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Very truly Yours
A. Williams

BENJAMIN SILLIMAN.

Benjamin Silliman was born in New Haven, Connecticut, on the fourth of December, 1816, and died in that city on the fourteenth of January, 1885. He was most fortunate in his ancestry and the circumstances of his early life. His father was Benjamin Silliman, Yale College, 1796, who, as professor in Yale College, from his appointment in 1802 until his retirement in 1853, had held a foremost position in the institution, and whose name was one of the most illustrious in the history of American science. His grandfather, Gold Selleck Silliman, a graduate of Yale College in 1752, rendered distinguished service in the War of the Revolution in the defense of the southwestern portion of the State of Connecticut, and attained the rank of brigadier general. His great-grandfather, Ebenezer Silliman, also a graduate of Yale College, in the class of 1727, was an eminent lawyer, a judge of the superior court of the Colony, and a member of the governor's council. Of earlier ancestors in this country, the first, Daniel Silliman, settled in Fairfield, Connecticut, establishing his residence upon an eminence still known as Holland Hill, and probably so named from the country from which he is believed to have emigrated to America. The tradition of the family indicates for it an Italian origin, and this is supported by the testimony of families of the same name living in Switzerland and in southern France. Mr. Silliman's great-grandmother, whose maiden name was Rebecca Peabody, was a great-grand-daughter of John Alden and Priscilla Mullins, of the *Mayflower* and the Plymouth Colony. On his mother's side he was connected with a family which had been identified most conspicuously with the early history of the State and the strenuous times of the war of independence. His mother, a woman of great strength of character and beauty of person, was Harriet Trumbull, the daughter of Jonathan Trumbull, governor of the State of Connecticut from 1798 to 1809, who was the second of the name to bear this title, his father, Jonathan Trumbull, having been

the famous governor of the State during the Revolutionary War.

The elder Silliman, a man of imposing presence, of great dignity and nobility of character, was of a most hospitable spirit, which made his home a center of refined and cultivated social life, where the many distinguished men of science, who from time to time visited the city, were made cordially welcome. His son thus from the first enjoyed the advantages of a wide acquaintance with the leading spirits of the scientific world, and grew up in an atmosphere of scientific culture, the influence of which in determining the character of his own favorite studies was very great. He very early became interested in chemical experiments and in the collection of mineral specimens, and was laying the foundation for that intimate knowledge of the characteristics of mineral species, which eventually made him an expert in this department, with remarkable facility in the quick and sure recognition of new or interesting things.

He was prepared for college in the schools of New Haven, and in 1833 entered Yale College with the class of 1837, a class especially notable for the number of its members who rose to high distinction in after life. His favorite studies were not discontinued during his college course, and in 1836, during the months of August and September, with Mr. Eli Whitney, a New Haven friend, he accompanied his father on a professional visit to the gold mines and a portion of the gold region of Virginia, which afforded him opportunity for valuable observations. He had, at this time, already become a member of the Yale Natural History Society, of which he was later secretary and treasurer.

After graduating from college in 1837, with the exception of an interval which he spent in the private laboratory of Dr. Charles T. Jackson, the distinguished chemist, of Boston, he remained in New Haven, pursuing his studies in his father's laboratory, and for the next three years his name appeared in the catalogue of Yale College as assistant to the professor of chemistry. In 1840 he received the degree of master of arts, in course, and was made assistant in the departments of chemistry, mineralogy, and geology. In the next year the title was

changed to assistant and lecturer in the same departments, and he thus definitely entered upon his career as an instructor. The situation remained unchanged until 1846, when he was made professor of chemistry and the kindred sciences as applied to the arts, his position being that of university professor.

During the winters of the four years 1840–1843 he had attended his father as his assistant in four courses of lectures on geology and chemistry, which were delivered at the Lowell Institute in Boston. They were brilliantly illustrated with experimental demonstrations, and had remarkable success and popularity. His father gave grateful recognition of his devoted and invaluable service and the experience was a most profitable one for him and an important element in the training for his own life work.

During the years immediately after his graduation, while acting as assistant to his father and busily occupied in his laboratory, he had naturally taken up the work of teaching, and he very soon had gathered around him a little group of young men engaged in the study of chemistry, most of whom became distinguished teachers and investigators in after years and occupied positions of great influence in the advancement of science. Among these were John Pitkin Norton, a student of great promise, who was destined to come into closer relations with him later as a colleague, and Thomas Sterry Hunt, who became distinguished for his work in chemistry and chemical theory, and in mineralogy, and was a loyal and devoted friend throughout his life. The little school which had thus grown up through his influence had received no recognition from the authorities of the college and the names of its students were not enrolled in the college catalogue. In 1846, with the hope of securing for it a more firmly assured position, Mr. Silliman had drawn up a memorial, addressed to the corporation of the college, embodying a plan of organization and outline of a scheme of studies. This was warmly seconded by his father, and as a result of their efforts the corporation, in 1847, established a new and distinct department of the college, under the title of the "Department of philosophy and the arts," and in this year for the first time there appeared in the college catalogue a list of "Students in philosophy and the arts" number-

ing eleven. The first appointment in the new department was that of Mr. Silliman, who in the previous year had been made "Professor of chemistry and the kindred sciences as applied to the arts," as already mentioned. His position was that of a university professor, and he now became an active promoter of the new school, giving instruction in elementary and analytical chemistry, mineralogy, and metallurgy. With J. P. Norton, who had been appointed professor of agricultural chemistry and vegetable and animal physiology, he organized the "School of applied chemistry," and opened a laboratory upon the college grounds in an old wooden house which had formerly been occupied as a residence by the presidents of the college, and was thenceforth known as the analytical laboratory.

Although the school had been thus formally recognized and had attained to an established position, it received little other encouragement and no substantial aid from the college. Except for an annual income of three hundred dollars, which was provided for a few years by a generous friend upon the solicitation of Mr. Silliman, it was entirely without resources. The cost of fitting up and equipping the laboratory and for providing apparatus, cabinets, and library was furnished from the private means of the two professors, who received no salaries from the college and even for two years paid a rent for the use of the building. But their self-sacrifice and devotion were not in vain, for the school lived and prospered, and the spirit of its founders was perpetuated in their successors. Its establishment was the first and most important step in the development of the college into the university.

Professor Norton had recently returned from a visit abroad, during which he had spent some time in Edinburgh, where, as a student with Prof. James F. W. Johnston, he had won a prize of fifty guineas, offered by the Highland Society, for his original researches upon the chemistry of the oat and the soil upon which it was grown. He was later at the University of Utrecht, where, under the eminent professor of chemistry, G. J. Mulder, he pursued studies in agricultural and physiological chemistry. He took up the duties of his new position with enthusiasm; was an energetic worker and a prolific writer.

Although naturally of a vigorous constitution, the burden of labor which he undertook proved too great for his strength, and he succumbed to pulmonary disease, closing his life in 1852 at the age of thirty years.

Among the earlier pupils of the Yale Scientific School, thus happily established as a recognized department of the college, were several who were later to become more closely identified with it as officers. The names of George J. Brush and William H. Brewer appear in the list of students in the department of philosophy and the arts for the first time in 1848, and that of Samuel W. Johnson in the following year. The two latter, after a few years, took up and carried on with distinguished success the labors of Norton in agriculture and agricultural chemistry, while the former, as professor, first, of metallurgy, and subsequently of mineralogy, and later as director of the school, as expanded by the munificent gifts of Mr. Sheffield, was associated with them in developing the Sheffield Scientific School to a position of great efficiency and influence.

After the death of Professor J. P. Norton the duties of his chair were discharged by John A. Porter, who had been appointed to the position as acting professor in 1852, and in the following year as professor of analytical and agricultural chemistry. In 1852, for the first time, the announcement of the department of philosophy and the arts in the college catalogue contained a list of the faculty of the department, which included, besides several names of professors in other departments, that of William A. Norton, professor of civil engineering. In the catalogue for 1854-1855 appeared for the first time the separate heading "Yale Scientific School," with the statement that the school was "under the immediate supervision of Professors William A. Norton, Benjamin Silliman, Jr., and John A. Porter," followed by a detailed account of the work of the school and the courses of instruction. The lectures in chemistry were given by Mr. Silliman, who, on the retirement of his father in 1853, had been made professor of general and applied chemistry, and who also from this time gave instruction in chemistry in the medical department of the college and lectures upon the same subject in the academical department.

During the year 1860 the school, by the liberality of Mr. Joseph E. Sheffield, had acquired a commodious building for its work and a generous addition to its funds for maintenance and instruction. In the following year the name Sheffield Scientific School was adopted, and it was enabled thenceforth to pursue a prosperous course, with enlarged resources and a faculty greatly increased in numbers. Mr. Silliman maintained his connection with the school until 1869, but for several years previous, owing to the multiplicity of engagements elsewhere, he had had little part in the work of instruction. He resigned his duties in the academical department of the college in 1870, but continued to give instruction in the medical department as long as he lived.

Mr. Silliman's activities were by no means confined to the class-room and laboratory, and throughout his life he was in sympathetic touch with movements of general public interest. He was a member of the common council of the city of New Haven from 1845 to 1849, was appointed State chemist of Connecticut in 1869, and for many years subsequent to 1848 was a director of the New Haven gas works and chairman of the committee on works and distribution. In 1853 he was active in connection with the Exhibition at the Crystal Palace in New York, where he was in charge of the departments of chemistry, mineralogy, and geology. As a result of this work he edited, in connection with Mr. Charles R. Goodrich, a large quarto volume entitled "The World of Science, Art, and Industry," which was published in 1853; and in 1854 Mr. Silliman published "The Progress of Science and Mechanism," a quarto volume of considerable size, the two works, which were profusely illustrated, constituting a valuable record of the most important results of the exhibition. In the winter of 1845-1846 he gave a course of public lectures in New Orleans upon agricultural chemistry, at the invitation of men of prominence in the professional and commercial circles of the city. This was doubtless pioneer work, as it is believed to be the first course of the kind delivered in the United States. Mr. Silliman was the secretary of his class, 1837, of Yale College, and issued several reports of the class meetings, with full biographical notices of the members, toward whom he always mani-

fested a warm interest and a cordial readiness for friendly service.

His early training in mineralogy and his interest in the subject had led to the acquisition of many mineral specimens, and he had thus gradually brought together a very valuable collection, which he disposed of in 1868 to Cornell University, where it has been on exhibition as the "Silliman Cabinet." From his many journeys made in connection with his mining and geological explorations he brought home numerous fine specimens, from which he made large contributions to the mineralogical cabinet of the college and the metallurgical collection of the Sheffield Scientific School. Through his personal efforts also funds were secured by means of which the mineralogical cabinet of Baron Lederer was acquired, in 1843, for the college collections.

In 1849 Mr. Silliman was elected professor of medical chemistry and toxicology in the medical department of the University of Louisville, Kentucky, and during five winters he discharged the duties of the position, taking up his residence in that city during the period of his professional labors. He resigned the position in 1854, to enter upon the enlarged duties of instruction in the college in New Haven, which fell to him in consequence of the retirement of his father. He had received the honorary degree of M. D. in 1849 from the Medical College of the State of South Carolina. In 1884 the honorary degree of LL. D. was conferred upon him by Jefferson Medical College, of Pennsylvania.

In 1851 Mr. Silliman accompanied his father upon a visit to Europe. They left New York on the fifth of March, and the course of their travels, after their landing at Liverpool, took them through England and Wales, France, the Italian States, Lombardy, Switzerland, Germany, Belgium, and again France and England on their return. Although the route was not markedly unlike the customary one of ordinary travel, the purpose of it was very different. It brought them into regions interesting to the geologist and the mineralogist, with visits to the volcanoes of Vesuvius, Stromboli, and Etna, the Alps and the Jura Mountains, with the glacial regions, as well as to the most important laboratories, art museums, and scientific col-

lections of the countries traversed. Not less important were the opportunities they enjoyed of meeting distinguished men of science, by whom they were most cordially received. In England they met Dr. Mantell, already a friend of many years, and through his kindly offices were present at a meeting of the Geological Society at Somerset House. Here they met and heard in discussion Murchison, Lyell, Sir E. Forbes, Sir Henry de la Beche, and others known to them by reputation, and were warmly welcomed. In Paris they made the acquaintance of Adolphe Brogniart and Milne Edwards, attended lectures of Wurtz and Frémy, met Dufrénoy, Élie de Beaumont, Sénarmont, and Verneulle, through whose courtesy they were enabled to visit the Panthéon, where was in progress the celebrated experiment of Foucault, then a novelty, for giving ocular demonstration of the rotation of the earth by the motion of the pendulum. They were escorted to one of the weekly sittings of the French Academy by the venerable Cordier, who had accompanied Napoleon to Egypt. Here were present, besides most of those mentioned above, Biot, Arago, Boussingault, Payen, Dumas, Leverrier, and many others equally distinguished. In Geneva they made the acquaintance of Marignac, De la Rive, Favre, and Pictet. In Italy they had the pleasure of meeting Matteucci, Meneghini, and Melloni, who presented to Mr. Silliman a copy of his celebrated work upon Heat, of which, owing to the interruption of his labors by arbitrary official interference on political grounds, only the first volume was completed. Turning homeward, they visited the family of Professor Agassiz, then living at Lausanne; Professor Liebig at Giessen, and Leonhard and Braun at Heidelberg. In Berlin they were invited by the distinguished geographer, Carl Ritter, to attend one evening a meeting of the Geographical Society, of which he was the president. Here they met Ehrenberg, the brothers Rose, Dove, Magnus, Pogendorff, editor of the *Annalen*, and Mitscherlich, as well as many others well known to fame.

An interesting visit was made to Alexander von Humboldt, then in his eighty-third year, but still full of vigor and most cordial in his welcome. He pointed out, by the aid of his maps, a way of communication for an interoceanic canal across

the isthmus of Darien, which he had observed and described more than forty years before. Antwerp, Brussels, and the battlefield of Waterloo were visited in their further progress toward home, and they arrived in New York in the middle of September, after a journey full of profit and interest to both, and especially to the younger traveler, who had enjoyed it to the utmost. The elder Silliman had kept a full record of the events of the journey during their progress, and after their return this was edited by his son. It had been originally intended to fill three volumes, but had been considerably abridged, and was published in two volumes in 1856. It is still a very entertaining work, and full of most valuable information for those interested in the progress of science and the illustrious men by whom it has been achieved. Of the various scientific observations of interest made by him during the journey, accounts were published by the younger Silliman in the *American Journal of Science* on his return.

In his work as an instructor, in consonance with the terms of his professorship, the applications of science in the arts had always received particular attention. He was deeply interested in the practical developments of science and in making it serviceable to the general welfare. His knowledge in this field was remarkably comprehensive and accurate, and his retentive memory enabled him to have it at ready command. His aid was much sought for as an adviser in practical matters involving the application of scientific principles, and in the courts he was often called upon to give testimony in questions whose solution demanded technical skill and knowledge. He made many journeys for mineralogical and geological exploration and to examine and report upon mines. On one of these he left New Haven in March, 1864, returning in February of the following year, during which period the death of his father occurred, in November, 1864. He published in the *American Journal of Science*, 1866, an account of this journey, which extended to Arizona, the Mojave desert, and the San Francisco mining district. The visit was repeated in 1867, and again in 1872, and these and later trips covered a large part of the mining country of the Rocky Mountains. Numerous choice mineral specimens were acquired by him on these tours, of

which many ultimately found a place in the cabinets of the college.

The reports made by Mr. Silliman on the results of his professional labors, in the cases where he had been consulted, were very thorough and often grew into elaborate treatises. Though usually privately printed, they often contained scientific information which made them of permanent value, and which in numerous instances led to their reproduction in scientific journals. Some of these are noted in the list of his scientific publications at the close of this memoir, but others are entitled to more extended consideration.

In a report, dated April 16, 1855, upon the rock oil, or petroleum, of Venango County, Pennsylvania, he described methods of investigation not hitherto employed and results which proved to be of signal importance and the first steps in the development of a great industry. Years afterward this was reproduced in the *American Chemist*, Vol. 2, 1871-1872, pp. 18-23, with the following editorial note:

We have obtained of Prof. Silliman permission to reproduce in this number of the *American Chemist* his original memoir on the Pennsylvania petroleum, written in April, 1855, as a report to the projectors of the first association ever formed for the purpose of developing this industry, since grown to such great proportions. The report has never before been published in any scientific journal, although a few copies were privately printed at the time, and we deem it of too much historical and scientific interest not to be placed on our pages for the convenience of reference. At the time Prof. Silliman made this research, all that was known of the "rock oil" of Pennsylvania was that on the waters of Oil Creek, in Venango County, the oil oozed out in pits dug in the soil and floated on the surface of the water as a dark green dichroous oil of high density (882° B.)* No artesian well then existed, or had been ever thought of as a possibility. Drake's well was sunk more than two years after the report of Prof. Silliman was written. In reading this report now, after sixteen years of experience in the development of this important industry, we are struck with the fact that its author very nearly exhausted the subject, and anticipated and described most of the methods which have since been adopted by manufacturers. He even suggests the distillation by high steam, which has since been adopted with so much success by Merrill, in the preparation of his neutral heavy oil. He also noticed the peculiar breaking up of

* ".882, water being 1.000," in the Report. W.

the heavier oils into lighter products, under the continued action of heats far below their boiling points, now called "cracking." He remarks that when "exposed for many days in an open vessel at a regulated heat below 112°," the oil gradually rises in vapor, etc., gradually and slowly disappearing, and finally leaving a small dark and pitchy residue."

Prof. Silliman was the first to demonstrate by accurate photometric experiments the high value of the rectified oil as an illuminator, devising for that purpose an original form of photometer † in advance of Bunsen's instrument, employing for its consumption a lamp which is the prototype of the extensive progeny of kerosene lamps which have since that time been devised.

We reproduce the report of Prof. Silliman precisely as it was written, and it must, in justice to its author, be remembered that he then had no guide but his own sagacity in the conduct of this interesting research.

The observations made by him in the course of his work in connection with the wet-fuel litigation were the subject of an extended paper read before the American Association for the Advancement of Science, at the Newport session in 1860, which was published in the proceedings of that meeting and also reprinted elsewhere. A paper upon the chemical principles involved in combustion, published in the *American Chemist* in 1872, was another result of the same work. His chemical investigations in the service of the New Haven gas works furnished the material for several important papers upon the economies of gas-lighting and the illuminating power of coal gas as affected by varying conditions in combustion. His investigations upon the petroleum region of California led him to the conclusion that the geological conditions were such as to require a method of procedure for the extraction of the oil unlike that which had been employed in Pennsylvania, and he confidently expressed his belief that with the employment of suitable means, which were indicated by him, it would be produced in abundance. Although vehemently assailed, his conclusions have been most completely sustained by events and by the development of a great industry involving financial interests of vast extent.

† For the description of this instrument, see *American Journ. Sci.*, 2d ser., Vol. 23, 1857, p. 315.

The American Journal of Science had been established by the elder Silliman in the year 1818, and it at once took the rank as the leading American scientific journal, which it has continued to maintain. In 1838 his son, then in his twenty-second year, was associated with him as assistant editor, and in 1841 his name appears upon the title page as one of the editors, and this arrangement remained unchanged until the close of the first series of fifty volumes in 1845. In 1846 the editorial staff was increased by the accession of Prof. James D. Dana, and the responsibility of the editorial management was largely borne by the two younger men, although the name of the elder Silliman continued to head the list of editors until his death, in 1864. After this time the conduct of the journal devolved upon the younger Professor Silliman and Professor Dana, his brother-in-law, with the co-operation of a number of scientific men as associate editors. Mr. Silliman maintained his editorial connection with the journal until the close of his life, in 1885, thus completing a period of forty-seven years of uninterrupted service upon it. His contributions were very numerous, including, besides innumerable notes, reviews, and biographical notices, many original articles in which were embodied the results of his own investigations.

In one of his early papers, published in 1842, he described the successful production in the Yale laboratory of daguerreotype pictures by the light of the carbon arc for the first time. In this experiment the arc was produced by the current from the great battery of nine hundred pairs of plates, which had been constructed under the supervision of his father and had been employed by him for the brilliant demonstrations which illustrated his lectures. In the same year he published an interesting paper suggesting the use of carbon for the costly platinum in Grove's battery, and in a second paper upon this subject in the following year he described the construction and operation of a large battery of ninety-six cells built upon this plan. In this occurs the remark that the "form of carbon most efficient in voltaic circuits is that exceedingly hard and pure carbon which is deposited from coal gas on the heated inner surface of the retorts of the gasworks." The battery gave an arc in air about two inches in length. The use of gas carbon

for this purpose was an original discovery with him, and although he learned subsequently that he had been anticipated by others, who had made the discovery at nearly the same time as himself, but had announced it more promptly, there is little question that he was the first to use it in the actual construction of a battery of large size and to obtain such decisive evidence of its efficiency.

In 1847 he published a volume entitled "First Principles of Chemistry," which was very successful, passing through several editions and having a sale of more than fifty thousand copies. He also published, in 1859, "First Principles of Physics, or Natural Philosophy," of which a second edition was issued in 1861. The subject was treated in a fresh and original manner, and the volume contained much new and interesting matter. It was widely used as a text-book, the most successful one of its time.

In 1871, on the fourteenth day of September, Mr. Silliman delivered, as introductory to his course given to the medical class in Yale College, a most interesting lecture with the title "A century of medicine and chemistry." After a rapid review of the early history of medical science, he took up the subject of the discovery and application of various substances which had come into use as anesthetic agents, and of the physiological action of certain chemical compounds which had been employed in modern medical practice. The fondness for historical investigation displayed in this lecture was still more strikingly exemplified in an address on "American contributions to chemistry," which he delivered on the occasion of the celebration of the centennial of chemistry (dating from the discovery of oxygen by Priestley), which was held at Northumberland, Pennsylvania, on the first of August, 1874. This place of meeting had been selected because Priestley had resided there while in America. The address was published in the *American Chemist* in the latter part of the same year, much enlarged by the inclusion of a full list of the papers published by American workers in chemistry. This list, the preparation of which involved a great amount of labor and research, is itself a very valuable contribution to the history of chemical

science in this country. The complete work was separately issued as a volume of 176 pages, Philadelphia, 1874.

Mr. Silliman was one of the fifty original members named in the act of Congress of March 3, 1863, incorporating the National Academy of Sciences. He was a constant attendant of its sessions, and read before it many papers as contributions to its proceedings. He was a member of several important commissions of the Academy. In 1881 he was named as chairman of the commission on sorghum sugar, and prepared the voluminous report, the first draft of which was submitted to the Academy at the April meeting of the next year, and the completed report, of which the official copy was transmitted to the commissioner of agriculture in November, 1882. The printed copy covered 139 pages. At the meeting in Washington in 1884 he read a biographical memoir of his colleague, Dr. J. Lawrence Smith, which he had prepared by appointment of the Academy. It was a warm tribute to the character and scientific work of his friend, and included a very carefully prepared list of his publications. It was his last communication to the Academy, and this meeting was the last that he attended.

Mr. Silliman was a member of many other scientific associations, among which may be mentioned the following: He was a corresponding member of the Meteorological Society of London; member of the Boston Society of Natural History, and of the Connecticut Academy of Arts and Sciences. He was a member of the Association of American Geologists and Naturalists from the second meeting, in 1841, and had been its secretary during several years. At the last meeting, in 1847, at which it was agreed to resolve the association into the American Association for the Advancement of Science, he was made a member of the standing committee. At the first meeting of the new association, in 1848, of which he thus became one of the original members, he was elected to the standing committee and the committee of publication, and was made secretary of the section of physics. He interested himself greatly in the success of the association, contributing numerous papers and taking an active part in the discussions. In 1864 he was elected life member of the California Academy of Sciences; in 1876, a member of the American Chemical Society; was

also associate fellow of the American Academy of Arts and Sciences, Boston, and corresponding member of the New York Academy of Sciences. He was elected a member, at its second annual meeting in 1872, of the American Institute of Mining Engineers, and in 1874 a corresponding member of the Société Nationale des Sciences, of Cherbourg, France.

In the preparation of his many published works Mr. Silliman was busily occupied during much of the time of his active life. When at home he would most usually be found at his library table, pen in hand, writing or correcting the proof of some fresh publication. He wrote rapidly, with fluent ease and with very few erasures or interlineations. If in the earlier years of his life this facility of utterance resulted in some degree of redundancy in vocabulary and expression, in his later writings this was less evident, and they are characterized by a style of marked individuality, of excellent literary quality, and a peculiar felicity in the choice of apt phrases for the expression of his ideas. They are clear, forcible, and withal interesting.

In person Mr. Silliman was of somewhat more than medium height, strongly and compactly built, with a massive head, indicative of intellectual power, and a countenance expressive of his sympathetic nature and genial social qualities. In manner he was dignified, but quite at ease, and with the power to put others at their ease in his society. His personal characteristics have been happily described in a sketch by Professor James D. Dana, published in the American Journal of Science, in February, 1885, soon after Mr. Silliman's death. Mr. Dana had been appointed by the National Academy of Sciences to prepare the memorial of his life and services, but did not live to accomplish it. The following passage appears near the close of the article:

Professor Silliman was a man of exceedingly generous nature and kindly disposition. He was ever cheerful, ever inclined to look upon the bright side of life, hopeful and sanguine of success where others might be discouraged; and if his expectations for himself and others were not always realized, it was largely owing to this element in his character. In society he was most genial, abounding in conversation based on a remarkable range of information on general topics and with anecdote ready for the entertainment of his guests. Hospitality to

friends of the college or to men of science or to those of his own kin and personal intimacy was his delight, and to this some of those present at the recent meeting of the British Association can testify.

During the greater part of his life Mr. Silliman enjoyed excellent health. He had much more than the ordinary amount of vigor, and rarely felt the necessity of considering whether he were able to undertake any labor proposed to him or not. Four years since, after an excursion, late in the autumn of 1880, among the mountains of Pennsylvania, he was prostrated for some weeks with heart disease; and it seemed to his friends for a while that at the best his days of active work were at an end. But in the course of another six months he was off to New Mexico on a visit to the Negretta Mountains (Black Range) in Socorro County; and he returned from the elevated mountain region apparently uninjured by the trip, though conscious of a weakened constitution. His energy was far from giving out, and other excursions were undertaken in the course of the following years, including another trip to New Mexico. His recent illness commenced in October last, with a severe return of his heart complaint, complicated by an attack of pneumonia; and from that time his decline made slow but steady progress—more visible to friends than to himself.

One of the last literary labors which he performed was the preparation, for the National Academy of Sciences, of a memoir of his old friend, Dr. J. Lawrence Smith, his successor at Louisville; and during the last few weeks of his life, when his strength was already largely gone, he gave directions, with a touching degree of affection and interest, for the completion of the medal which was to commemorate the labors of his academic associate. The generous, whole-souled affection for his friends, which characterized his entire life, was never more strongly manifested than during his last days.

In September, 1884, Mr. Silliman was present at the meeting of the American Institute of Mining Engineers in Philadelphia, and read an elaborate paper upon the Siemens improvements in glass-furnaces, with suggestions for their use with natural gas. This was published in the volume of the transactions of the institute for 1884-1885, and the secretary, in a note at the end of the paper, mentions the fact that Professor Silliman's death had occurred while the paper was in press, which prevented any revision of the proofs by him, and that it was probably his last work, the manuscript, which was mostly in his own hand, giving evidence of feebleness.

It was, indeed, his last work, and the steady progress of the disease soon compelled him to remain within doors and to forego active exertion of any kind. As the close of his life

drew near, his sufferings were very great, but he bore them with the most admirable fortitude and cheerfulness, until, on the evening of January 14, 1885, he passed away, surrounded by members of his family, for whom to the last he manifested the most affectionate solicitude.

Mr. Silliman was married on the fourteenth of May, 1840, to Susan Huldah Forbes, the eldest child of William Jehiel and Charlotte (Root) Forbes, of New Haven. She was a woman of rare beauty and personal charm, whose character and accomplishments served to make their household distinguished for its refined and gracious hospitality. She died, after a long illness, in March, 1878. Mr. Silliman was survived by an only son, of the same name, and four daughters.

BIBLIOGRAPHY.

The following list contains the titles or subjects of the principal published works and papers of Professor Silliman. It does not include, except in occasional instances, the very numerous notes, reviews, and notices of current events in science published by him in the course of his editorial work upon the *American Journal of Science* or elsewhere. Of his many publications in connection with his professional services of a technical character, a few, which have more than a temporary interest and are of importance for their historical bearing or as embodying scientific results of permanent value, are included in the list.

BOOKS AND PAMPHLETS.

Edited: *The Chemistry of Vegetable and Animal Physiology*, by Dr. G. J. Mulder, professor of chemistry in the University of Utrecht. Translated from the Dutch by P. F. H. Fromberg, first assistant in the laboratory of the Agricultural Chemistry Association of Scotland; with an introduction by Prof. J. W. F. Johnston, F. R. S. L. & E. First authorized American edition, with notes. Part I, New York, 1845, pp. 176.

First Principles of Chemistry, for the use of colleges and schools. Philadelphia and Boston, 1847, pp. 492. Revised in 1850 and 1853.

The World of Science, Art, and Industry, illustrated from examples in the New York Exhibition, 1853-1854. (With C. R. Goodrich.) New York, 1854, 4to, pp. [14], 207; with 500 illustrations, plans, and diagrams.

The Progress of Science and Mechanism. New York, 1854, 4to, pp. 258. A record of the chief results of the Exhibition of 1853-1854.

First Principles of Physics, or Natural Philosophy, designed for the use of schools and colleges; with six hundred and seventy-seven illustrations. Philadelphia, 1859, pp. xix, 720. Second edition revised and rewritten, with seven hundred and twenty-two illustrations. Philadelphia, 1861, pp. xvii, 700.

A Description of the Recently Discovered Petroleum Region in California, with a report on the same, by Professor Silliman. New York, 1865, pp. 25. Professor Silliman's report covers pages 9-21, with a note on p. 25. It relates to the Ojai ranch in Santa Barbara County, California.

The Truly Practical Man, Necessarily an Educated Man. Oration delivered at the commencement of the College of California, June 5, 1867. Published by the trustees of the college, San Francisco, 1867, pp. 22.

The Hydrocarbon Gas Process; report of working results on a large scale, under the Gwynne-Harris patents, November, 1868, to May, 1869. (With Henry Wurtz.) New York, 1869, pp. [9], 126.

Researches on Water-Gas. (With Henry Wurtz.) Published in book form in the spring of 1869; republished in American Gas Light Journ., commencing with the issue of January 16, 1874, p. 21; also in London Journ. Gas Lighting, Water Supply, and Sanitary Improvement, commencing with October 20, 1874, and running through many issues.

A Century of Medicine and Chemistry. A lecture introductory to the course of lectures to the medical class in Yale College, delivered September 14, 1871. New Haven, 1871, pp. 65.

Address before the Chemical Society of Lehigh University, June 17, 1872. New York, 1872.

Deep Placer Mining in California. Lecture at the Cooper Union, March 8, 1873. Tribune Lecture Series, Vol. 1.

American Contributions to Chemistry. An address delivered on the occasion of the celebration of the centennial of chemistry, at Northumberland, Pennsylvania, July 31 and August 1, 1874. Afterwards published, revised, and much extended, in American Chem., Vol. 5, 1874, 1875, pp. 70-114, 195-209, 327-328. Also issued separately in one volume, Philadelphia, 1874, pp. 176.

Sketch of the Great Historic Mines of the Cerro de Proaño at Fresnillo, State of Zacatecas, Mexico. New Haven, 1883, 4to, pp. xxxix, 79.

ARTICLES.

Electrography or the electrotpe. Review of "Instructions for the multiplication of works of art in metal by voltaic electricity; by Thomas Spencer"; with many original experiments and suggested applications. American Journ. Sci., 1st ser., Vol. 40, 1841, pp. 157-164.

Analysis of the alluvium of the Nile. *Idem*, pp. 190-192.

A daguerreotype experiment by galvanic light. (With W. H. Goode, M. D.) *American Journ. Sci.*, 1st ser., Vol. 43, 1842, pp. 185-186; *Ann. Electr.*, Vol. 9, 1842, pp. 354-356.

On the use of carbon in Grove's battery. *American Journ. Sci.*, 1st ser., Vol. 43, 1842, p. 393.

Description of a carbon voltaic battery. *American Journ. Sci.*, 1st ser., Vol. 44, 1843, pp. 180-186; *Ann. Fis. Chim.*, Vol. 18, 1845, pp. 285-287.

Review of Dana's Mineralogy. *American Journ. Sci.*, 1st ser., Vol. 46, 1844, pp. 362-387.

Analysis of meteoric iron from Burlington, Otsego Co., N. Y. *Idem*, pp. 401-403.

Report on the intrusive trap of the New Red Sandstone of Connecticut. Read before the Association of American Geologists and Naturalists at the fifth annual session, Washington, May, 1844. *American Journ. Sci.*, 1st ser., Vol. 47, 1844, pp. 107-108; abstract and summary.

Natural polariscope. *Idem*, p. 418. Thin tourmalines in mica of Grafton, New Hampshire, capable of being used as polariscopes.

Analysis of waters of the Dead Sea. *American Journ. Sci.*, 1st ser., Vol. 48, 1845, pp. 10-12. In note to article on the Dead Sea, by J. D. Sherwood.

Analysis of the blue mud of New Haven harbor. *Idem*, p. 337. Note quoted in article by J. W. Bailey.

Notice of a mass of meteoric iron found at Cambria, near Lockport, in the State of New York. *American Journ. Sci.*, 1st ser., Vol. 48, 1845, pp. 388-392; *Bibl. Univ. de Genève*, Vol. 60, 1845, pp. 179-181; *Notizen aus dem Gebiete der Natur- und Heilkunde*, 2d ser., Vol. 37, 1846, cols. 181-182.

On the chemical composition of the calcareous corals. *American Journ. Sci.*, 2d ser., Vol. I, 1846, pp. 189-199; *Chemist*, Vol. 7, 1846, pp. 111-117; *Edinburgh New Philos. Journ.*, Vol. 40, 1846, pp. 243-255. Reprinted from J. D. Dana's work on zoophytes, for which the work was undertaken.

Chemical examination of several natural waters. *American Journ. Sci.*, 2d ser., Vol. 2, 1846, pp. 218-224. Reprinted from Report of the Water Commissioners of Boston, 1845.

On the meteoric iron of Texas and Lockport. (With T. S. Hunt.) *Idem*, pp. 370-376; with plate, an impression from etched surface of the iron.

Hydrate of nickel, a new mineral. *American Journ. Sci.*, 2d ser., Vol. 3, 1847, pp. 407-409.

On fossil trees found at Bristol, Conn., in the New Red Sandstone. *American Journ. Sci.*, 2d ser., Vol. 4, 1847, pp. 116-118.

Description of a meteoric stone which fell in Concord, New Hampshire, in October, 1846. *Idem*, pp. 353-356; with analysis.

On chloroform. *American Journ. Sci.*, 2d ser., Vol. 5, 1848, pp. 240-243.

On emerald nickel from Texas, Lancaster County, Pa. *American Journ. Sci.*, 2d ser., Vol. 6, 1848, pp. 248-249; *Edinburgh New Philos. Journ.*, Vol. 46, 1849, pp. 80-82.

On gibbsite and allophane, from Richmond, Mass. *American Journ. Sci.*, 2d ser., Vol. 7, 1849, pp. 411-417.

Descriptions and analyses of several American minerals. I: Description and analyses of several mineral species belonging to the family mica. II: Description and analyses of unionite, a new mineral species. III: Description and analysis of a species resembling worthite. IV: Identity of sillimanite, bucholzite, and fibrolite with kyanite. V: Analysis of a granular albite, associated with the corundum of Pennsylvania, and a new analysis of the indianite of Bournon. VI: On boltonite, and Thomson's bisilicate of magnesia. VII: On nuttalite of Brooke. *American Journ. Sci.*, 2d ser., Vol. 8, 1849, pp. 377-394; *Journ. Prakt. Chem.*, Vol. 49, 1850, pp. 195-208; *Philos. Mag.*, Vol. 35, 1849, pp. 450-465, 484-486.

On boltonite of Shepard and bisilicate of magnesia of Dr. Thomson. Read before the American Association for the Advancement of Science, Cambridge, August, 1849. *Proc. American Assoc. Adv. Sci.*, 2d meeting, pp. 109-110.

Identity of sillimanite of Bowen, of bucholzite of Brandes, and of fibrolite of Bournon with the species kyanite. Read before the American Association for the Advancement of Science, Cambridge, August, 1849. *Proc. American Assoc. Adv. Sci.*, 2d meeting, pp. 111-113; *Edinburgh New Philos. Journ.*, Vol. 48, 1850, pp. 157-160.

Chemical examination of *Gorgonia antipathes*. Read before the American Association for the Advancement of Science, Cambridge, August, 1849. *Proc. American Assoc. Adv. Sci.*, 2d meeting, pp. 130-131.

On "indianite" of Count Bournon, and on the American mineral which has been distributed under the same name. *Idem*, pp. 131-133.

Optical properties of mica. *Idem*, p. 133.

Analyses of "green picrolite" and "slaty serpentinite," so called, from Texas, Lancaster County, Pa. *Idem*, p. 134.

Gadolinite in New York. *Idem*, p. 134.

On the origin of a curious spheroidal structure in certain sedimentary rocks. Read before the American Association for the Advancement of Science, New Haven, August, 1850. *Proc. American Assoc. Adv. Sci.*, 4th meeting, pp. 10-12.

Notice of two American meteoric irons. *Idem*, pp. 36-38.

Optical examination of several American micas. Read before the American Association for the Advancement of Science, New Haven, August, 1850. *American Journ. Sci.*, 2d ser., Vol. 10, 1850, pp. 372-383; *Edinburgh New Philos. Journ.*, Vol. 50, 1851, pp. 339-345; Vol. 51, 1851,

pp. 55-61. Contains observations upon the diathermancy of certain micas, and description of instruments used, and shows for the first time that the specific characters of muscovite, phlogopite, and biotite rest upon optical phenomena.

Notice of a powerful permanent magnet. Read before the American Association for the Advancement of Science, New Haven, August, 1850. Proc. American Assoc. Adv. Sci., 4th meeting, pp. 227-228.

On the new American mineral lancasterite. American Journ. Sci., 2d ser., Vol. 9, 1850, pp. 216-217.

Analysis of emerylite. American Journ. Sci., 2d ser., Vol. 10, 1850, p. 117.

On the Mammoth Cave of Kentucky. American Journ. Sci., 2d ser., Vol. 11, 1851, pp. 332-339; Edinburgh New Philos. Journ., Vol. 51, 1851, pp. 227-233; from a letter to Prof. Guyot, dated November 8, 1850.

Daguerreotypes by galvanic light. American Journ. Sci., 2d ser., Vol. 11, 1851, pp. 417-418. Repetition of experiments of 1840, with a bunsen battery of fifty cells. Excellent impressions were obtained in forty seconds, and good portraits in about one minute. Done at the laboratory of Louisville University, February, 1851.

Miscellaneous notes from Europe. 1: Present condition of Vesuvius. 2: Grotto del Cane and Lake Agnano. 3: Sulphur Lake of the Campagna, near Tivoli. 4: Meteorological observatory of Mount Vesuvius. 5: Light for illumination obtained from the burning of hydrogen, by M. Gillard. (H. from steam led over heated charcoal, purified of CO₂ by lime, and burned in platinum cage giving intense light.) American Journ. Sci., 2d ser., Vol. 12, 1851, pp. 256-261; Edinburgh New Philos. Journ., Vol. 52, 1852, pp. 141-148.

An excursion on Etna. American Journ. Sci., 2d ser., Vol. 13, 1852, pp. 178-184.

Zinc oxyd as a pigment. Idem, pp. 430-431.

Fuel for locomotive steam use. New York, 1855, 8vo, pp. 11.

Notice of a photometer and of some experiments therewith upon the comparative power of several artificial means of illumination. (With C. H. Porter.) American Journ. Sci., 2d ser., Vol. 23, 1857, pp. 315-318.

The Atlantic cable. American Journ. Sci., 2d ser., Vol. 26, 1858, pp. 285-288.

Museum of Comparative Zoology at Cambridge, Notice of. American Journ. Sci., 2d ser., Vol. 27, 1859, pp. 450-451.

Note on the discharge of atmospheric electricity through gas mains. Read before the American Association for the Advancement of Science, Springfield, August, 1859. Proc. American Assoc. Adv. Sci., 13th meeting, pp. 207-208.

Meteor of Aug. 11, 1859. American Journ. Sci., 2d ser., Vol. 28, 1859, pp. 300-303.

On the combustion of wet fuel, in the furnace of Moses Thompson. Read before the American Association for the Advancement of Science,

Newport, August, 1860. Proc. American Assoc. Adv. Sci., 14th meeting, pp. 89-101; Chem. News, Vol. 3, 1861, pp. 151-153; American Journ. Sci., 2d ser., Vol. 30, 1860, pp. 243-253.

Note on loss of light by glass shades. American Journ. Sci., 2d ser., Vol. 30, 1860, pp. 423-424.

Report on the water supply from Upper Mystic Pond, for Charlestown (Mass.), July, 1862. New Haven, 1862, pp. [6], 31.

On the gold mines of Canada and the manner of working them. Canadian Naturalist, Vol. 8, 1863, pp. 13-19.

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On glacial action in Nova Scotia. From Report on the gold property of the New York and Nova Scotia Gold Mining Co. American Journ. Sci., 2d ser., Vol. 37, 1864, pp. 417-419.

On the so-called "barrell-quartz," of Nova Scotia. From Report on the Waverly Gold Mining Co. American Journ. Sci., 2d ser., Vol. 38, 1864, pp. 104-106.

Notes on the New Almaden quicksilver mines. *Idem*, pp. 190-194.

Shooting stars of 11-14 Nov., 1864. American Journ. Sci., 2d ser., Vol. 39, 1865, pp. 229-230.

Examination of petroleum from California. Analysis, by fractional distillation, of crude oil from Santa Barbara County, Cal. *Idem*, pp. 341-343.

On the deep placers of the South and Middle Yuba, Nevada County, California, in connection with the Middle Yuba and Eureka Lake canal companies. American Journ. Sci., 2d ser., Vol. 40, 1865, pp. 1-19.

On some of the mining districts of Arizona near the Rio Colorado, with remarks upon the climate, &c. Read before the National Academy of Sciences, Washington, January, 1866. American Journ. Sci., 2d ser., Vol. 41, 1866, pp. 289-308; reprinted in Eng. and Min. Journ., Vol. 24, 1877, pp. 111-113.

On gay-lussite from Nevada territory. American Journ. Sci., 2d ser., Vol. 42, 1866, pp. 220-221.

On sodium amalgamation, with special reference to saving the precious metals, and especially gold. Read before the National Academy of Sciences, Washington, January, 1866. Chem. News, Vol. 14, 1866, pp. 170-171.

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Notes on the Grass Valley gold-mining district. American Journ. Sci., 2d ser., Vol. 44, 1867, pp. 236-244.

Notes on the quartz mines of the Grass Valley district. Nevada City, 1867, pp. 14. Written for Bean's History and Directory of Nevada County, California.

Notice of a peculiar mode of occurrence of gold and silver in the foot-hills of the Sierra Nevada, and especially at Whiskey Hill, in Placer County, and Quail Hill, in Calaveras County, California. Read before the California Academy of Natural Sciences, April, 1867. Proc. California Acad. Nat. Sci., Vol. 3, 1863-1867, pp. 349-351; American Journ. Sci., 2d ser., Vol. 45, 1868, pp. 92-95.

Notice of new localities of diamonds in California. Proc. California Acad. Nat. Sci., Vol. 3, 1863-1867, pp. 354-355. Dated San Francisco, May 6, 1867.

Note on three new localities of tellurium minerals in California, and on some mineralogical features of the mother vein. *Idem*, pp. 378-382. Dated San Francisco, December 2, 1867.

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On flame temperatures, in their relations to composition and luminosity. (With Henry Wurtz.) Read before the American Association for the Advancement of Science, Salem, August, 1869. Proc. American Assoc. Adv. Sci., 18th meeting, pp. 135-145; American Journ. Sci., 2d ser., Vol. 49, 1870, pp. 339-347; Chem. News, Vol. 21, 1870, pp. 281-284; Franklin Inst. Journ., Vol. 59, 1870, pp. 337-345; Philos. Mag., Vol. 39, 1870, pp. 290-298; Journ. Gas Lighting, Water Supply, and Sanitary Improvement, London, Vol. 19, 1870, pp. 412-413.

On the effect of atmospheric air when mixed with gas in reducing its illuminating power. (With Henry Wurtz.) Read before the National Academy of Sciences, Washington, April, 1869. American Journ. Sci., 2d ser., Vol. 48, 1869, pp. 40-46; Journ. Gas Lighting, Water Supply, and Sanitary Improvement, London, Vol. 18, 1869, pp. 762-763.

Note on wollongongite, a remarkable hydro-carbon found in the Wollongong district of the Illawarra Coal Field, N. S. Wales. American Journ. Sci., 2d ser., Vol. 48, 1869, pp. 85-92. Name given by B. S.

On the relation between the intensity of light produced from the combustion of illuminating gas and the volume of gas consumed. Read before the American Association for the Advancement of Science, Salem, August, 1869. Proc. American Assoc. Adv. Sci., 18th meeting, pp. 149-159; American Journ. Sci., 2d ser., Vol. 49, 1870, pp. 17-24; Journ. Gas Lighting, Water Supply, and Sanitary Improvement, London, Vol. 19, 1870, pp. 59-60.

Note on Mr. Stimpson's paper on Farmer's Theorem. American Journ. Sci., 2d ser., Vol. 50, 1870, pp. 377-378.

On the determination of the photometric power of a rich gas by dilution with a poor gas of known value; the "method of mixtures." *American Journ. Sci.*, 2d ser., Vol. 50, 1870, pp. 379-383; *Journ. Gas Lighting, Water Supply, and Sanitary Improvement*, London, Vol. 19, 1870, pp. 878-879.

The London gas referees and the sulphur question. *American Chem.*, Vol. 1, 1871, pp. 89-90. Review of "First report upon the sulphur question," of the Gas Referees of London.

On combustion. *American Chem.*, Vol. 2, 1871-1872, pp. 249-253.

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Mineralogical notes on Utah, California, and Nevada, with a description of priceite, a new borate of lime. *American Journ. Sci.*, 3d ser., Vol. 6, 1873, pp. 126-133.

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Chem., Vol. 7, 1877, pp. 349-356; Journ. Gas Lighting, Water Supply, and Sanitary Improvement, London, Vol. 29, 1877, pp. 423-424, 460-461.

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Joseph Henry, LL. D. Biographical notice. *American Journ. Sci.*, 3d ser., Vol. 15, 1878, pp. 462-468.

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