JOHN SHAW BILLINGS, 1838-1913: NINETEENTH CENTURY GIANT

CARLETON B. CHAPMAN, M.D., M.P.H.
Professor Emeritus of the History and Philosophy of Medicine,
Albert Einstein College of Medicine of Yeshiva University.
Bronx, New York

ISAAC NEWTON, in a 1675 letter to Robert Hooke, said: "If I have seen further it is by standing on the shoulders of Giants."[1] As a result, he has wrongly been credited with the idea that moderns are pygmies, culturally and intellectually, compared with the giants on whose shoulders they sit. As Robert Merton has shown in a book-length bit of whimsey,[2] Bernard of Chartres actually originated the idea in the twelfth century and passed it on to a devoted pupil, John of Salisbury, who was for a time Bishop of Chartres. He rendered it more provocatively than Newton. "We are," said the Bishop: "like dwarfs on the shoulders of giants, so that we can see more than they, and things at a greater distance, not by virtue of any sharpness of sight on our part. . . , but because we are carried high, and raised up by their giant size."[3]

Bernard's concept is visually expressed in four stained-glass windows in the south transept at Chartres Cathedral depicting four Hebrew prophets as giants on whose shoulders sit the four Christian evangelists, represented as pygmies peering intently over the giants' heads. Theological commentary usually has them perceiving great principles rather than fussy detail; and it is highly probable that Newton's reference in his letter to Hooke was to broad scientific concept rather than to observation of scientific minutiae.

In the Western World in the latter part of the tumultous twentieth century, we sit on the shoulders of quite a few giants, although our characteristic disdain of the past keeps us, for the most part, blissfully ignorant of the fact. A handful of those giants were American born and bred; and one of the most remarkable is little known in the United States. One reason may be that he was a man of medicine and a career army officer, callings sometimes thought more pragmatic than intellectually significant. But the positive influence, powerful and continuing, of this remarkable and relatively obscure man reaches far beyond the boundaries of medicine and the military calling.

He was John Shaw Billings (1838 -1913), of Switzerland County Indiana, Washington, and New York who, despite his relative obscurity, belongs be-

yond question in genus *Genius*; "...a man of an angel's wit and singular learning..., and sometimes of...sad gravity: a Man for All Seasons."[4]

Billings' great work and much of his intellectual development took place between two devastating wars: the Civil War of 1861 -1865, and the First World War, which began in Europe the year after he died. His span included most of the Victorian period, the Gilded Age, and the time of the Robber Barons.[5] He understood the characteristics of his times far better than most, and was able to bend many of those characteristics *pro bono publico* brilliantly. But at no time during his most creative periods, when he was directing his penetrating and serene gaze far beyond his own life and times, did he lose sight of the fact that he, himself, sat on the shoulders of giants.

CHILDHOOD

The bare facts of Billings' life are well-recorded and, as such, do not enable us even to approximate how he arrived at giant status, nor why he is relatively unknown, even among educated Americans.[6] His origins were unpretentious. He was born in 1838 in quasifrontier southeast Indiana on the Ohio River between Cincinnati and Louisville of undistinguished but bookish parents who had migrated to Indiana from the northeast. His early education, unstructured and informal, is described briefly in autobiographical fragments he wrote in 1905.[7] His powerful and unchanging emphasis in these and other items is on books, reading, and self-learning. The Bible, *Pilgrim's Progress*, the works of James Fenimore Cooper, and Plutarch's *Lives* are specifically mentioned as works he encountered before he was ten; and they, along with other experiences, inclined him powerfully away from farming. He began to learn Latin, probably in his early teens, with the help of a young clergyman; and, a few years later, he taught himself enough Greek, geometry, and other subjects to meet the requirements for admission to the "Preparatory Department" of Miami University at nearby Oxford, Ohio.

The Miami University catalog of 1854, the year Billings entered, set out a formidable list of books and subjects (Caesar, the *Aeneid*, Cicero's orations, Xenophon's *Anabasis*, elementary algebra, geometry, anatomy and physiology, American history, and portions of the Bible) with which students in the preparatory department were confronted. The catalog also listed the courses required for the baccalaureate degree, including the most important Greek and Roman classics; algebra, trigonometry and the calculus; various aspects of religion and the Bible; history and political science. In the junior and senior years, natural philosophy, chemistry and physiology were added as subjects with which all educated men, regardless of vocational

or professional goals, were expected to be at least on speaking terms. "The standard of education is high," said an official of the university, "[and] our young men seem to appreciate the fact, that, if a thorough course of study is required, they are richly repaid in the mental stores and discipline with which they go forth to the duties of life."[8]

Billings left no detailed record of his reaction to his experience at Miami but, judging from its intellectual content and his later performance, its effect cannot have been negligible. In any event, it is clear that he continued, even while carrying a considerable load of classwork, to read voraciously on his own. Shortly before he died he told an audience that when he was a student at Miami University, its library contained about 8,000 volumes (a very respectable number for the time) and was open only on Saturday mornings from 9 to noon. He overcame this limitation by borrowing to the allowable limit and, during summer vacations, by burglarizing the library to read undisturbed for hours on end, skimming most books but concentrating on those that interested him.[9]

After graduating second in his class at Miami in 1857, he went the next year to the Medical College of Ohio at Cincinnati, an institution founded forty years earlier by the brilliant and irascible Daniel Drake. Medical school was a struggle owing to shortage of funds but not, apparently, to intellectual deficiency. Today's medical students, were they familiar with his writings, would almost certainly applaud his confession that he seldom attended lectures because he found "...that by reading the textbooks I could get more in the same time and with very much less trouble." Then he goes on to say that "...the systematic teaching of those times I have had to unlearn for the most part,"[10] criticism still applicable to medical education.

The bare facts of Billings' educational period provide abundant proof of his intelligence and industry. They also attest wide-ranging and largely unfocussed intellectual curiosity, as well as dogged determination to overcome official strictures that, one way or another, got in his way. These characteristics and attributes are in evidence, often strikingly, in many later phases of his career.

Stirrings of Genius

No record indicates that, at this stage, Billings was scientifically inspired; but of greatest significance is what he tells us about writing his graduation thesis at the Medical College of Ohio, "The Surgical Treatment of Epilepsy," published in full in the *Cincinnati Lancet and Observer*.[11] Commendably conservative, the article is significant in one remarkable aspect: in preparing it, the 22-year-old Billings assembled reports by 51 authors from

44 medical journals and books, most of them British or French. Only a few were available to him in Cincinnati; others he had to collect by mail. The dates of the sources ranged from 1776 to 1860, indicating that he was not content with a superficial survey of the most recent literature, but set out to consult everything of importance that touched on his topic. It was, viewed in context, an astonishing performance for a backwoods student. Years later, looking back at the experience, he noted that "...while there was nowhere in the world a library which contained all medical literature, there was not in the United States any fairly good library, one in which a student might hope to find a large part of the literature relating to any medical subject." Even if the student could go to Europe, he added, he would have to visit not one but many major cities before he could feel sure that he had exhausted his search.[12]

Billings may well have assigned the difficulties he encountered in collecting the literature on the surgical management of epilepsy more importance than they warranted, but it would be unreasonable to dismiss the incident out of hand. It may not actually have been the beginning of the thinking that led ultimately to the creation of the great Surgeon-General's Library and, much more significantly, to the even greater *Index-Catalogue of the Library of the Surgeon-General's Office, United States Army*, a bibliographic tool of unparalleled value and scope and, in the words of a later librarian, "...the most comprehensive piece of bibliography ever attempted in any field of knowledge."[13] But his graduation thesis clearly set him apart from the average student of his own time or, for that matter, of today. In 1860 no student would have been held to account if, in assembling material for his thesis, he had looked no further than his school's own meager library. And today no student is faulted if, in looking into a subject for a student thesis of some sort, he does no more than request the librarian to obtain an on-line printout of recent articles allegedly relevant to his topic. But Billings himself felt compelled to examine his subject in its entirety; and the difficulties he encountered may well have put the concept of systematic information storage and retrieval in his mind. Love of books was already firmly planted there.

Billings' grisly experiences as a battlefield surgeon during the Civil War, although impressive enough, are not germane to the present concern. His career really began when he was assigned to the office of the Surgeon-General late in 1864.

The Finest Medical Library

Working in Washington, service as military surgeon in the past, Billings found in the Office of the Surgeon General of the Army about 1,800 medi-

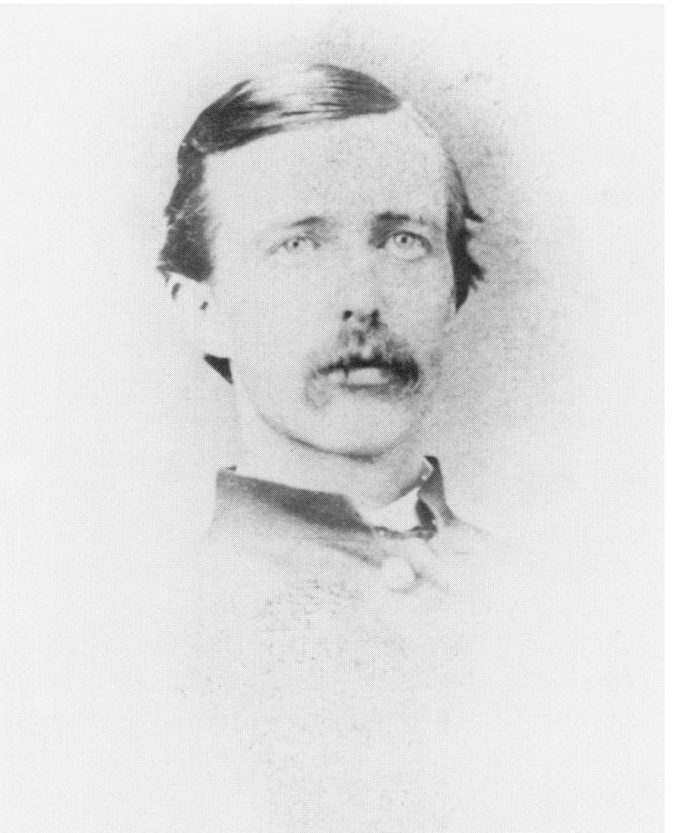

Fig. 1. John Shaw Billings aged about 25. Courtesy of the National Library of Medicine.

cal volumes, unsystematically collected and inadequately catalogued. Deep down, Billings the bookman must have seen a unique opportunity, but it is not at all clear how he persuaded his superiors that a great medical library, not merely for the Army but also for the whole country, was a worthwhile goal. He must have been persistent, forceful, persuasive, and thoroughly ingenious in finding his way through Army red tape to have succeeded so monumentally. But within five years, he was hard at it in an astonishingly systematic way. The Billings files at the National Library of Medicine at Bethesda, direct descendent of the Surgeon General's Library and the world's greatest medical collection, contain hundreds of communications to do with acquiring material for the small unit which, even then, Billings sometimes called the National Medical Library. Year after year through the 1870s and 1880s he was in contact by mail with a vast assortment of individuals and institutions all over the country and in Europe, mostly having to do with as-

sembling files of medical periodicals, many of them obscure. There are records of trades, purchases, gifts, even what amount to amiable extortions, most of them initiated by Billings himself. In addition, he put military medical officers in the field to work in his good cause and, leaving no stone unturned, pestered foreign service officers mercilessly to the same end.[14]

Intermingled with communications relating to acquisitions is another type of correspondence, huge in volume, which undoubtedly played a role in reinforcing Billings' preoccupation with what in today's vernacular is called information storage and retrieval. The Billings files make it abundantly clear that in the seventies Billings had himself become *the* national resource for biomedical information. When anyone in the nation could not find information on a medical topic of any sort, he wrote to Billings. There are innumerable requests for medical information, trivial and crucial, from thousands of individuals in and out of the medical profession. Billings seems to have replied to most of them, or directed someone else to reply for him, and the job must have been onerous. Sometimes his replies were curt, especially if he thought the questioner had not done his homework, but he labored conscientiously to meet the demand. Even so, the volume grew so hugely that something had sooner or later to give. It may be supposed that the volume of inquiries would have forced him to create the *Index-Catalogue* even if he hadn't understood the need for it on other, more compelling, grounds.

The Great Index-Catalogue

Creating the nation's greatest medical library was in itself an immense achievement. But the *Index-Catalogue of the Library of the Surgeon-General's Office, United States Army* was beyond doubt John Shaw Billings' magnum opus; and it alone would, in a rational world, have easily placed Billings among the giants. It is impossible to know which came first in his mind: building the library or creating the *Index-Catalogue*. In any event, the library grew prodigiously under Billings' direction; when he left the library in 1895 it contained more than 300,000 items and was rapidly becoming the finest collection of its kind in the world.

In 1872, having been librarian for seven years, Billings compiled a complete catalog of the library's monographs, alphabetical by author, followed by a short subject index. Next (1874) came a three-volume catalogue, including articles in periodicals, that listed holdings alphabetically by author followed by a supplement which arranged the listings by author in fourth groupings. It is also listed 369 individuals and 105 medical societies from

15 European countries and the United States that had contributed works for the library. In all, the catalog contained about 50,000 titles—books, pamphlets, articles and theses—and was in itself a considerable achievement;[15] but it provided no subject index as such, and the user had to know authors' names to gain access to literature that related to subjects under investigation.

Billings' first two catalogs were, in retrospect, important steps toward the definitive compilation. But it was the *Specimen Fasciculus* of 1876 that disclosed Billings' master plan and departed from known examples of the time, including that of the Library of Congress. His special contribution was the citing in easily readable form of authors and subjects, along with emphasis on the importance of articles in periodicals, all contained in one alphabetic listing.[16] This was impressive enough. But the scope of the undertaking was and remains beyond the comprehension of ordinary mortals: how could a single individual, however talented, aim to create a bibliographic tool that would include all "...the very best and most select material, but...no other," in a field as expansive as medicine? Yet this was Billings' goal; and he came as close as humanly possible to attaining it. The size of the undertaking was shown in 1878 when he wrote that the subject cards alone then numbered about 400,000, and that the entire work would take up at least ten volumes of 1,00 pages each (the First Series alone, as it turned out, occupied 16 volumes and contained 679,669 listings).[17]

With the publication and circulation of the *Specimen Fasciculus*, Billings' labors to create his remarkable storage and retrieval system had to take another turn. Congress was in no hurry to appropriate funds to publish the first volume of the *Index-Catalogue* and Billings, by now no stranger to the political intricacies of the Washington scene, began persuading everyone he could reach to write to his Congressman, urging publication. He used the logical approach in an article published in 1878. "What," he asked, "is the value of such an index...as compared with an expedition to the North Pole, five miles of subsidized railroad, one company of cavalry, or a small post-office building?" He also raised other points, some remarkably fresh in the light of events occurring over a century later. They included "...the low state of medical education in this country, and the part which government should or can take with regard to its improvement; the peculiar value.... [of clinical] phenomena which cannot be repeated at will, like those of a chemical experiment...."[17] He was, however, far too pragmatic to let his case rest on logic alone; although the record is somewhat lacking on the point, it is safe to assume that he pulled every string he could honorably reach to bring his great project to fruition.

That he was successful is now history. Congress appropriated what today seems a paltry sum ($20,000), and the first volume of the first series appeared in 1880, the sixteenth and last of the first series appearing fifteen years later. It was an instant success, especially in Britain and continental Europe. Within a very few years, Billings' unique bibliographic tool was available to students of medicine defined in its broadest terms. Until comparatively recent times (circa 1965), research planning and description were unthinkable without the *Index-Catalogue* which, as Osler pointed out, covered virtually all authors and subjects of note, both ancient and modern.[19]

The *Index-Catalogue* did what Billings intended that it should do: it put discerning and conscientious investigators in touch with everything of note in the biomedical field except the most current articles and books. But, by design it was always a few years (sometimes as much as 20) out of date; to fill the gap, Billings and his assistant, Robert Fletcher, began to produce the original *Index-Medicus*, another bibliographic tool, of simpler design and purpose than the *Index-Catalogue*, which listed references a few weeks or months after publication.

The *Index-Catalogue* went through five series and sixty-one volumes before it was discontinued in 1961.[20] The *Index-Medicus*, the key to current biomedical literature, has had its ups and down but still survives in modified form as the *Cumulated Index Medicus*. Its future is, in turn, very much in doubt because of the advent of electronic techniques for information storage and retrieval. "For the near future (five to 10 years)," one authority assures us, "books and journals will persist." They will, he adds, gradually be replaced by "online sources of information," which "...may gradually become the dominant form of archival storage."[21]

That prophecy has to date become reality only partially, and when—or whether—it will go on to completion remains to be seen. Ironically, the prospect may be said to have grown from seeds planted by Billings himself. Before further examination of those activities, two other aspects of his incredible career require mention.

Johns Hopkins University and Daniel Coit Gilman

By 1880, when the *Index-Catalogue* began to appear, Billings' counsel was increasingly sought on a great many topics. There was, quite simply, no one with such an array of talents and expertise who, *pari passu*, was also an able administrator. His critical influence on the early development of the Johns Hopkins Medical School is merely one example of his effectiveness as historian, teacher, architect, and educator. But all was not sweetness and

light when he and Gilman came into conflict. On the positive side, it was Billings who brought such outstanding figures as Osler and Welch to Hopkins, and it was Billings who laid out the form of its teaching hospital. But he took a dim view of Gilman's design for what amounted to premedical and preclinical medical education. Gilman was apparently committed to the punitive theory of pedagogy and seems at times to have found outside counsel, including Billings', somewhat unwelcome. He paid lip service to advice and admonitions from many sources, but he sometimes heard only what he wanted to hear.

Conflict arose when Billings, at the request of the university trustees, prepared a statement on the education of the physician which came into Gilman's hands before it was sent to the trustees. Billings' plea for a strong liberal arts education before students enter medical school was contrary to Gilman's view that what he called the "preliminary medical course" should be hard going "...for a scholar of health, industry, and talent," and placed heavy emphasis on chemistry, botany, and zoology.[22] Gilman seems, one way or another, to have deemphasized those of Billings' views that differed from his own, apparently without troubling to inform Billings, before forwarding the document to the trustees. Billings wrote in protest but received no reply. His resentment, however, is evident in a letter he wrote to J. Collins Warren, editor of the *Boston Medical and Surgical Journal* in reply to Warren's request for Billings' views on medical education. "It is sufficient to say," Billings wrote, "that the President of the University does not agree with me as to the course to be pursued. I do not think that at the present time it would be proper for me to write anything for publication relating to the points of difference...between President Gilman and myself, for we must take what we can get from such parties. On the other hand, I cannot speak approvingly of certain points in the programme.... It must be inferred that he [Gilman] does not think it specially necessary that a physician should possess the culture which is presumed to belong to an A.B. or B.S. in the Hopkins University."[23]

In the light of experience since Billings' and Gilman's time, Billings appears more mature and accurate in his views than President Gilman. But Gilman's censorship of Billings' statement to the trustees, and Billings' own restraint in the matter along with his views on medical education, say a great deal about both men. In any event, they composed their differences and worked together very productively in later years, both at Hopkins and in connection with the Carnegie Institution at Washington.

THE NEW YORK PUBLIC LIBRARY

Billings came to New York, after a short sojourn at the University of Pennsylvania, to direct the enormously complicated process of creating from several components the New York Public Library.[24,25]

He was appointed Director (sometimes rendered Superintendent-in-Chief) early in 1896 and the *New York Times* carried the news on page one. The account accurately recorded his achievements to that date and, very significantly, noted that "...his great work on which his fame as a bibliographer rests is the Index-Catalogue of the Library of the Surgeon-General's Office.... This catalogue is said to be the best and most complete of its kind in the world."[26] It was, as it turned cut, probably the fairest and most extensive recognition he ever received in New York. One of his first chores was to create a catalogue for the new library which was composed of three formerly independent units. This in itself was a considerable challenge.[27] Even more taxing were the political complications precipitated when a Tammany mayor, Robert van Wyck, raised a pious ruckus about leasing city-owned land to a private corporation over which the citizens of New York had no control.[28] In this and in many other connections, Billings' experience with the political process plainly stood him in good stead. He remained in the background during the controversy over the site, but was probably instrumental in persuading the *New York World* and other newspapers to take the library's case to the public. After extracting maximal visibility from the matter, the Mayor finally relented and the site at Fifth Avenue and Forty-second Street was made ready to receive the handsome building as we now know it.

Then as now, the New York press could sometimes turn nasty. This was the case when Billings was accused by the *New York Daily News* of profiting from contracts for steel shelving in the new library. "Easy graft in Library contracts! Learned and ingenious rogues...!" said the *News* before going on to name Billings and others in its list of alleged thieves. The smear came out on Friday, 23 March 1905, and Billings, the very epitome of integrity and honesty, must have been furious. But the record shows that he moved calmly and deliberately to strike back at his tormentors. With the help of the District Attorney, he convinced the editor of the *Daily News* that the attack would, if left to stand, bring the newspaper and the editor himself into deep water. The conclusion of the episode came when the editor, Thomas C. Quinn, published an abject apology, adding that the editor and staff

Fig. 2. John Shaw Billings aged about 55, at or soon after his appointment as Superintendant-in-Chief of the developing New York Public Library in 1896. Courtesy of the National Library of Medicine.

"...wished to do whatever lies in our power to remedy any harm or wrong...because of the error into which we were led."[29]

Probably the greatest controversy that has arisen in the decades since the New York Public Library at Fifth Avenue and Forty-second Street was opened to the public concerns its design and who was responsible for it. Phyllis Dain says flatly that "...the building was in essence Billings' creation, originally sketched on a postcard which is preserved in the library's Manuscript Division." Henry Hope Reed, architectural historian, conveys the same message: "[Billings], more than any other person, shaped the institution and *the building* we have today."[30] There is not the slightest doubt that Billings, in dealing with the architects, told them the functions the building must serve in no uncertain terms. In addition, he probably knew as much

or more about ventilating, lighting, and heating public buildings as anyone in the country[31] and possibly more than Hastings and Carrère, whose design had been selected out of many that were submitted. But his primary concern was that the building be functionally adequate, and on this point he was adamant. When, however, it came to artistic details and matters of decor, he deferred to the architects.

The result was a structural and functional masterpiece, and Billings' last article described it in sober but glowing terms. The article was dominated on its first page by one of Edward C. Potter's now famous lions and, characteristically, Billings praised the architects while claiming no credit for himself. The architects, he wrote, "...have shown that it is possible to supply all the demands of library administration in a building which is a work of art worthy of its site."[32]

Among the several circulars the New York Public Library has recently distributed (1986) as part of its seventy-fifth birthday there is one mention of Billings. "The basic plan," the account says, "was conceived by Dr. John Shaw Billings, the extraordinary man who was the first Director of the Library."

The chief architect, John Merven Carrère, with whom Billings worked closely if not always in complete harmony, was killed in a traffic accident early in March 1911, and the building was opened to the public for the first time on March 4 when his body lay in state in the building's rotunda.[33] The official opening of the library was on 23 May 1911, the event providing maximal public visibility for New York's high society and politicians. Billings was in the procession but his role in creating the library was mentioned by none of the speakers, one of whom was President Taft. It was an unforgivable omission, whether intentional or merely inept, but Billings was said to have been unperturbed.[34] It is, however, inconceivable that he felt no hurt at such an affront.

Throughout his New York years, Billings was heavily engaged in many sizeable projects, the grandest of which was to persuade Andrew Carnegie to put up the money to build New York City's system of branch libraries. And although his health was beginning to be a limiting factor, he continued to go to Europe almost every year to attend congresses, receive honorary degrees, still on the hunt for books and manuscripts. In all, he seems to have made about fourteen voyages to Europe, travelling on one occasion as far as Moscow, between 1876 and his last voyage in 1911. But in his last year, and especially after his wife died, he began to withdraw from commitments that took him away from New York City.

Billings and the New York Academy of Medicine

The records of the New York Academy of Medicine show that Billings, along with some thirty other notables, most of them European, was an Honorary Fellow of the Academy and that he frequently took part in its activities. Of greatest significance, however, was his warm friendship with Dr. Samuel S. Purple of New York, who is credited with establishing the Academy's great medical library. It was a case of two fanatically addicted bibliophiles working together in common cause. The exchange between them began early in 1872—and possibly even earlier—when Billings was collecting medical periodicals for the Surgeon-General's Library. One of his volunteer agents called on Dr. Purple in January 1872, and reported that Purple "...was very amiable, [had already] disposed of many duplicates he had a few years ago on the occasion of moving to a new house...." But, the correspondent (Charles Smart) added, Purple still had "...a box which contains he knows not what." The same agent reported a month later that he had found a dealer with an immense stock of books, largely unsorted, and that he had bought a copy of Nathan Smith's *Memoirs*, under protest, for the exhorbitant price of $2.[35] Purple himself wrote to Billings in August, 1872, offering odd issues of obscure journals and "...wishing you all success in the praiseworthy efforts you are putting forth."[36] The correspondence between these two remarkable men continued on a fairly regular basis, becoming warmer as time passed. Billings sent Purple proof sheets of the first volume of the *Index-Catalogue* which Purple returned promptly, presumably with whatever corrections he thought indicated, and copies of the finished work were sent to the Academy's library as they came from the printer.

As early as 1898, Billings was discussing with officials of the New York Academy of Medicine the desirability of coordinating acquisition policies: the New York Public Library would not attempt to build a medical collection but would, to avoid duplicate purchasing, expand its holdings in biology and other sciences allied to medicine, "an arrangement which cannot fail to be distinctly advantageous to both institutions."[37] He spoke at a number of special events involving the Academy and sat on some of its committees and commissions, including one on the evils of alcohol, which foundered after a few years because of general apathy.[38]

The Academy has two letters written by Billings, one of which, in reply to a query from the Academy's librarian concerning subject headings, tersely instructed him to consult the *Index-Catalogue*. The other was addressed to

Abraham Jacobi, who had, apparently, inquired about the possibility that the New York Public Library might accommodate within its new building all 30,000 volumes of the Academy's medical collection and, in addition, provide space for a catalogue and for medical readers. Although Jacobi and Billings were good friends, Billings minced no words in his answer: it was, said Billings, out of the question; he advised the Academy to rent space for its collection.[39]

Billings' son, John Sedgewick Billings, born 1869, went into public health and became a Fellow of the New York Academy of Medicine in 1903. Some years later he was involved in an infraction of undisclosed type and charges were brought against him in the Academy. They were, however, later withdrawn (circa 1909), without explanation in the Academy's records.[40]

Other men bearing the name Billings were in the public eye in John Shaw's time but none, as far as is known, were related to him. One of them, Frank Seaver Billings, of 46 Dudley Street, Boston, raised John Shaw's hackles for some reason. In a letter dated 14 February 1880, John Shaw took Frank Seaver to task in no uncertain terms. The addressee, John Shaw said, is tactless and too self-assertive. For good measure he added: "Your reputation is getting to be that of a man who has too good an opinion of himself and too much contempt for everyone else in this country to get along pleasantly with. I am writing very frankly. . . because I think you have good prospects if you alter your style, whereas I predict your total failure to achieve the object you have in view if you do not."[41] Billings' purpose in writing the letter, although not specified, may have had to do with the National Board of Health of which he was vice-president. Frank Seaver Billings was a veterinarian who was also a socialist, a political leaning with which John Shaw Billings probably had little sympathy. He was, however, on cordial terms with Frank Billings of Chicago, president of the American Medical Association in 1903, the originator of the now-defunct concept of focal infection, and for whom Billings Hospital in Chicago is named.[42]

Of John Shaw Billings' social life in New York we know very little. He became a member of the Century Club in 1896, having been proposed by John Cadwalader and W. E. Dodge, and not infrequently dined there. He lived at 32 East 3lst Street, just east of Madison Avenue and within easy walking distance of the library, but the brownstone building he inhabited has long since given way to commercial construction. In Billings' time the neighborhood was a respectable one but was already being deserted by the rich and powerful for locations farther north on Fifth and Madison Avenues.

JOHN SHAW BILLINGS AND HERMANN HOLLERITH

If there is a single unifying theme in Billings' illustrious career it is information storage and retrieval; and although he may never have heard the word computer, he was brought to consider ways and means to manage great masses of numerical data by his involvement with the census and with vital statistics.[43]

An omnivorous reader, he may have known about thinkers who, impatient with the tedium of arithmetic operations by hand, had tried to devise mechanical means for the purpose. Such would include Pascal, Leibnitz, and Babbage, among others.[44] Billings himself joined the list in the 1870s when he began to think about punch card systems. He had dealt with masses of data concerning illness and death in the Surgeon General's office and later when he was vice-president of the National Board of Health. Then came the census of 1880. As that vast process went on, month after month, entirely by hand, Billings at some point recalled a prototype device that might, with adaptation, meet the needs of tabulating census results. In a conversation with a young engineer, Herman Hollerith, Billings said "...there ought to be some mechanical way of doing this job, something on the principle of the Jacquard loom, whereby holes in a card regulate the pattern to be woven."[45]

Joseph-Marie Jacquard (1752-1834) had devised a loom on the feed-forward (as opposed to the feed-back) principle in 1790 but, owing to dislocations brought on by the French Revolution, he had not patented his invention until 1801. It utilized sets of punched cards to instruct the loom as to patterns to be woven; in today's computer jargon, the punch cards *programmed* the loom. In any case, within a few decades the Jacquard loom had revolutionized the textile industry in Britain and the United States, and was a factor in accelerating the industrial revolution. Billings' contribution was to perceive that the Jacquard principle could be adapted to the recording and sorting of numerical data; and that perception was one stimulus, no doubt among many, that produced what we now call the computer revolution.

Hollerith, with Billings' cooperation and encouragement, took up the idea and designed a card, the exact size of a dollar bill of the day, with locations for 288 holes. Probably on his own, he devised an electromagnetic system to rapidly sort cards into groups, depending on the locations of holes that had been punched in them.

The device proved its worth beyond question when it was used for tabulation for the census of 1890. And although Billings never devised a punch card system for storage and retrieval of the literature of medicine, it is al-

together likely that he recognized the similarities between the problems of tabulating census data, on the one hand, and the management of a highly complex body of information in the form of titles of books, articles, authors, and subjects, on the other. Both were, reduced to their simplest terms, systems for storage and retrieval. So also was the *Index-Catalogue*, the format of which had taken shape in his mind many years before his memorable suggestion to Hollerith about mechanical recording and sorting.

Parenthetically, it is refreshing to note that there was no controversy between Billings and Hollerith concerning priority for devising a primitive computer based on punch cards and mechanical sorting: the basic concept was Billings', borrowing from Jacquard; the implementation and development were by Hollerith. Other accounts, including that by Raymond Pearl, are all in agreement on these points.[46]

Predictably, Billings was much too committed to his concept of public service to consider the money-making potential for the device Hollerith had developed. That potential was not lost on Hollerith himself. In 1896 he set up his Tabulating Machine Company, which was almost immediately successful. There were competitors in later years but, with various mergers and hiring of competitors' technical personnel, Remington-Rand and IBM finally emerged, lineal descendants in an important sense of the exchange between Billings and Hollerith as they walked through the census office during the tabulation of the 1880 census. Hollerith, born the year Billings received his medical degree, was a millionaire at age 51.[47]

The Billings Legacy in the Twentieth Century

When John Shaw Billings died in 1913, the *Index-Catalogue* and the *Index-Medicus* were the bibliographic tools on which conscientious medical researchers and students relied; and, despite shortcomings, they made the biomedical literature readily accessible for the first time. Searching them was, however, time-consuming and they were not available in all medical libraries. And, soon after World War II, evidence began to accumulate that the *Index-Catalogue* was consulted far more by librarians than by physicians who turned, by preference, to the *Quarterly Cumulated Index Medicus*, successor to the *Index-Medicus*.[48]

It was inevitable that, with improvement in mechanical recording and sorting, some modification in the use of the *Index-Catalogue*, the *Quarterly Cumulated Index Medicus*, and the National Library's vast card catalogue would occur. When changes came under discussion during the late forties, officials of the Library took up more or less where Billings had left off fifty years

earlier. The first discussions had to do with variants of the punch card and mechanical sorting systems of the 1880s.

Implementation of these plans began in 1958 and resulted in a system based on punch cards, mechanical sorting, and photographic methods. The equipment that evolved proved satisfactory for preparing the Library's *Current List* and other items was much too slow to serve as a retrieval system. Over the next two years the possibility of using computers, in lieu of systems based on punch cards, emerged and in November 1960 MEDLARS (Medical Literature Analysis and Retrieval System) came into being. Finally, MEDLARS evolved into MEDLINE and the overall system was largely decentralized. It then became possible to obtain very recent references on specific biomedical topics within a few minutes using the online approach. Offline searches, requiring a few days, were also developed, mainly to reach further back into the Library's listings of published materials than the online approach permitted.[49] But he who would search the periodical literature of the past—1966 or earlier—still has to turn to the *Quarterly Cumulative Index Medicus*, the *Index-Medicus*, or to John Shaw Billings' own creation, the great *Index-Catalogue* itself.

The entire development, beginning in the late forties, was one of which Billings would beyond doubt have approved. It involved Director Frank Bradway Rogers, Acting Librarian Scott Adams, Editor Seymour Taine, and Director Martin Cummings, among many others; all men who have responded to the towering influence of Billings as well as to their own vision. The library, now much more than a storehouse of printed material, officially became the National Library of Medicine on October 1, 1956, and on May 3, 1962 it moved into its new quarters at Bethesda.

What might Billings think if he could spend a day in the present-day National Library of Medicine? Probably he would be amazed and for the most part delighted. It is quite safe to assume, however, that he would strenuously object to the practice of taking our storage systems for articles in periodicals (*data bases* to cognoscenti) back no further than ten or twenty years. That practice is slowly but relentlessly destroying the record except for its most recent twenty years. No stranger to fiscal constraints, Billings would understand the reasons for the policy; but he would at least sound the alarm with regard to the dangers inherent in its uncritical application.

It must be recognized that the growing abandonment by modern investigators of the older literature and of the *Index Catalogue* in favor of online printouts of recent articles is a giant step toward assigning inappropriate authority to the computer. Both are, as Billings pointed out, bibliographic

tools, with only limited capabilities for deciding what is relevant and what is not. As matters now stand, they are adjuncts that complement each other; but neither is dispensable. In addition, if the online search is the investigator's sole resource, the researcher becomes helpless when the mechanical device, for any reason, declines to function. Dr. Vartan Gregorian, today's Director of the New York Public Library, has been quoted to the effect that: "when we say the computer is down, we give the computer itself a say in the development of knowledge."[50] It would be more accurate to say that when the computer is down, there is delay in acquiring information on which knowledge may be based. But the investigator who is accustomed to using the various printed indexes placed in our hands by the intelligence and industry of John Shaw Billings is never paralyzed by computer failure. Nor is it irrelevant to point out that it costs nothing to consult the printed indexes. Computer searchers, in contrast, usually require a fee, sometimes a substantial one.

John Shaw Billings died in New York City of postoperative pneumonia on March 11, 1913, a month short of his seventy-fifth birthday. Funeral services were at St. John's Church, Georgetown, where he had been married in 1862, and he was buried in Arlington National Cemetery. As Rogers noted, he had in his lifetime "...fought a war, revolutionized hospital construction, had been a prime mover in public hygiene and sanitation..., had done more to advance American medical education than any other individual of his generation, had created a great national medical library and built for it bibliographical keys of comparable magnitude.... He had vision, managerial adroitness, and a dogged and relentless power of will."[51] Rogers, a National Library of Medicine stalwart, may be pardoned for omitting mention in Billings' list of achievements of the New York Public Library. Just so, many New Yorkers know little or nothing of Billings' greatest achievements, concluded before he came to New York.

With so fantastic a record of solid devotion and achievement in so many fields, why has he never received appropriate recognition for his contributions? Harvey, in his account of Billings as "forgotten hero of American medicine," recognizes Billings' achievements but, like other biographers, is unable to account for his comparative obscurity on the American scene.[52]

What sort of man was Billings? It is tempting to compare him with Osler, his contemporary who, although of less varied accomplishment, is well-known throughout the English-speaking world. One reason may be that Osler, a near-genius in his own right as clinician and teacher, was anything but shy, retiring, and self-effacing. He was, in fact, something of a showman and

he used the quality to good effect in his teaching. Billings, in sharp contrast, was self-effacing to a fault and, from his early years, a very private person.

It is probably oversimplification to say that Billings was too far in front of the herd, too exacting, too strongly results-oriented, and never "one of the boys." There is truth in such allegations but they are singularly unsatisfying as explanations for his obscurity, which was probably not altogether fortuitous. It is likely that some of his contemporaries, possessing ordinary intellects and abilities, at times damned him with faint praise and claimed credit that properly belonged to Billings himself. But the full and sufficient explanation for his obscurity eludes us.

Conclusions

As we have seen, there is a solid theme—the storage and retrieval theme—running all through the Billings story and continuing to the present day. Many of the library's current programs continue programs and practices he originated.

No Luddite, he made clear that he was in favor of improved techniques for searching the literature and used the phrase "the modern mechanical way" more than once.[53] He never subscribed to the confused and hackneyed notion that technological advance is necessarily accompanied by moral and intellectual decay, or that there is "...a direct causal relation between the two."[54] But on the correct uses and definitions of storage and retrieval tools, he issued warnings pertinent in his own time and much more so today. "Subject-catalogues," he warned, "may easily be put to improper uses, or thought to give more information that they actually do. They are not bibliographies, but mechanical aids in bibliographic work."[55] He speaks disparagingly of "...mere uncritical lists of all the books and journal articles relating to a given subject,"[56] and he quotes a French author who, in this connection, wrote that "...it is a part of elementary scientific honesty to cite only the books [and articles] one has read."[57] Speaking before the Association of American Physicians in 1887, Billings said that while the researcher may be aided by "systematic works of medical bibliography," he can, and indeed should, move on his own well outside their confines. Only in this way can his search be anywhere near complete; and only in this way can the depradations of the literary culprits—erroneous quotations, incorrect references, and even plagiarism—be rooted out. Even more critical is the serendipitous aspect of the search. The conscientious researcher, Billings tells us, "...will soon find himself wandering off into all sorts of curious by-paths and out-of-the-way corners into which he is led by obeying

the golden rule. . .to 'verify your references.' " He may, and very often does, stumble ". . .over several interesting points not precisely connected with his original quest. . ." which may alter his approach or, occasionally, lead to much more important results than were at first contemplated.[58] To Billings the principle of serendipity was a very vital matter; to late twentieth century scientific sophisticates it is usually no more than an occasion for amusement and tolerant smiles.

One of the most important features of Billings' life and thought is that he never confused information with knowledge.[59] The *Index-Catalogue*, and its lineal descendent MEDLINE, are brilliantly capable of providing information but not knowledge. We are, in our own time, said to be in the midst of an information explosion and, to one remarkably uncritical contemporary author, we have, by mass-producing information, ". . .systematized the production of knowledge and amplified our brainpower. . . . We now mass produce knowledge and this knowledge is the driving force of our economy."[60] This general view, and all that it entails, represents the growing trend to equate the computer with superior intellect, and to place blind faith in the proposition that "artificial intelligence" is rapidly becoming superior to the naturally-developed variety.

Information and knowledge are not synonymous; this is inherent in Billings' comments about storage and retrieval systems. He also perceived, although not in infinite detail, some of the negative effects that would flow from misuse of "mechanical" storage and retrieval systems. One can well imagine that he would have smiled grimly at a modern paraphrase of Coleridge's lines in *The Ancient Mariner*: "Data, data everywhere, but not a thought to think."[61]

There seem to be no busts, memorial plaques, or framed proclamations recognizing the immense devotion to duty of this great man. The New York Public Library has a portrait of him, painted by Ellen Emmet, that usually hangs in a corridor leading to the Trustees' Room but that is not currently on display; the National Library of Medicine has an undistinguished portrait of him in academic robes, and there is a historic site marker at the corner of State Road 250 and a county road at Allensville, Indiana, near his birthplace. But that seems to be all: he has not won a place in the American Hall of Fame, no postage stamp commemorates him and his labors, and even the medical profession has not seen fit to recognize in a formal way its great debt to him.

It may well be that modern pygmies, sitting on the shoulders of this giant, can see further than he did in some respects. But it will do us nothing

but harm if we fail to heed his chief message: ingenious technologic adjuncts are immensely useful as tools of astonishing complexity and effectiveness. But they can never displace intelligence, conscience, or conceptualization; nor can they, of and by themselves, generate knowledge.

NOTES AND REFERENCES

1. Newton, I.: *The Correspondence of Isaac Newton,* Turnbull, H.W., editor. Cambridge, University Press, 1959. Volume 1. Letter 154, Newton to Hooke, February 5, 1675/6, p. 416.
2. Merton, R. K.: *On the Shoulders of Giants.* New York, Harcourt Brace Jovanovich, 1965, pp. 40-41.
3. Ionnis Saresberiensis: *Metalogicon,* Webb, C.I., editor. [1159]. Oxford, Clarendon Press, 1929. Book 3, chapter 4, p. 136; lines 23-27.
4. Whittington, R.: *The Vulgaria of John Stanbridge and the Vulgaria of Robert Whittington,* White, B., editor. [1521]. London, Kegan Paul, Trench, Trubner and Co., 1932, [Early English Text Society No. 187] pp. 64-65. The phrase, concluding with *vir omnium horarum,* was used by Whittington, a Latin grammarian, in reference to Sir Thomas More with whom he was contemporary.
5. The term "Gilded Age" is attributed to Mark Twain and his co-author, Charles Dudley Warner, and referred mostly to the early and very corrupt years of the Grant administraiton. The robber barons were mostly industrial and financial tycoons who flourished from the end of the Civil War to the turn of the century. (Cochran, Thomas C.: The legend of the robber barons. *Pennsylvania Mag. 74*:307-321, 1950). Andrew Carnegie, with whom Billings was on close if not intimate terms, was one of the most prominent of them.
6. There are two book-length biographies of Billings. The more informative is Fielding H. Garrison: *John Shaw Billings: A Memoir.* New York, Putnam's Sons, 1915. The other is Henry Miller Lydenburg: *John Shaw Billings. Creator of the National Medical Library and its catalogue. First Director of the New York Public Library.* Chicago, American Library Association, 1924. Frank Bradway Rogers included a short biography of Billings in his *Selected Papers of John Shaw Billings.* Baltimore, Medical Library Association, 1965, pp. 1-13. In addition, many writers set out the bare facts of Billings' life, mostly drawn from the preceding accounts, in various papers.
7. Billings, J.S.: *An Autobiographical Fragment,* 1905. The manuscript is in the Billings collection at the National Library of Medicine and was published in facsimile by the library in 1965.
8. *Catalogue for 1854.* Miami, Miami University, 1854, pp. 25-31.
9. Billings, J.S.: Address given at the opening of the new library building at Radcliffe College. *Radcliffe Mag. 10*:107-117. Rogers, *Selected Papers*, ref. 6, pp. 275-284., 1908.
10. Billings, J.S.: Address to the Harvard Medical Alumni Association. *Boston Med. Surg. J. 131*:140-42, 1894.
11. Billings, J.S.: The surgical treatment of epilepsy. *Cincinnati Lancet Observer 4*:334-41, 1861; Abstracted in *Am. J. Med. Sci. 44*:299-300, 1861.
12. Billings, J.S.: The Medical College of Ohio before the war. *Cincinnati Lancet-Clinic 24*:297-306, 1888.
13. Hume, E.E.: Letter of transmittal, *Index-Catalogue of the Library of the Surgeon General's Office, United States Army.* Fourth Series *1*:iii, 1936.
14. This period of Billings' professional life is covered by Miles, W.: *History of the National Library of Medicine: The Nation's Treasury of Medical Knowledge.* Washington D.C., Government Printing Office, 1982, pp. 41-90. See also Schullian, D.M.: Adams Jewett and John Shaw Billings: Partners in acquisition. *Bull. Med. Library Assoc., 49*:443-49, 1961.

15. Billings, J.S.: *Catalogue of the Library of the Surgeon General's Office, United States Army.* Washington D.C., Government Printing Office, 1873-1874, 3 vols.
16. Billings, J.S.: *Specimen Fasciculus of a catalogue of the National Medical Library under the direction of the Surgeon General, United States Army, at Washington, D.C.* Washington, D.C., Government Printing Office, 1876. This key document displayed the format of the proposed *Index-Catalogue* in detail, authors and subjects being listed dictionary-wise in a single alphabet. Most significantly, articles in periodicals were listed alphabetically by author both in groupings under main headings and by author in the main text. The investigator thus has access to the literature both by subject headings and by author.
17. Billings' letter of transmission to the Surgeon General in volume 1 of the first series of the *Index-Catalogue* (pp. iii-v) lists a few of the policies that dictated the arrangement of the contents of the volume, and forcefully denies that it is a complete medical bibliography. Another letter, written exactly 15 years later to a later Surgeon General, gives the statistics of the first series, acknowledges the assistance of many assistants and donors, and announces that this, the 16th volume, is the last with which he will be associated. "...It has," he says, been to me a "labor of love, and...I am very thankful that I have been allowed to complete it, so far as the first series is concerned (Volume 16, first series, pp. iii-v).
18. Billings, J.S.: National catalogue of medical literature. *Library J. 3:*107-108, 1878.
19. Osler, W.: Address at the Memorial Meeting in honor of the late Dr. John Shaw Billings, April 25, 1913. *Bull. New York Public Library 17:*515-18, 1913. Osler also said: "No undertaking in bibliography of the same magnitude dealing with a special subject has ever been issued, and its extraordinary value was at once appreciated all over the world." Osler went on to say: "There is no better float through posterity than to be the author of a good bibliography." It was his view that long after the "inquity of oblivion" has obscured Billings' work in the army, with hospitals, and by inference in education, his great *Index-Catalogue* "will remain an enduring monument to his fame." It has not worked out that way. The real enigma is why Osler himself has become almost a cult figure, while Billings is today relatively unknown except at the National Library of Medicine and at a few other centers where intellectual and medical history are respected and pursued.
20. Rogers, F.B. and Adams, S.: The Army Medical Library's publication program. *Texas Rep. Biol. Med. 8:*271-300, 1950.
21. Friedman, R.B.: The future of medical information and medical libraries. *Bull. N.Y. Acad. Med. 61:*291-97, 1985.
22. Chesney, A. M.: Two documents relating to medical education at the Johns Hopkins University. *Bull. Inst. Hist. Med. 4:*477-504, 1936. (p. 487) Billings' views on medical education were published in several places over a considerable period of years. Most of his ideas are included in Chesney's two papers by John Shaw Billings on medical education. *Bull. Inst. Hist. Med. 6:*285-359, 1938. Chesney's two publications, the first in 1936 and the second in 1938, are often confused. To add to the possibilities for confusion, Sanford V. Larkey had an article bearing the title, Two letters by John Shaw Billings on the history of medicine. *Bull. Inst. Hist. Med. 6:*394-398, 1938.
23. JBS to J. Collins Warren, 13 September 1878. NLM Box 10, MS/C/31.
24. Dain, P.: *The New York Public Library. A History of its Founding and Early Years.* New York, New York Public Library, 1972, pp. 87-89. Billings' name was originally proposed by his good friends S. Weir Mitchell of Philadelphia, and John Cadwalader (Mitchell's brother-in-law) of New York. Dain's description of Billings' background and accomplishments is generous and scrupulously accurate.
25. Lydenburg, H.M.: *History of the New York Public Library.* New York, New York Public Library, 1923, pp. 350-52. Also the same author's, John Shaw Bill-

ings and the New York Public Library. *Bull. Inst. Hist. Med.* 6:377-86, 1938.
26. *New York Times*, January 14, 1896, pp. 1, 9.
27. Dain, ref. 24, pp. 99-103; Lydenburg, ref. 25, pp. 62-69.
28. *New York Times*, January 14, 1898, p. 12. Also Dain, ref. 24, pp. 172-177.
29. Lydenburg, H.: ref. 25, pp. 492-494. There is confusion in Lydenburg's quote in that the events are dated both 1905 and 1906. The articles could not be found in the issues of the *New York Daily News* (1905) at the New York Public Library. The Library does not have the issues for the corresponding dates in 1906. The *New York Times* thought the opening guns of the ruckus were fit to print; but only just barely (17 January 1905, p. 2, col. 6; and 22 February 1905, p. 4, col. 4.). The *Times* made no accusations.
30. Dain, ref. 24, p. 159. Reed, H.H.: *The New York Public Library; its Architecture and Decoration.* New York, Norton, 1986, p. 6.
31. Billings, J.S.: *The Principles of Ventilation and Heating, and Their Practical Application.* New York, The Sanitary Engineer, 1884. Billings wrote many articles, of which this book is a compilation, on these subjects which, at the time, had usually been neglected by architects and builders. Billings' views were influenced by his experience in construction of military hospitals and prevailing views about transmission of disease via ambient air.
32. Billings, J.S.: The New York Public Library. *Century Illustrated Monthly Mag.* 59:839-52, 1911.
33. *New York Times*, March 4, 1911, p. 11.
34. *New York Times* tells part of the story (24 May 1911, p. 3). Garrison (ref. 6, pp. 321-322) and Dain (ref. 24, pp. 334-335) fill in some of the details. Whatever the explanation, Billings seems to have been considered a mere *fonctionnaire* by whoever was in charge of planning the event.
35. Charles Smart to JSB; 30 January and 7 February, 1872. NLM MS/C/81.
36. Samuel Purple to JSB, 1 August 1872. Archives of the New York Academy of Medicine.
37. Annual Report of the Library Committee. New York Academy of Medicine, 1862-1901, p. 291 (1898). The same source contains many exchanges between Billings and the Academy Library, the last entry being May 9, 1912, concerning deposition of 606 volumes of Paris theses. See also Van Ingen, P.: *The New York Academy of Medicine: The First Hundred Years.* New York, Columbia University Press, 1949. pp. 174-279 contain many mentions of Billings.
38. Billings is listed as Honorary Fellow in the Academy's *Quinquinnial List of Past and Present Officers, Fellows...and Honorary Fellows.* January 1911.
39. JSB to Abraham Jacobi, 30 October, 1911. Archives of the New York Academy of Medicine.
40. The Academy's Committee on Admissions reported that John S. Billings, Jr., was a candidate for admission on 22 December, 1902. The reference, however, is to Billings' son, John Sedgewick Billings; but not junior. He was admitted to Fellowship on January 26, 1908.
41. JSB to Frank Seaver (F. S.) Billings, 14 February 1880. NLM Box 11, MS/C/81.
42. Garrison, ref. 6, p. 263.
43. Billings had been assigned to collection of battlefield statistics in 1863. Subsequently, in the Surgeon General's office, it was mainly Billings who collected and analyzed vital statistics for inclusion in the *Medical and Surgical History of the War of the Rebellion.* Also, he was advisor to the government with regard to the tenth census (1880), a role he continued to play for the next thirty years. He wrote an article entitled "Medical Statistics" for Clifford Allbutt's *System of Medicine* (New York, Macmillan and Co., 1896. Vol. 1, pp. 3-20) which, for its time, was remarkably sound and inclusive. But for reasons undisclosed, the article was eliminated from Allbutt's second edition.
44. Goldstine, H.H.: *The computer from Pascal to von Neumann.* Princeton, Princeton University Press, 1972, pp. 3-26.
45. Goldstine (ref. 44, pp. 66-71) refers to

the critical conversation between Billings and Hollerith. Billings himself wrote about it in *Public Health Papers and Reports, APHA 13*:203-23, 1887, and in his mechanical methods used in compiling data of the llth U. S. Census, with an exhibition of a machine. *Proc. Am. Asso. Adv. Sci. 40*:407-09, 1891. See also Rogers, *Selected Papers*, ref. 6, p. 207; also Truesdell, Leon: *The Development of Punch Card Tabulation in the Bureau of the Census, 1890-1940.* Washington, D.C., Government Printing Office, 1965, pp. 26-27; Also Cummings, M.M.: Books, computers, and medicine. *Med. Hist. 10*:130-37, 1966.

46. Pearl, R.: Some notes on the contributions of Dr. John Shaw Billings to the development of vital statistics. *Bull. Inst. Hist. Med. 6*:387-93, 1938.
47. Austrian, G.D.: *Herman Hollerith: Forgotten Giant of Information Processing.* New York, Columbia University Press, 1982, pp. 312-16. Billings, in contrast, left an estate valued at $139,801, distributed *per stirpes* among his five children. It was, for the time, a comfortable sum, but fell far short of the estate Hollerith assembled. (*New York Times*, August 26, 1913, p. 18.)
48. Rogers and Adams, ref. 20, pp. 289-290. Also Miles, ref. 14, pp. 289-311.
49. Miles, ref. 14, pp. 384-88.
50. Hamburger, P.: Searching for Gregorian. *New Yorker 61*:60. 14 April, 1986.
51. Rogers, ref. 6, p. 10.
52. Harvey, A.McG.: John Shaw Billings: forgotten hero of American medicine. *Persp. Biol. Med. 21*:35-57, 1977.
53. Billings' use of the term "modern mechanical way" in reference to bibliographic searches left little doubt that he was critical but not opposed. He used the term in his Medical Bibliography. *Trans. Med. Chir. Fac. Maryland*, 1883, pp. 58-80. Also in Rogers, *Selected Papers* ref. 6, pp. 149-169; p. 154) See also Billings' address to the Association of American Physicians of 1887, Methods of research in medical literature. *Trans. Assoc. Amer. Physicians* 2:57-67, 1887. Also in Rogers, *Selected Papers*, ref. 6, pp. 198-206; p. 201). In that presentation Billings said prophetically: "...mechanical bibliography may be used to excellent advantage, and the field for this kind of work will expand in the future."
54. Dodds, E. R.: *The Ancient Concept of Progress.* Oxford, Clarendon Press, 1985, p. 2.
55. Billings, J.S.: Our medical literature. *Trans. 7th Internat. Med. Congr. London, 1881. 1*:54-70. Rogers, *Selected Papers*, ref. 6, pp. 116-138 (p. 130).
56. Billings, J.S.: Some library problems of tomorrow. *Library J. 27*:1-9, 1902. Rogers, *Selected Papers*, ref 6, pp. 249-262, p. 260.
57. Billings, J.S., ref. 53, p. 155.
58. Billings, J.S., ref. 53, p. 58.
59. Machlup, F.: *Knowledge and Knowledge Production.* Princeton, Princeton University Press, 1980, vol. 1, p. 132n. The author holds that information and knowledge are, for his purposes, synonymous. His purposes, it is necessary to point out, seem to be strictly technical.
60. Naisbitt, J.: *Megatrends.* New York, Warner, 1982, p. 7.
61. Roszak, T.: *The Cult of Information: The Folklore of Computers and the True Art of Thinking.* New York, Pantheon Books, 1986, p. 37. Roszak quotes the quote, third hand, from Machlup.