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THE BEGINNINGS OF AMERICAN ASTRONOMY.

IT is impossible, even in the briefest sketch, not to emphasize the debt of American science and learning to the intelligent interest and patronage of our early Presidents—Washington, John Adams, Jefferson, Madison, Monroe, John Quincy Adams. The powerful impetus given by them and through them has shaped the liberal policy of our governments, National and State, towards education and towards science. Sir Lyon Playfair, in his address to the British Association for the Advancement of Science (1885), has recognized this influence in the truest and most graceful way. He said: "In the United Kingdom we are just beginning to understand the wisdom of Washington's Farewell Address to his Countrymen (1796) when he said: 'Promote, as an object of primary importance, institutions for the increase and diffusion of knowledge; in proportion as the structure of a government gives force to public opinion, it is essential that public opinion should be enlightened.'"

Until the Revolution (1776) American science was but English science transplanted, and it looked to the Royal Society of London as its censor and patron. Winthrop, Franklin and Rittenhouse were, more or less, English astronomers. Franklin was the sturdiest American of the three. As early as 1743 he suggested the formation of the American Philosophical Society of Philadelphia. John Adams founded the American Academy of Arts and Sciences in Boston in 1780. These two societies, together with Harvard College (founded in

1636), Yale College (1701), the University of Virginia (founded by Jefferson in 1825) and the United States Military Academy at West Point (1801), were the chief foci from which the light of learning spread. Other colleges were formed or forming all over the Eastern and Middle States during the early years of the century.

The leading school of pure science was the Military Academy at West Point, and it continued to hold this place until the Civil War of 1861. From its corps of professors and students it gave two chiefs to the U. S. Coast Survey; and the army, particularly the corps of engineers, provided many observers to that scientific establishment, besides furnishing a large number of professors and teachers of science to the colleges of the country. The observatory of the Academy was founded by Bartlett, in 1841, and much work was done there, only a small part of which is published. The Coast Survey was a school of practice for army officers, and their experience was utilized in numerous boundary-surveys during the period 1830–50. Colonel J. D. Graham, for example, was Astronomer of the survey of the boundary between Texas and the United States in 1839–40; Commissioner of the Northeast boundary survey 1840–43; Astronomer of the Northwest boundary survey 1843–47; of the boundary between the United States and Canada 1848–50; of the survey of the boundary between Pennsylvania and Virginia 1849–50; of the boundary survey between Mexico and the United States 1850–51. The names of Bonneville, Talcott, Cram, Emory and other army officers are familiar in this connection, and their work was generally of a high order. It was in such service that Talcott invented or reinvented the Zenith Telescope, now universally employed for all delicate determinations of latitude. The mechanical tact of Americans has served astronomy well. The sextant was invented by Thomas Godfray, of Philadelphia, in 1730, a year before Hadley brought forward his proposal for such an instrument.* The chronograph of the Bonds, the Zenith Telescope of Talcott and the break-circuit chronometer Winlock are universally used to-day. The diffraction-gratings of Rutherfurd were the best to be had in the world till they were replaced by those of Rowland. The use of a telescope as a collimator was first proposed by Rittenhouse. The pioneer opticians of the United States were Holcomb (1826), Fitz (1846 or earlier), Clark (1845), Spencer (1851). Only the Clarks have a world-wide reputation. Würdemann, instrument maker to the U. S. Coast Survey (1834) had a decided influence on observers and instrument-makers throughout the United States, as he introduced extreme German methods and models among us, where extreme English methods had previously prevailed. The system of rectangular land surveys which proved to be so convenient for the public lands east of the Rocky Mountains was devised and executed by Mansfield, a graduate of the Military Academy.

The list of army officers who became distinguished in civil life as professors in the colleges of the country is a very long one. Courtenay (class of 1821 at West Point) was professor of mathematics at the University of Pennsylvania, 1834–36, at the University of Virginia, 1842–43, and was the author of admirable text-books. Norton (class of 1831) became professor at New Haven, and wrote a very useful text-book of astronomy in 1839; and the list

* In 1700 Sir Isaac Newton sent drawings and descriptions of a reflecting sextant to Halley for his advice. At Halley's death these were found among his papers. Hadley's device (1731) was undoubtedly derived from Newton's MSS. The Royal Society of London granted £200 to Godfray for his invention which his brother, Captain Godfray, had previously put into practical use in the West Indies.

could be much extended. The excellent training in mathematics at West Point (chiefly in French methods) early made itself felt throughout the whole country. The mathematical text-books of Peirce of Harvard and of Chauvenet of the Naval Academy, brought the latest learning of Europe to American students. Mitchell (class of 1829 at West Point) was the only graduate who became a professional astronomer (1842–61). His direct service to practical observing astronomy is small, but his lectures (1842–48), the conduct of the Cincinnati observatory (1845–59), and his publication of the *Sidereal Messenger* (1846–48), together with his popular books, excited an intense and widespread public interest in the science, and indirectly led to the foundation of many observatories. He was early concerned in the matter of using the electric current for longitude determinations and his apparatus was only displaced because of the superior excellence of the chronograph devised by the Bonds. His work was done under immense disadvantages, in a new community (Ohio), but the endowment of astronomical research in America owes a large debt to his energy and efforts.

The Navy and the U. S. Naval Academy (founded by Bancroft in 1845, at the suggestion of Chauvenet) were very active in astronomical work. Chauvenet (Yale College, 1840) published a text-book of Trigonometry, in 1850, which had an important share in directing attention to rigid, elegant and general methods of research. His astronomy (1863) is a hand-book for all students. Walker, Gilliss, Coffin, Hubbard, Ferguson, Keith, Yarnall, Winlock, Maury, Wilkes, were all connected with the Navy, more or less intimately. Walker's career was especially brilliant; he graduated at Harvard College in 1825, and established the Observatory of the Philadelphia High School in 1840. He was the leading spirit in the U. S. Naval Observatory at Washington (1845–47) and introduced modern methods into its practice at the beginning. From the Observatory he went to the Coast Survey to take charge of its longitude operations, and he continued to direct and expand this department until his death, in 1853. To him, more than to any single person, is due the idea of the telegraphic method ('the American method') of determining differences of Longitude. His assistant in this work was Gould, who succeeded to the charge of it in 1853. His researches extended to the field of mathematical astronomy also, and his theory of the planet *Neptune* (then newly discovered) marks an important step forward. His investigations and those of Peirce were conducted in concert and attracted general and deserved attention.

The exploring expedition of Wilkes required corresponding observations to be made in America, and during the period 1838–42 William Bond, at Dorchester, and Lieutenant Gilliss, at Washington, maintained such a series with infinite assiduity and with success. The results of Gilliss' astronomical expedition to the southern hemisphere (Chile, 1849–52) were most creditable to him and to the navy, though his immediate object—the determination of the solar parallax—was not attained.

The Coast Survey began its work in 1817 under Hassler, a professor from West Point, who impressed upon the establishment a thoroughly scientific direction. Bache, his successor (a grandson of Benjamin Franklin), was a graduate of West Point in the class of 1825, and took charge of the Survey in 1843. He is the true father of the institution, and gave it the practical efficiency and high standard which characterized its work. He called around him the flower of the army and navy, and was ably seconded by the permanent corps of civilian assistants —Walker, Saxton, Gould, Dean, Blunt,

Pourtales, Boutelle, Hilgard, Schott, Goodfellow, Cutts, Davidson and others.

Silliman's (& Dana's) *American Journal of Science* had been founded at New Haven in 1818, and served as a medium of communication among scientific men. A great step forward was made in the establishment of the *Astronomical Journal* by Dr. Gould on his return from Europe at the close of 1849.* *Silliman's Journal* was chiefly concerned with the non-mathematical sciences; though it has always contained valuable papers on mathematics, astronomy and physics, especially from the observers of Yale College—Olmsted, Herrick, Bradley, Norton, Newton, Lyman and others. In Mason, who died in 1840 at the age of 21, the country lost a practical astronomer of the highest promise.† *Gould's Journal* was an organ devoted to a special science. It not only gave a convenient means of prompt publication, but it immediately quickened research and helped to enforce standards already established and to form new ones. The *Astronomical Notices* of Bruennow (1858–62) might have been an exceedingly useful journal with an editor who was willing to give more attention to details, but, in spite of Bruennow's charming personality and great ability, it had comparatively little influence on the progress of the science.

The translation of the *Mécanique Céleste* of Laplace by Nathaniel Bowditch, the supercargo of a Boston ship (1815–17), marks the beginning of an independent mathematical school in America. The first volume of the translation appeared in 1829; at that time there were not more than two or three persons in the country who could read it critically. The works of the great mathematicians and astronomers of France and Germany — Laplace, Lagrange, Legendre, Olbers, Gauss, W. Struve, Bessel—were almost entirely unknown.

Bowditch's translation of the *Mécanique Céleste*, and, still more, his extended commentary, brought this monumental work to the attention of students and within their grasp. His *Practical Navigator** contained the latest and best methods for determining the position of a ship at sea, expressed in simple rules. American navigators had no superiors in the first half of this century. Nantucket whalers covered the Pacific, Salem ships swarmed in the Indies, and the clipper-ships made passages round the Horn to San Francisco, which are a wonder to-day. Part of their success is due to the bold enterprise of their captains (who were said to carry deck-loads of studding-sail booms to replace those carried away!), but an important part depended on their skill as observers with the sextant. One of the sister ships to the one of which Bowditch was supercargo was visited at Genoa by a European astronomer of note (Baron de Zach), who found that the latest methods of working lunar distances to determine the longitude were known to all on board, sailors as well as officers. His bewilderment reached its climax when the navigator called the negro cook from the galley and bade him expound the methods of determining the longitude to the distinguished visitor.

On Bowditch's own ship there was "a crew of twelve men, everyone of whom could take and work a lunar observation as well, for all practical purposes, as Sir Isaac Newton himself." Such crews were only to be found on American ships in the palmy days of democracy. All were cousins or

*The *Astronomische Nachrichten* had been founded in Altona, by Schumacher, in 1821.

†See the *International Review*, Vol. X., p. 585.

*First edition, 1802. Sumner's method in navigation (1843)—a very original and valuable contribution from a Boston sea-captain—and Maury's Wind and Current Charts, begun in 1844, are two other notable contributions from a young country to an art as old as commerce.

neighbors, and each had a 'venture' in the voyage. But these anecdotes may serve as illustrations of the intellectual awakening which came about as soon as our young country was relieved from the pressure of the two wars of 1776 and 1812. An early visitor, Baron Hyde de Neuville (1805), felt 'an unknown something in the air,' 'a new wind blowing.' This new spirit, born of freedom, entered first into practical life, as was but natural; science next felt its impulse, and, last of all, literature was born. Emerson hailed it (in 1837) 'as the sign of an indestructible instinct.' "Perhaps the time is already come," he says, "when the sluggard intellect of this country will look from under its iron lids and fill the postponed expectation of the world with something better than the exertions of mechanical skill. Our day of dependence, our long apprenticeship to the learning of other lands, draws to a close. The millions that around us are rushing into life cannot always be fed with the sere remains of foreign harvests."

Benjamin Peirce, a graduate of Harvard in the class of 1829, had been concerned with the translation of the *Mécanique Céleste*, and was early familiar with the best mathematical thought of Europe. He became professor in Harvard College in 1833, and, after the death of Bowditch in 1838, he was easily the first mathematical astronomer in the country. His instruction was precisely fitted to develop superior intelligences, and this was his prime usefulness. Just such a man was needed at that time. Besides his theoretical researches on the orbits of the planets (specially *Uranus* and *Neptune*) and of the moon, his study of the theory of perturbations, and his works on pure mathematics and mechanics, he concerned himself with questions of practical astronomy, although the observations upon which he depended were the work of others. He was the consulting astronomer of the *American Ephemeris* and *Nautical Almanac* from its foundation in 1849, and its plans were shaped by him to an important degree. His relative, Lieutenant Davis, United States Navy (the translator of Gauss' *Theoria Motus Corporum Cœlestium* (1857)), was placed in charge of the *Ephemeris*, and the members of its staff—Runkle, Ferrel, Wright, Newcomb, Winlock and others—most effectively spread its exact methods by example and precept. Professor Peirce undertook the calculations relating to the Sun, *Mars* and *Uranus* in the early volumes of the *Ephemeris*. As a compliment to her sex, Miss Maria Mitchell was charged with those of *Venus; Mercury* was computed by Winlock, *Jupiter* by Kendall, *Saturn* by Downes, *Neptune* by Sears Walker.

The Smithsonian Institution was founded in 1846, and Joseph Henry was called from Princeton College to direct it. There never was a wiser choice. His term of service (1846–78) was so long that his ideals became firmly fixed within the establishment and were impressed upon his contemporaries and upon a host of younger men. The interests of astronomy were served by the encouragement of original research through subsidies and otherwise, by the purchase of instruments for scientific expeditions, by the free exchange of scientific books between America and Europe, and by the publication of the results of recondite investigations. It is by these and like services that the Institution is known and valued among the wide community of scientific men throughout the world.

But this enumeration of specific benefits does not convey an adequate idea of the immense influence exercised by the Institution upon the scientific ideals of the country. It was of the first importance that the beginnings of independent investigation among Americans should be directed towards right ends and by high and unselfish aims. In the formation of a scien-

tific and, as it were, a moral standard a few names will ever be remembered among us; and no one will stand higher than that of Henry. His wise, broad and generous policy and his high personal ideals were of immense service to his colleagues and to the country.

The establishment of a National Observatory in Washington was proposed by John Quincy Adams in 1825; but it was not until 1844 that the U. S. Naval Observatory was built by Lieut. Gilliss, of the Navy, from plans which he had prepared. By what seems to have been an injustice Gilliss was not appointed to be its first Director.* This place fell to Lieut. M. F. Maury. Gilliss had been on detached service for some years, and a rigid construction of rules required that he should be sent to sea, and not remain to launch the institution which he had built and equipped.

The first corps of observers at Washington (1845) contained men of first-class ability—Walker, Hubbard, Coffin. Gilliss's work as astronomer to Wilkes Exploring Expedition (1838–42) at his little observatory on Capitol Hill, had shown him to be one of the best of observers, as well as one of the most assiduous. His study and experience in planning and building the the Naval Observatory had broadened his mind. To the men just named, with Peirce, Gould and Chauvenet, and to their coadjutors and pupils, we owe the introduction of the methods of Gauss, Bessel and Struve into the United States, and it is for this reason that American astronomy is the child of German, and not of English science.

The most natural evolution might seem to have been for Americans to follow the English practice of Maskelyne and Pond. But the break caused by the War of Independence, by the War of 1812, and by the years necessary for our youthful governments to consolidate (1776–1836) allowed our young men of science to make a perfectly unbiased choice of masters. The elder Bond (William Cranch Bond, born 1789, Director of Harvard College Observatory, 1840–1859) was one of the older school and received *his* impetus from British sources during a visit to England in 1815.

In estimating the place of the elder Bond among scientific men it is necessary to take into account the circumstances which surrounded him. He was born in the first year of the French Revolution (1789); he was absolutely self-taught; practically no astronomical work was done in America before 1838. When Admiral Wilkes was seeking for coadjutors to prosecute observations in the United States during the absence of his exploring expedition he was indeed fortunate in finding two such men as Bond and Gilliss. Their assiduity was beyond praise and it led each of them to important duties. Bond became the founder and Director of the Observatory of Harvard College, while Gilliss is the father of the United States Naval Observatory at Washington, as well as of that of Santiago de Chile, the oldest observatory in South America. Cambridge, though the seat of the most ancient university in America, was but a village in 1839. The College could afford no salary to Bond, but only the distinction of a title, 'Astronomical Observer to the University,' and the occupancy of the Dana house, in which his first observatory was established. His work there, as elsewhere, was well and faithfully done, and it led the College authorities to employ him as the astronomer of the splendid observatory which was opened for work in 1847. At that time the two largest telescopes in the world were those of the Imperial Observa-

of Russia (Poulkova) and its com-

*He was, however, Director during the years 1861–65.

panion at Cambridge. Each of these instruments has a long and honorable history. Their work has been very different. Who shall say that one has surpassed the other? We owe to Bond and his son the discovery of an eighth satellite to *Saturn*, of the dusky ring to that planet, the introduction of stellar photography, the invention of the chronograph by which the electric current is employed in the registry of observations, the conduct of several chronometric expeditions between Liverpool and Boston to determine the Transatlantic longitude, and a host of minor discoveries and observations.

Gilliss visited France for study in 1835, before he took up his duties at Washington. The text-books of Bond and Gilliss were the Astronomies of Vince (1797–1808) and of Pearson (1824–29). The younger Bond (George Phillips Bond, born 1825, Harvard College 1844, Director of the Harvard College Observatory 1859–65) and his contemporaries, on the other hand, were firmly grounded in the German methods, then, as now, the most philosophical and thorough.

It was not until 1850, or later, that it was indispensable for an American astronomer to read the German language and to make use of the memoirs of Bessel, Encke and Struve and the text-books of Sawitsch and Brünnow.* This general acquaintance with the German language and methods came nearly a generation later in England. The traditions of Piazzi and Oriani came to America with the Jesuit Fathers of Georgetown College (1844), of whom Secchi and Sestini are the best known.

The dates of the foundation of a few observatories of the United States may be set down here. Those utilized for the observation of the transit of Venus in 1769 were temporary stations merely. The first college observatory was that of Chapel Hill, North Carolina (1831); Williams College followed (1836); Hudson Observatory (Ohio) (1838); the Philadelphia High School (1840); the Dana House Observatory of Harvard College (1840); West Point (1841); the United States Naval Observatory (1844); the Georgetown College Observatory (1844); the Cincinnati Observatory (1845); the new observatory of Harvard College (1846); the private observatory of Dr. Lewis M. Rutherfurd in New York City (1848); the observatory at Ann Arbor (1854); the Dudley Observatory at Albany (1856), and that of Hamilton College (1856).

These dates and the summary history just given will serve to indicate the situation of astronomy in the United States during the first half of the present century. A little attention to the dates will enable the reader to place an individual or an institution on its proper background. It must constantly be kept in mind that the whole country was very young and that public interest in astronomical matters was neither educated nor very general. The data here set down will have a distinct value as a contribution to the history of astronomy in America. The developments of later years have been so amazing that we forget that the first working observatories were founded so late as 1845.

American science is scarcely more than half a century old. The day will soon come—it is now here—when we shall look back with wonder and gratitude to ask who were the men who laid the wide and deep foundations which already maintain so noble an edifice.

EDWARD. S. HOLDEN.

MT. HAMILTON, CAL., April, 1897.

*Dr. Bowditch learned to read German in 1818, at the age of 45.

*INHERITANCE OF ACQUIRED CHARACTERISTICS.**

IN approaching the subject of 'The inheritance of acquired characteristics' from

*Paper read at the Boston meeting of The American Society of Naturalists.