk did not check correctly with the new test.

One Cow Forced Perfection of Test

The need for speedy publication of a suitable test was so great that Dr. Babcock was urged to go ahead and publish his results on the assumption that the test would be mainly used with mixed factory milks, where consistently satisfactory results had been obtained. To this program Babcock refused to be a party, stoutly maintaining that he would not allow the announcement of a test bearing his name until wholly satisfactory results could be secured with *every* cow. The doctor was obdurate; when he finally made up his mind, nothing could swerve him from his course. So old Sylvia killed his first test.

Going back to his problem, he tried other chemical solvents and ultimately found that common sulphuric acid, *in the proper degree of concentration*, gave perfect results. This acid had been used by other workers, but they had not hit upon the right strength to dissolve properly the non-fat solids in the milk. Thus simplified, the test could be safely placed in the hands of the factory operator.

How thoroughly the test was perfected before it was made public is evident from the fact that its technical details stand today essentially unaltered after a lapse of more than fifty years. This exacting thoroughness was characteristic of Babcock's way of working. No piece of work was laid aside as complete until it was perfect in every detail.

Faulty Manufacturing Threatened Test

No patent was taken out either on the method or the apparatus. Since the work had been done under the auspices of the Experiment Station on federal and state time, Dr. Babcock felt that he should derive no personal gain from the work.

This decision, however, came near wrecking the test. Because there was no supervision whatever over manufacturing details, some dairy-supply houses started to put out machines that were too frail to stand hard factory usage. Also, cheap glassware came on the market that was imperfectly calibrated. It is not surprising that with such equipment inaccurate results were obtained.

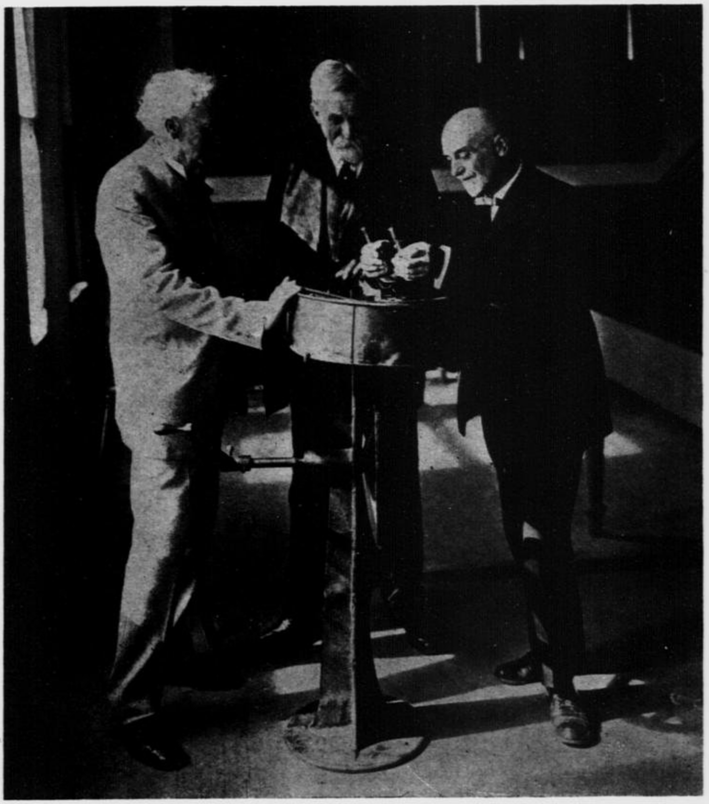
Finally the earnest protests of the Experiment Station were heeded by the better class of manufacturers, who were induced to adhere to the original specifications. In a number of the more important dairy states, also, testing laboratories were organized under state control in which the glassware used in the tests was officially calibrated before being sold.

All this trouble could have been avoided if the apparatus had been controlled by patent and only licensed manufacturers permitted to put out properly standardized equipment. Babcock's disinclination to accept pecuniary reward for his efforts could have been met by the arrangement which now obtains in the University of Wisconsin. The Wisconsin Alumni Research Foundation assumes the responsibility for commercializing the patents that are voluntarily assigned to it by staff members, and holds the financial returns, if any, in trust for the continued prosecution of research in the University. Dr. Babcock has told the writer that had such an organization existed when he invented his test he would have been entirely willing to assign to it any patent he might have been able to secure.

Dr. Babcock had never any thought of financial reward for himself. It was his refusal to profit personally from his discoveries that first brought him prominently into public notice. Soon after the success of the milk fat test he was offered a handsome salary to join the staff of a large commercial dairy company. Days passed, and the company heard nothing from him. Finally, upon writing him again, they received this reply: "I am working on a couple of unfinished experiments and cannot accept the position." His wants were few, and his relatively meager salary sufficed to fill these. Why bother with more?

The Test Made Dairying a Science

With a simple accurate method of measurement such as the Babcock test, not only were factory operations put upon a sound and economical basis, but the dairy farmer or breeder was furnished a means of studying the individual performance of each animal in his herd. With the Babcock test and a pair of scales the farmer can tell exactly how productive each animal is. Thus the "star boarder" that does not pay her way can soon be eliminated from the herd. When the dairyman learns to employ herd testing, he has started on the way toward economic salvation. The test strikes the shackles which bind him to past tradition.



THE FIRST MILK-TESTING MACHINE

In making the first tester Babcock designed and used a centrifugal machine that had a conical rack in which the test bottles of milk were held and revolved in an inclined rather than a horizontal position. In modern high-speed centrifuges it has been found that this is by far the more effective position, and patents have been taken out on this principle. Babcock hit upon the improvement without recognizing its great commercial value. It is highly probable, however, that even if he had recognized the value of this feature, he would still have refused to apply for patent protection. With Dr. Babcock are Dean W. A. Henry (left) and President T. C. Chamberlin (center).

The farm operator who arranges to have his herd tested is likely to be one who reads agricultural and dairy papers regularly. He begins to delve into the mysteries of balanced rations and to run his farm on modern lines. With the attainment of economic independence come not only better barns and livestock, but better homes, labor-saving devices for the wife and family, and mechanized machinery for the farm.

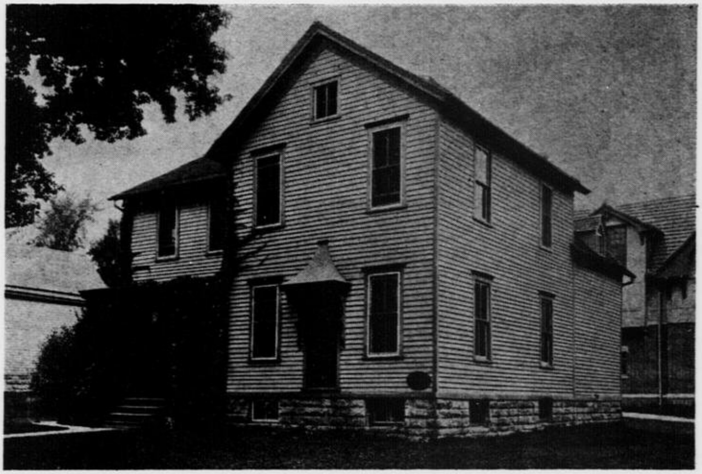
Fat Test Influences Dairy Education

The Babcock test was really the foundation stone on which modern dairy education has been built. Since it was designed to be so simple that the factory operator could use it, some type of vocational instruction had to be organized to give him the necessary experience. Prior to this time butter-makers and cheese-makers learned their job under the apprentice system. The "know how" was acquired by actual factory experience until an operator was able to run a factory himself. Now definite instruction became necessary. At the same time that manufacturing companies began to make the necessary apparatus, a course of instruction in its manipulation was planned. The first course was given in the winter of 1890, only a few months after the test had been made public by the Experiment Station.* Two students registered for this first course; the next fall more than seventy students registered for the work and were crowded into a small building on the west end of the university campus.

The demand for this instruction induced the 1891 legislature to provide better quarters, and in October, 1891, ground was broken for a new dairy building, the first structure of its kind in the country. On January 11, 1892, the new building, although still far from complete, was opened for instructional purposes to about one hundred students.† From all over the United States and Canada dairymen came to learn the details of manipulation.

* Bulletin No. 24, Wisconsin Experiment Station, July, 1890.

† From unpublished data prepared by Dean W. A. Henry in 1912.



THIS BUILDING, STILL STANDING ON THE CAMPUS OF THE UNIVERSITY OF WISCONSIN, HOUSED THE FIRST DAIRY SCHOOL IN AMERICA

From old Hiram Smith Hall,* the first dairy building in the western hemisphere, thousands of students have gone forth all over the world. Soon other states extensively engaged in dairying developed similar courses of study.

Thus the Babcock test was really the prime factor in transforming dairying from an art into a definite science. In no small measure Wisconsin's agricultural importance today, which is largely dependent upon her dairy activity, is attributable to the simple test of this Wisconsin scientist.

Dean Henry leaned heavily on the counsel of Babcock in administering the agricultural college of those early days. It was uphill business then to win the support of the farmers, who were wont to scoff at academic learning, and at the same time gain the respect of the leaders of older University departments, who

* Named for Hiram Smith, of Sheboygan, a leading dairyman of the time, who was then a Regent of the University.

had none too much sympathy with this effort to put farming on a collegiate basis.

The serious-minded Henry and the genial Babcock made a happy and effective team in working toward this end. Babcock had a hearty and irrepressible laugh; at any moment he was likely to give vent to his enthusiasm in the laboratory, which in those days was situated, with the other quarters of the agricultural college, in Old South Hall. Often there would reverberate through the corridor an uproarious laugh, and everyone knew that Babcock was getting a great "kick" out of some story he had recently heard. Dean Henry, who always had a severe and dignified mien—as might occasionally befit a dean—would come rushing into the laboratory, expostulating with the good doctor for such unseemly levity. Babcock would quiet down until the Dean disappeared, then forget his promise to keep quiet.

Babcock was always playing jokes on his associates. One day an engineering colleague came to him for help. He had been employed to lay out a suburban tract below San Diego, California, and develop a model city, and he wanted the Doctor's assistance with reference to the milk supply for the new development. Dr. Babcock elaborated on the difficulties one would encounter in trying to develop dairy herds in so dry a country as southern California in the heat of summer. So he humorously implored his engineering friend to try the experiment of domesticating the South Pacific whale, bringing them into the harbor where, if a pipe line was constructed to the ocean, the milk supply of this mammalian species could be piped directly to the new town. I believe the suburb finally adopted some other method of insuring an adequate dairy supply.

Was a "Sports" Fan

Babcock was an intensely human person with an unusually wide field of interests. During the ball season, either football or baseball, he was always to be found in the grandstand with his bag of peanuts or popcorn, seated with some of his old cronies. He knew the batting record of every man in both the national baseball leagues, and he watched the ups and downs of his favorites with all the enthusiasm of a kid fan.

He was invariably clad in an old grey sweater and cap that had served him well for years. The tight clinging sweater was the only extra garment he wore even during the most severe winter weather. Rubbers and an overcoat he disdained, insisting that they made "softies."

DR. BABCOCK IN CHARACTERISTIC ATTIRE

In his Lake Street home he refused to install a telephone, claiming that it was too much bother to answer the contraption. He did, however, adopt the automobile. When he was past seventy-seven, although blind in one eye, he bought a Franklin car and often toured southern Wisconsin with Mrs. Babcock.

His relations with his fellow workers were always most cordial. No one ever heard him make a disparaging remark about anyone. His helpful suggestions were freely given to associates and students alike.

His Backyard Hollyhock Garden

Babcock was always a great lover of flowers. Soon after he came to Wisconsin he sent back home for seeds of the hollyhocks which grew on the old farm homestead. These he planted in the backyard of his Lake Street home in Madison, where they grew so vigorously that they soon overran the other flowers in the garden. For years the Babcock hollyhocks were a sight to behold as they came into a blaze of color in July.

After Dr. Babcock's death fellow members of the college staff conceived the idea of gathering seed from the garden and sending it to all the agricultural colleges and experiment stations in the country with the request that "Babcock Memorial Gardens" be established. Seed was also sent to Tufts College in Massachusetts, Dr. Babcock's Alma Mater, and to the University of Göttingen, Germany, where he had taken his doctor's degree. Reports received indicate that in at least forty-four states of the Union these memorial gardens have been established on the campuses of agricultural schools and colleges.

Seed was also distributed to many thousands of boys and girls, members of the 4-H Club, and others; thus Babcock's memory is kept alive through the perpetuation of his hollyhocks.

The Babcock Home Inspires Youth

After the death of Dr. Babcock in 1931, the old Babcock home on Lake Street was put to a splendid use, one that would

A CORNER OF THE BABCOCK HOLLYHOCK GARDEN have won the good doctor's hearty approval. It was made into a cooperative housing project for agricultural college students, who greatly reduce their living expenses by doing much of their own housework. This enterprise is enabling a group of agricultural students to make their way through college at a fraction of the cost that other living accommodations would require.

Bacteriologist and Chemist Team Together

It was my good fortune, in the early years of Babcock's scientific career, to work with him for almost a decade in the closest possible relationship. For a number of years he had been interested in dairy problems, the constitution of milk, etc. Naturally he approached the problem from the chemical point of view. But the highly nutritious fluid, milk, is also very readily affected for good or ill by the activities of microorganisms.

The combination of a dairy chemist and a dairy bacteriologist in those early days was a novel one, and was brought about by Dean Henry, who had the idea that the joint efforts of two men approaching the same problem from different angles might be more fruitful than a single approach.

The outcome of this "combination" of effort resulted in a number of discoveries that have exerted a substantial influence on farm and dairy operations. It was found that the reduced consistency of pasteurized cream is due to the breaking up of the fat globule clusters in milk, thus impairing the "whipping" properties of the product. A practical means of restoring this property was devised through the addition of a few drops of sucrate of lime (quicklime dissolved in a cane sugar solution).

Develop Cold-Curing Process for Cheese

It was also discovered that milk naturally contains a hitherto unrecognized enzyme or ferment, which was named galactase. This enzyme acts on the casein constituents of cheese, causing this insoluble protein factor to "break down" and gradually become more soluble. The maturing or ripening of cheddar or American cheese is intimately associated with the action of this natural ferment, together with the peptic enzymes added in the rennet used to coagulate the curd in milk.

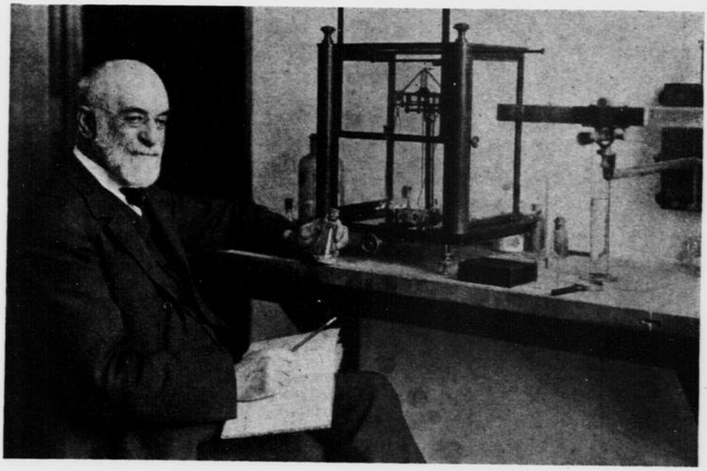
This discovery led to the development of the "cold-curing" of cheese at lower temperatures than those commonly in use at the time. The much improved quality of cheese cured at 60° F. and below, and the marked reduction in loss of weight due to lower temperature curing, have led to the widespread use of this system not only in the United States and Canada but in New Zealand and Australia.

The studies made on the production of silage showed that the keeping quality of this highly valued feed is primarily dependent upon the respiration of the ensiled tissues. The oxygen of the entangled air is rapidly used up, and carbon dioxide is produced. Intramolecular respiration of the combined oxygen of the organic matter then continues under anaerobic conditions—in other words, in the absence of air. In a tight container, such as a silo, where access of air is prevented, the fermentative changes due to this intramolecular respiration produce the necessary acids and carbon dioxide to prevent the production of molds which injure the quality of the silage.

Studied Role of "Metabolic" Water

As an indication of Dr. Babcock's breadth of vision his contribution to the physiology of plants and animals may be cited. Not often has a scientist made such classic experiments in a field foreign to his own as did Babcock when he explored the role of "metabolic" water in connection with the phenomena of life.

It had long been known that in the processes of respiration the oxidation of organic matter in the food and tissues of an organism resulted from the absorption of free oxygen of the air



PONDERING ANOTHER QUESTION

and the evolution of carbon dioxide. Water always results from this chemical process, whether it takes place in animal or in plant life. This type of water, produced under such circumstances, is called "metabolic" water, because it originates as a result of the process of metabolism, a fundamental characteristic of *living* protoplasm.

The physiological approach of this problem of metabolic water—what little work had been done on the subject—had been concerned with experiments on *either* plants or animals, depending upon the specific training of the scientist undertaking the study. Babcock, a chemist, became interested in the problem when his curiosity was excited as to how a clothes moth gets its necessary water supply when it is forced to live on the air-dry wool fiber which it consumes in the larval stage of its development. A micro-chemical analysis of the larvae showed over ten times as much water in the tissue of the animal as in the wool fibers and fur on which the larvae fed. For more than six years the inquiring doctor watched his clothes moths breed generation after generation, living upon dry wool cloth and hair (astrakhan fur).

He also studied other insect types. The bee moth, which lives on empty honeycomb, types of weevils which infest dry seeds, such as peas and beans, and flour moths all indicated that the water needed to enable metabolism to proceed is dependent not so much on "imbibed" water as on water produced as a result of respiratory processes.

These studies led Babcock to undertake basic and fundamental experiments on the germination of seeds, the ripening of fruits, and similar phenomena in the plant field, experiments which contributed greatly to a more complete understanding of the influence that respiration exerts on many of these natural phenomena.

The simplicity of his experiments and the thoroughness of their execution have made his work on metabolic water an outstanding contribution to the physiology of both plant and animal life.

Babcock Work in Physics

More than twenty years of Dr. Babcock's later scientific career was spent in fundamental work in the field of physics, especially on the constitution of matter. Even in his earlier years he had given much thought to this subject and had formulated in his own mind a hypothesis that departed radically from the commonly accepted ideas concerning the relation of matter and energy. About 1896 he began a series of experiments in which he weighed a large mass of water on a very delicately constructed balance to study the variations in the weight of the water in a solid and liquid state. As was his custom, he constructed the entire apparatus with his own hands. The persistence with which he stuck to these studies, even at the advanced age of eighty-seven, inspired the admiration of all his colleagues.

The later years of his life were spent in reducing his observations to written form, but he would not publish on the subject during his lifetime. After his death the manuscript which he left was critically examined by a number of prominent physicists and mathematicians, not only at Wisconsin but elsewhere. It

MEDAL BESTOWED UPON DR. BABCOCK IN 1899 BY THE LEGISLATURE OF WISCONSIN

"Recognizing the great value to the people of this state and to the whole world of the inventions and discoveries of Professor STEPHEN MOULTON BABCOCK *of the University of Wisconsin, and his unselfish dedication of these inventions to the public service, The State of Wisconsin presents to Professor Babcock, this Medal."*

was the general consensus that the work was more qualitative than quantitative and that the conclusions drawn were not sufficiently definite to warrant publication. But Dr. E. B. Hart has expressed the opinion that many of the basic principles now recognized in the new science of physics were foreshadowed in the bold postulates that Babcock set forth in these early studies.

Dr. Babcock left no long list of contributions, for he was as sparing a writer as a speaker. For the most part he played a lone hand. The freshness of his ideas came from long brooding over a subject. His inquisitive mind was always subjecting the observed fact to more crucial experimentation.

Whatever the field, he brought to it a fresh point of view, and this made him invaluable in the laboratory. Everyone with whom he came in contact was stimulated and inspired by his suggestions. The atmosphere of the entire laboratory was charged as with an electric impulse. The phenomenal results that have flowed from the biochemical department of the College of Agriculture of the University of Wisconsin stem back largely to the influence of this shy and quiet man of science.

Saint of Science

GLENN FRANK
LATE PRESIDENT OF THE UNIVERSITY OF WISCONSIN

EXPRESSING the mood of myriads of men and women throughout the world, who have known the boon of his spirit or the beneficence of his science, the University of Wisconsin bares its head and bows its heart before the memory of Stephen Moulton Babcock.

Inventor of a device and a formula that emancipated the dairy farmer from the injustice of the rule of thumb that long prevailed in the market place!

Trail blazer in the crucially important field of vitamin research!

Symbol of the best that the pursuit of science generates in the scholar and gives to the state!

Joyous comrade!

A friend beloved beyond measure!

Inspirer incomparable of that army of young scholars serving as acolytes at the altar of science!

Like the great seminal minds of the Renaissance, this grand old doctor of science was himself greater than anything he did, and thus he gives to us, the legatees of his spirit, a goal toward which to point the education and the science of our time.

This merry man of many years was made of the stuff that gives mankind its saints and its martyrs. But he was a saint without seriousness, and he could have gone to martyrdom, without a murmur of self-pity, as part of the day's work.

For his was a casual greatness!

He pursued the most painstaking research as if he were playing a game. He brought to his tasks that gaiety of spirit which authentic greatness can afford. His spirit never surrendered that incorrigible playfulness which so often marks men of power. He brought laughter into the laboratory, for there was about him that deceptively careless air which creative spirits have as they go about their business.

But there was toughness to the fiber of his mind.

He was a teacher who scorned the tyranny of the textbooks, and he did not think it impertinent to doubt the authorities. Each morning he met the universe with a question. His was the creative heresy of an insatiable curiosity. The cleansing winds of the critical spirit swept freely and forever through his mind.

He belongs to the apostolic succession of the great pioneers of research—Pythagoras, Aristotle, Archimedes, Copernicus, Galileo, Harvey, Newton, Lavoisier, Dalton, Faraday, Helmholtz, Darwin, Pasteur, Gregor Mendel, and Einstein—for, like them, he was an adventurer into the unknown to whom research was an intellectual passion rather than an institutional ritual, to whom creative thinking was more important than elaborate equipment, and for whom there was no barricaded frontier between pure and applied science.

In an age when scholars all too often hasten to publish even before they prove their findings, he was content to let his greatest work speak for itself, for perhaps the most illuminating fact of his career is that he never published so much as a word about his part in the discovery, definition, and defeat of that "hidden hunger" from which man and beast might die while eating their fill.

In an age smitten with the passion of publicity, he forgot himself into immortality.

And in the midst of the sickness of an acquisitive society, his spirit remained unsullied by legitimate personal considerations!

Scholar of a great university!
Servant of a great state!
Shy benefactor of mankind everywhere!
Laughing saint of science!

Being dead, he yet speaks!

To Dr. Babcock on His Seventy-Seventh Birthday

A. S. ALEXANDER

Not selfishness has ruled your life, philosopher and sage,
Not gain and luxury of wealth have been your aim and wage;
But service rich, of head and heart, in love for all mankind,
You've freely, fully, gladly given, with never self in mind.

Such service has its sure reward, unlooked for tho it be,
Not told in titles, 'graved on stone, or paid in golden fee;
In your own heart there is the joy of noble work well done,
And in the heart of all the World deathless esteem you've won.

Milestones in Babcock's Career

1843 Born at Bridgewater, New York, on October 22.

ACADEMIC CAREER

1866 Was graduated from Tufts College, Medford, Massachusetts.

1867 Attended Rensselaer Polytechnic Institute, Troy, New York, intending to specialize in engineering. He was forced to discontinue his course when a death in the family compelled him to assume the responsibility of operating the home farm.

1868–72 He continued this farm work and simultaneously worked on a part-time basis in the chemical laboratory of Dr. G. C. Caldwell of Cornell University.

1877–79 Studied in Germany at the University of Göttingen.

1879 Received the Ph.D. degree from the University of Göttingen.

1881–82 Instructor in Chemistry at Cornell University.

1882–88 Chemist at the New York Agricultural Experiment Station at Geneva.

1888 Chief chemist at the Wisconsin Experiment Station.

1893 President of the American Association of Official Agricultural Chemists.

1901 Made Assistant Director of the Wisconsin Experiment Station.

1913 Retired as Emeritus Professor at the University of Wisconsin.

1931 Died on July 1.

INVENTIONS AND DISCOVERIES

1883 Viscosimeter to determine the viscosity of oils and other fluids as to the presence of adulterants. Used commercially.

Gravimetric method of analyzing milk, which later was adopted by the American Association of Official Agricultural Chemists as the standard control method for the analysis of milk.

1885 Method of determining the size and number of fat globules in milk.

1890 Milk fat test. A short, accurate method, capable of application by the factory operator, of determining the amount of butterfat in milk and factory by-products.

1896 Method of separating casein mechanically from milk.

A mathematical formula for determining the yield of cheese based on lactometer readings.

Determination of the cause of reduced consistency in pasteurized cream and the invention of "viscogen" as a means of restoring the consistency or "body" to cream (with H. L. Russell).

1897 Discovery of galactase, a proteid-dissolving enzyme in milk (with H. L. Russell).

"Cold curing" of cheese (with H. L. Russell).

1899 The development of the Wisconsin Curd Test for use in cheese-making to detect the presence of undesirable types of bacteria (with H. L. Russell and John W. Decker).

This method hastens the fermentative processes in milk by applying a low degree of heat to individual milk samples to bring out the potential development of abnormal fermentations in cheese.

Discovery of the causes operative in the production of silage (with H. L. Russell).

1906–12 Metabolic water. This is generally regarded as the most important piece of scientific work done by Dr. Babcock. Finds that the process of metabolism of such animal forms as clothes and carpet moths, weevils infesting dried seeds and grains, insects affecting honey comb, etc., results in the formation of "metabolic" water, which bathes the animal tissues. Most living forms require "imbibed" water for their life processes.

1896–1931 Studies on the constitution of matter, involving long-continued experimentation and observation. No work was published prior to his death. He left a manuscript covering these studies.

Honors Bestowed upon Babcock

1893 The original fat test apparatus was exhibited at the World's Columbian Exposition at Chicago, where it was used in the official testing of the dairy breeds in the exposition.

1899 The Wisconsin legislature passed a joint resolution providing that a bronze medal be presented to him as a testimonial of his service to the state. This medal, designed by Spinx & Son of London was selected by a special legislative committee and was presented by Governor Robert M. La Follette, Sr., to Dr. Babcock during the 1901 session of the legislature.

1900 The fat test was exhibited at the World Exposition at Paris, where it was awarded the "Grand Prize."

The dairymen of New Zealand sent Dr. Babcock, in recognition of their country's high regard for the fat test, an illustrated testimonial containing a number of water colors of New Zealand scenes.

1901 The Australian provinces of Victoria and New South Wales presented him with an oil painting representing an Australian dairy scene.

The test was displayed at the Pan-American Exposition at Buffalo. Dr. Babcock was also a member of the Jury of Awards at this exposition.

Tufts College, his Alma Mater, conferred upon him the honorary degree of Doctor of Laws.

1904 Test exhibited at Louisiana Purchase Exposition at St. Louis, when again it received the "Grand Prize."

1916 Babcock "Silver Jubilee."

1917 Awarded the honorary degree of Sc.D. by the University of Wisconsin.

1930 Received the Senator Capper Award for Distinguished Service to American Agriculture—a medal and a purse of five thousand dollars.

1931 Fifty-two years after he received his degree of Doctor of Philosophy in course, the Mathematical and Natural Science Faculty of the University of Göttingen, in conformity with its usual custom, renewed the degree, extending at the same time the University's heartiest greetings. This recognition was conveyed personally by Professor Freudenberg, Carl Schurz Exchange Professor, then resident at the University of Wisconsin, who said to Babcock, "Your old alma mater is proud to call you her pupil."

DATE DUE

DEC 1 ? 1997			