SCIENCE

VOL. LXIV JULY 9, 1926 No. 1645

CONTENTS

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 8, 1879.

WILLIAM CHAUVENET[1]

IT is eminently fitting that the prize for mathematical exposition recently established by the Mathematical Association of America at the suggestion of its president, Dr. J. L. Coolidge, should bear the name of Chauvenet.[2] For Professor William Chauvenet, in whose honor this prize was named, had a real genius for exposition and lucid presentation, combined with a power of expression and purity of language unexcelled in American scientific literature. Although Professor Chauvenet's name has lived and will continue to live for many reasons, this new honor to his memory naturally revives an interest in his life and work.

It is therefore very appropriate that a biographical sketch of Professor Chauvenet should be read at this time before a combined meeting of mathematicians, astronomers and members of the History of Science Section of the American Association for the Advancement of Science, not only because of the historic value of his work but also because he was one of the first members of this association as well as one of its first presidents.

Professor Chauvenet's father, William Marc Chauvenet, the youngest of ten children, was born in Narbonne, France, in 1790, and, on account of the early death of his parents, was educated by two older brothers who lived in Italy. As secretary to one of these, who at that time was a chief commissary in Napoleon's army in Italy, he spent the early part of his life in that country. While there he had the time and means to cultivate a natural taste for music and literature. However, at the downfall of Napoleon he was forced to look elsewhere for means of support. He then came to Boston, and later to New York, as a partner in a silk importing company. This enterprise failing, he gave up business and bought a farm near Milford, Pike County, Pennsylvania. In the

[1] An address (here somewhat abridged) delivered at a joint session of Sections A, D and L of the American Association for the Advancement of Science, Kansas City, December 30, 1925. See SCIENCE, Vol. LXIII, No. 1622 (Jan. 29, 1926), pp. 123, 126, 138.

[2] See, *The American Mathematical Monthly*, Volume XXXII, No. 8, p. 439.

meantime he had married Miss Mary B. Kerr, of Boston. After a brief trial on the farm he removed to Philadelphia in 1821, where he again engaged in business.[3]

It was during the brief residence of his parents on the farm near Milford, Pennsylvania, that William Chauvenet entered Yale at the age of sixteen years. child he was carefully brought up, and the best schools were selected for his instruction. He lived in Philadelphia until he had attained the age of manhood. Early in life he manifested decided mathematical and musical abilities, as well as a mechanical proficiency. To his father he owed his love for music and literature, and from his mother he appears to have inherited his logical exactness and methodical reasoning power. He had a remarkable teacher in Dr. Samuel Jones, who at that time was head master of a boys' school in Philadelphia. It was due to the influence of Dr. Jones that Mr. Chauvenet consented to send his son William to Yale College. William Chauvenet entered Yale at the age of sixteen years. He graduated in 1840 with high honors, due as much to his classical as to his mathematical attainments.

When confronted with the choice of a career, it was a question with him whether it should be music or mathematics. However, the direction of his activities was to a large extent determined by his association with two eminent men. One of these was Professor Alexander Dallas Bache, head of Girard College in Philadelphia and later first president of the National Academy of Sciences. The other was Mr. Sears C. Walker, who established and directed the Astronomical Observatory at the Philadelphia High School. To the latter, Professor Chauvenet, in common with others, attributed the direction of his studies in astronomy.

Soon after leaving college, William Chauvenet was selected by Professor Bache to assist in a series of observations on terrestrial magnetism, which were undertaken at Girard College. An enduring friendship resulted from the association thus afforded these two men, and in later years Professor Bache's counsels were often sought by Professor Chauvenet.

In 1841 William Chauvenet was appointed professor of mathematics in the navy. According to the custom at that time, he was assigned to duty on shipboard to instruct midshipmen. However, after a few months of such service on the U. S. steamer *Mississippi,* he was so thoroughly convinced of the uselessness of the plan of teaching on shipboard, subject to the many inconveniences and interruptions of alternate life at sea and in port, that he resigned his appointment. The inadequacy of such instruction had already been so generally recognized in the navy that in 1839 the secretary of the navy established a school of preparation at the Naval Asylum in Philadelphia (originally intended and later used for veteran seamen). At this school midshipmen were permitted, but not required, to pass an academic year of eight months in the study of mathematics, necessary for promotion.

Professor David McClure was appointed to take charge of the class in mathematics and navigation. His death occurring early in 1842, Professor Chauvenet was appointed his successor. Professor Chauvenet showed so much ability and met with such marked success that it was decided to close all other schools gradually and discontinue all shore instruction elsewhere.[4]

Upon taking charge of the school, Professor Chauvenet immediately began the work of reform as far as was possible within the limits of the system then existing.[5] He arranged a more severe course of mathematical study than had before been prescribed and obtained for it the formal sanction of the secretary of the navy. He also introduced regular recitations and a system of marks for daily recitations. From the governor of the Naval Asylum he obtained a well-lighted classroom, blackboards, chronometers, sextants, etc. Not stopping there, he drew up a plan for the expansion of the institution into a regularly organized school in which all the subjects conceived to be indispensable to the naval officer were to be taught under competent instructors. In addition to this he pointed out the way which, at that time, made possible the establishment of the United States Naval Academy.

Seeing that attempts to get bills through Congress had failed and in all probability would fail again, it seemed to him that the only practical method was first to expand the course at the Naval Asylum. Then in frequent interviews with the secretary of the navy, Professor Chauvenet represented to him that the same power exercised by the secretary in sending the midshipmen to the Naval Asylum for one year and in sending one professor there to teach them might be exercised in retaining them there two years and in sending not only more naval professors, but also other officers of the service.

[3] Memoir of William Chauvenet, by J. H. C. Coffin, *National Academy of Sciences, Biographical Memoirs,* Vol. I. Washington, 1877, pp. 227–244.

[4] "History of the U. S. Naval Academy," J. R. Soley, Washington: Government Printing Office, 1876 (p. 38).

[5] See: A letter from Professor Chauvenet to Mr. T. G. Ford in an article (with a portrait) on William Chauvenet by Wm. H. Roever, "Washington University Studies," Vol. XII, Scientific Series, No. 2, pp. 97–117, 1925. See also: "The Teaching and History of Mathematics in the United States," Florian Cajori, Washington: Government Printing Office, 1890 (pp. 239–244).

Mr. George Bancroft, who was appointed secretary of the navy on March 4, 1845, at once appreciated the importance of a reform in naval instruction and resolved to avail himself of the power in his hands to effect it. He called upon the Board of Examination, which met at the Naval Asylum in June, 1845, for a detailed plan of a school, and especially consulted them upon the propriety of adopting Fort Severn at Annapolis as the site for such a school. He had fully adopted the idea of expanding the course of instruction without consulting Congress, but foresaw that as a regularly organized institution might thus gradually be brought into existence, room for expansion would be needed which could not be afforded by the Naval Asylum. Secretary Bancroft's next step was to refer the report of the board and all other documents relating to the subject in the possession of the department, to Commander F. Buchanan, with instructions to prepare, with such assistance as he might require, a plan for the organization of the Naval School at Fort Severn. At the same time he appointed Commander Buchanan superintendent of the school. This plan of organization, after some revision, was published in August, 1846, but carried into effect in October, 1845. Thus the United States Naval Academy was founded by Secretary of the Navy George Bancroft. But Professor Chauvenet did much to direct his attention to its necessity and feasibility and prepared the way for his success.

This was a great achievement, in view of the fact that numerous unsuccessful attempts had been made during the preceding thirty years to induce Congress to establish a school for the navy similar to that which it had established years before at West Point for the army.

Professor Chauvenet's efforts did not cease with the founding of the Academy at Annapolis. He was constantly urging farsighted plans for its further development, and during the next fourteen years his was the chief influence in its upbuilding.

From 1845 to 1850 there were only two classes, called the junior and senior classes, but even yet attendance was uncertain because of the fact that midshipmen were subject to call for sea service at any time. In 1850 a change was made which required of students a continuous attendance during two periods of two years each with an intermission between these of three years for sea service. Finally, a consecutive course of four years before sea service, with summer cruises, was adopted. The course was also improved as to the subjects taught, and the admission requirements were gradually raised.

Professor Chauvenet also advocated that graduates should be brought back, nominally as assistant instructors, in order to give them an opportunity for further study, and that the academy by its equipment for professional studies should offer inducements to this end. In his own department he made provision for such purpose by the erection of a small observatory which he equipped with an equatorial telescope and a meridian circle. This resulted in 1853 in the creation of a separate department of astronomy and navigation, with Professor Chauvenet at its head and director of the observatory.

The connection of Professor Chauvenet with the academy and its predecessor, the Naval Asylum, for a period of about eighteen years, in the various capacities of professor of mathematics and astronomy, member of the Academic Board and director of the observatory, is one of the most important facts in the early history of the academy. Various writers agree that he did more than any one else to establish the institution on a firm and scientific basis and that he raised the calling of the United States naval officer to a place of distinction.

In recognition of this service a memorial to Professor Chauvenet, in the form of a bronze tablet, has been placed in the library of the Naval Academy. The upper half is a bas-relief of the distinguished scientist and the lower half bears the following inscription:

1820 1870
William Chauvenet
Professor of Mathematics
United States Navy and
President of the Academic
Board from 1847 to 1850
Largely Through Whose
Efforts and Plan the Naval
Academy was Established
and Organized at Annapolis.

Professor Chauvenet's scientific writings, which will be discussed later, and his success as a teacher and administrator at Annapolis had attracted wide attention. It was therefore natural that his Alma Mater should wish to have him on the faculty. In 1855 he was asked to become professor of mathematics, but he was not ready then to give up his work at the Naval Academy. Again in 1859 he was sought as professor of astronomy and natural philosophy. At this time he was also offered the chair of mathematics and natural philosophy at Washington University, then recently established in St. Louis. Considering well the claims of these two institutions, one well established and of great reputation, the other just beginning life, but organized on plans which he approved, he decided in favor of Washington University, "where conscious usefulness would be his best reward."

Professor Chauvenet had a broad general culture and in addition to this he was already an outstanding figure in the scientific world. Thus he brought to Washington University a symmetry of intellectual development which lent distinction to that new institution. It was not surprising, therefore, when his classmate of Yale, Joseph G. Hoyt, the first chancellor, died in 1862, that the directors of Washington University should select Professor Chauvenet as his successor.

He entered this new field of activity with the same energy and zeal which had characterized his work at the Naval Academy and he soon won the confidence and esteem of those with whom he was here associated. His inaugural address, delivered shortly after his appointment to the chancellorship, reveals his broad vision of the function of education.[6]

During Professor Chauvenet's connection with Washington University that institution prospered and became well known. The later years of his life were mainly occupied in building up this new institution much as the earlier ones had been in developing the Naval Academy. Thus, to use the words of his biographer, Professor J. H. C. Coffin, "In developing and giving character and reputation to two distinguished educational institutions, he had done a noble work."

Great as this work was, the contribution which Professor Chauvenet made to American science was of even more value, because it influenced and made possible the raising of the standard of instruction in many institutions, besides advancing this science. Of his masterful treatises on trigonometry, astronomy and geometry his biographer, Professor J. H. C. Coffin, says: "It is a marked evidence of the advancing progress of science among us that each of these works, published as a hazardous experiment and with the supposition that few copies only would be required, has met with an increasing demand from year to year." To obtain a notion of the scope and character of these works, one has only to read the reviews of them made shortly after they appeared. While these were made more than fifty years ago, it can still be said that no other trigonometry has yet appeared in America which is of the comprehensive character of Professor Chauvenet's. His work on astronomy is a classic and will long continue to be a valuable work of reference in all observatories. His geometry has been a model for many which have followed it.

The *Journal* of the Franklin Institute (Vol. XX, 3d series, p. 215) regards the work on trigonometry entitled, *"A Treatise on Plane and Spherical Trigonometry,"* published in 1850, as "an important addition to our mathematical literature, being the most complete treatise on trigonometry extant in the English language. While it contains everything useful to the mathematician and astronomer, the more elementary portions of the work are easily distinguished by the large type in which they are printed, and form of themselves a connected treatise, adapted to the wants of the young student." "Yet it pursued the subject," says Professor Coffin, "to its higher developments, supplying almost every want in astronomy and geodesy." "It introduced the American student to the methods of the German school, noted for the rigor and generalization and exhaustive character of its discussions, and to many topics wanting in all the textbooks in the highest colleges in this country and in England, and found by our mathematical students only in German, French or Latin. The Gaussian equations, the finite variations and differentials of trigonometric expressions, the solution of the general spherical triangle, the development of several functions into series of multiple angles, are instances most readily noted. What was found in many books was digested into a connected treatise, remarkable for its symmetry, its thorough exactness and the clearness, conciseness and purity of language of every expression. After the writings of Cagnoli, Gauss, Bessel and others, it was hardly to be expected that anything new could be developed. Yet there are not a few topics which are new, and others in which he improved the discussions of these great masters. At the time of its publication, trigonometry in many of our colleges was restricted to the simple cases of plane and spherical triangles, by trammeling geometric processes. Analytical trigonometry was but little known except to those engaged in astronomical or geodesic work. This book supplied a pressing need of the times, and, as a classic and complete work on the subject of which it treats, it will be long before it is superseded."

Of his "Manual of Spherical and Practical Astronomy," begun at Annapolis, but completed at St. Louis, his biographer says,

> In Spherical Astronomy it embraces all the topics which come up in the work of an observatory, or in astronomical work on land or at sea, and each is treated with the exhaustive generality and mathematical rigor of the German school. The whole is wrought into a symmetrical treatise remarkable for its clearness and simplicity, which could only be the work of a master mind, fully conversant with the subjects which it discussed. As has been aptly said by one able to judge, "It represents astronomy in its most modern and perfected forms of research. Many of its investigations are either wholly or in part original, such, for example, as some of the formulae for latitude and eclipses, occultations of planets, improved method of lunar distances, etc." The second volume on Practical Astronomy evinces the same completeness and thoroughness of

[6] Inaugural Address of William Chauvenet, LL.D., as Chancellor of Washington University, June 17, 1863, St. Louis (George Knapp & Co.).

analysis. It discusses, in an elaborate and exhaustive manner, all the best instruments used for astronomical observatories, whether in the higher observatories, or in the more modest work in the field or at sea. An appropriate chapter on the method of least squares is added, in which the subject is treated with a perspicuity, and freedom from the mystery in which it has been shrouded, found nowhere else. Each chapter is a monograph by itself, but here treated in unison with the rest, and with a noted symmetry. The theory of each instrument is admirably discussed with all its needful appendages. It is not a minute description of a particular instrument, with its peculiar arrangements, but of its essential parts, while, as also in the first volume, there are many valuable suggestions and examples, illustrating what is needed and what is best in practice.

During the last winter of his life, Professor Chauvenet completed and published "A Treatise on Elementary Geometry," which was outstanding in many respects. Following the improved methods of the French school in presenting the elementary geometry of Euclid, he also added two appendices of great value. Of these the first contained numerous exercises with suggestions given less and less frequently as the work progressed. In this way "the discouraging difficulties which the young student commonly experiences in his first attempts at demonstrating new theorems, or solving new problems, are here obviated in a great degree." The second appendix was on the subject of modern geometry and although restricted to the properties of the straight line and circle, it served to give the student an introduction to this recently developed new geometry, which was but little known in America at that time.

In connection with the first appendix, and the work in general, Professor Coffin reminds us that next to those who are directly laboring to extend and advance science, they contribute to its progress who prepare fitting aids to the young beginner and remove the difficulties in his way.

In his early years in Philadelphia, Professor Chauvenet prepared a little book entitled "Binomial Theorem and Logarithms for the use of the Midshipmen at the Naval School, Philadelphia." (*Philadelphia,* 1843, pp. 92.) According to Professor Coffin it manifests the same thoroughness and exactness which are conspicuous in his later writings.

In addition to these books, Professor Chauvenet published a number of articles, a complete list of which is given in article of footnote 5. These were chiefly on trigonometrical and astronomical subjects. The most noted of these was on "A Method for Determining Lunar Distances." Concerning this method Professor Coffin says, "While equally rigorous with that of Bessel, it was adapted to the usual tables in the British and American Ephemerides, and so simply and admirably arranged that the non-mathematical navigator could use his method with almost as much facility as the imperfect processes usually employed."

It is evident that Professor Chauvenet had studied the great masters in the subjects which he treated and that he presented their conclusions and point of view, with his own original investigations, in his clear and forceful style, thus enriching and making accessible the literature in these subjects. That he had access to a well-selected library in his fields of work is shown by a glance at the catalogue of the library of the U. S. Naval Academy prepared by Professor J. H. C. Coffin in 1860. Professor Chauvenet was also responsible for the selection of much of this library, for, as Professor Coffin says in this catalogue, "the Academy is greatly indebted to Professor Chauvenet for his judicious selections, and his care of the Library for many years."

Another illustration of his ability, as well as of his versatility, is shown by some work which he did in connection with the design of the St. Louis (Eads) Bridge. Professor C. M. Woodward, who wrote a history of that bridge, says of Professor Chauvenet in an article entitled "Personal Recollections of Chancellor Chauvenet" and published in the Bulletin of the Washington University Association for 1905–1906, "If the reader would see a specimen of his work in Applied Mechanics, let him read the 'Theory of the Ribbed Arch' in my 'History of the St. Louis Bridge.' The analytical work is given almost exactly as it came from the hand of Professor Chauvenet." He also invented the apparatus for measuring with the greatest accuracy the elongation and compression of the specimens being tested by Colonel Henry Flad for modulus of elasticity and elastic limit in the preliminary work for the Eads Bridge. This apparatus is fully described in the history above referred to, and it contains the feature of a revolving mirror, which was Chancellor Chauvenet's personal invention.

Thus we have also an illustration of Professor Chauvenet's mechanical ability, which was already displayed in his youth. Another evidence of this, as well as of his thorough knowledge of stereographic projection, is shown by the invention of a device called the "great circle protractor" by which the navigator is enabled to lay down his course on a great circle of the globe with almost as much ease as on a rhumb line by a Mercator chart. Spherical triangles could readily be solved by this "protractor" to the nearest quarter of a degree. This invention was purchased by the U. S. Hydrographic Office not long after the close of the Civil War.

When one considers that all this work was done amidst his numerous duties of teaching and administration, it is not surprising to learn that on several occasions Professor Chauvenet was obliged to relinquish his duties on account of poor health. In the spring of 1864 his health gave way. Fortunately after a sojourn in Wisconsin and Minnesota it was so far restored that in the fall of 1865 he was again able to resume his duties at the university. But he devoted himself so assiduously to his duties that his health again failed and he was obliged in 1869 to give up his work. This time the effort to regain his health was in vain. He passed a summer in Colorado and Minnesota, the following winter in Philadelphia and the spring in South Carolina. Returning to St. Louis and then to Minnesota, "he finally closed a laborious, useful life at St. Paul, Minnesota, on December 13, 1870, in the 51st year of his age." He was buried in Bellefontaine Cemetery in St. Louis.

In his family the warmest traits of character were constantly exhibited. In 1842 soon after taking charge of the Naval School in Philadelphia, he married Miss Catherine Hemple of that city. Even in his most laborious days, he found time to join in the sports and amusements of his children and in later years to guide their reading and studies. He constantly manifested the religious faith which he professed, but he never obtruded the peculiarities of his faith on those who differed from him.

Professor Chauvenet was honored by being elected to the American Philosophical Society and to the American Academy of Arts and Sciences. In 1860 St. John's College, Annapolis, Maryland, conferred on him the degree LL.D. At the formation of the National Academy of Sciences he was one of the prominent members. He served on a number of its committees and was its vice president at the time of his death. As already stated, he was one of the first members of the American Association for the Advancement of Science. In 1859 he was elected general secretary and in 1869 at the Salem meeting he was elected president. At the next meeting in 1870, in the absence of Professor Chauvenet, who was too ill to attend, the vice president, Thomas Sterry Hunt, presided. At the following meeting, the president, Mr. Hunt, in announcing the death of Professor Chauvenet, said in part:

It was already feared at the time of his election to the presidency that failing health would prevent his presence in 1870, as was the case. He died at the age of fifty leaving behind him a record of which science and his country may be proud. During his connection of fourteen years with the Naval Academy he was the chief instrument in building up that institution, which he left in 1859 to go to St. Louis. It is not for me to pronounce a eulogy, to speak of his profound attainment in astronomy and mathematics or of his published works which have taken rank as classics in the literature of these sciences. Others more familiar with his field may in proper time and place attempt the task.

All who knew him can, however, join with me in testifying to his excellences as a man, instructor and friend. In his assiduous devotion to scientific studies he did not neglect the more elegant arts, but was a skillful musician and possessed of great general culture and refinement of taste. In his social and moral relations, he was marked by a rare elevation and purity of character, and has left to the world a standard of excellence in every relation of life which few can hope to attain.[7]

WM. H. ROEVER

WASHINGTON UNIVERSITY

THE TRANSMISSION OF HUMAN PROTOZOA[1]

EVERY class in the phylum Protozoa contains species that live in man, and some of these are of considerable importance in various parts of the world as disease-producing agents.

One of the most interesting phases in the life cycle of these parasitic Protozoa is that during which they are transmitted from one host to another, either directly or through an intermediate host. It is at this time that measures for prevention and control can most successfully be applied, measures which, from the standpoint of personal hygiene, protect the individual from infection, and, from the standpoint of public health, protect the general population, either rural or urban, from infection. The twenty-five species of human Protozoa that are usually recognized by protozoologists at the present time may be classified as follows with respect to their habitat within the body and the method by which they are transmitted.

I. *Intestinal Protozoa:*
- (1) Species transmitted by the contamination of food or drink by cysts.
  - (a) Intestinal Amœbae.
    - (1) *Endamœba histolytica,* the organism of amœbic dysentery and amœbic liver abscess.
    - (2) *Endamœba coli,* a harmless commensal living in the large intestine.
    - (3) *Endolimax nana,* similar to (2).
    - (4) *Iodamœba williamsi,* similar to (2).
    - (5) *Dientamœba fragilis,* similar to (2).
  - (b) Intestinal Flagellates.
    - (6) *Chilomastix mesnili,* a possible causative organism of flagellate diarrhea.
    - (7) *Embadomonas intestinalis,* probably a harmless commensal.

[7] Proceedings of the American Association for the Advancement of Science (1871) Vol. XX.

[1] From the Department of Medical Zoology, School of Hygiene and Public Health, the Johns Hopkins University and the London School of Hygiene and Tropical Medicine. This paper is an abstract of three lectures delivered at the London School of Hygiene and Tropical Medicine on April 18, 19 and 20, 1926.