Chapter 2
Historical Overview: The United States and Astronomy Until the 1860s

Astronomy as an amateur recreation was entrenched in much of Western Europe by the eighteenth century, where there were the financial means, the knowledge base, the manufacture of tools and the genuine interest among those with the time to engage in such a recreation. It took most of the first half of the nineteenth century for this pastime to become popular in the relatively young United States. This new country had no wealthy aristocracy to indulge in subjects of personal interest. In other words, there was no American Carrington, Common, Cooper, Dawes, De la Rue, Lee, William Herschel, John Herschel, Huggins, Lassell, Lockyer, Nasmyth, Parsons (Third Earl of Rosse), Smyth or South—to mention just Britain alone (see Chapman 1998). Nor was there an established mechanism for the newly-created American Federal Government to finance science education and technology on a national level. With respect to the last, it was felt that much of these matters would, in any case, fall under the purview of the individual states. What little knowledge base was present on the subject of astronomy in America was inherited from Europe and, for most people, that was considered sufficient for the practicalities of everyday life. The value of this science in navigation, surveying and time-keeping was accepted as a given, but most Americans saw no reason to spend money or time to extend knowledge beyond what was needed for these routine tasks. Through much of the first half of the nineteenth century, required astronomical instruments were purchased from Europe rather than manufactured within the United States. It was also some time before American books on the subject were published. The English publications were considered adequate. Americans were satisfied with the situation as it was at the time.

There were documented instances of some early American interest in the science of astronomy for its own sake, but these are rare. A European account of note is cited by Professor W.C. Rufus (1924, pp. 121–122) in his article on astronomical observatories in the United States:

> Mr. Thomas Brattle, of Boston in New England, is the annonymus [sic] person alluded to by Newton, in his Principia, as having made such good observations of the comet of 1680. Several of his observations are preserved in the Transactions of the Royal Society of London.

S. Cottam, W. Orchiston, *Eclipses, Transits, and Comets of the Nineteenth Century*, Astrophysics and Space Science Library 406,
DOI 10.1007/978-3-319-08341-4_2

Another colonial observer, the noted New England scientist and physician Thomas Robie (1689–1729), made significant observations of the lunar eclipse of 15 March 1717 as well as the Sun and the planet Mercury (ibid.). In truth, it must be remembered that these colonists were not Americans, but rather English subjects who had relocated across the Atlantic.

In the second quarter of the nineteenth century in particular, a distinct change in attitude developed regarding the value of astronomy. According to Lick Observatory Director Edward Holden (1846–1914), there was an "… intellectual awakening which came about as soon as our young country was relieved from the pressure of the two wars of 1776 and 1812." (Holden 1897, p. 933). Donald Zochert (1974, p. 463) quotes an editorial comment from a popular newspaper, the Milwaukee *Courier* of 9 April 1845, that exemplifies this rising interest: "The works of Nature are so wonderful – so passing strange – that we are often tempted to turn aside from the tedious duties of editorial life to investigate them."

Just what types of celestial objects or phenomena aroused such curiosity at this time in American history? In the second quarter of the nineteenth century, particularly inspirational events included the Leonid meteor shower of 1833 and the advent of the Great Comet of 1843. While the Leonid meteor shower is visible every year, at 33-year intervals a major shower, termed by astronomers a Leonid 'meteor storm', occurs (see Dick 1998). There was one of these 'storms' in 1833.

2.1 The Leonid Meteor Storm of 1833

On the night of 12–13 November 1833 a meteor shower occurred that was so spectacular that it would be a prominent topic of conversation among scientists and non-scientists alike, and noted in professional publications, popular journals, newspapers and personal chronicles.

In his book of 1878 the author R.M. Devens deemed the Leonid meteor shower of 1833 to be among the 100 most significant events of the first century of the United States:

> Extensive and magnificent showers of shooting stars have been known to occur at various places in modern times, but the most universal and wonderful which has ever been recorded is that of the thirteenth of November, 1833, *the whole firmament, over all the United States, being then for hours, in fiery commotion!* No celestial phenomenon has ever occurred in this country, since its first settlement, which was viewed with such intense admiration by one class in the community, or so much dread and alarm by another. It was the all-engrossing theme of conversation and of scientific disquisition, for weeks and months. (Devens 1878, p. 329, his italics).

Reproduced here in Fig. 2.1 is a nineteenth century woodcut depicting the Leonid meteor shower as it appeared on the evening of 13 November 1833 from the U.S.A. This picture is so famous that Professor David Hughes—an authority on meteor showers—wrote a research paper about it and published this in the journal *Earth, Moon, and Planets* in 1995.

It would be Denison Olmsted (1791–1859; Fig. 2.2), Professor of Mathematics and Physics at Yale University, who would take this opportunity to uncover much

Fig. 2.1 A nineteenth century woodcut of the 1833 Leonid meteor shower (courtesy: en.wikipedia.org)

that had been, until then, unknown about meteors. He was primarily responsible for bringing the study of meteors into the realm of astronomy (see Hoffleit 1992, pp. 24–32; Hughes 1982).

On the evening of 12–13 November 1833 Olmsted was awakened by a friend to observe this spectacular meteor shower which was already in progress. His impressions were published on the 13th in the *New Haven Daily Herald*, where he also requested reports of observations made by others. He was pleasantly surprised to

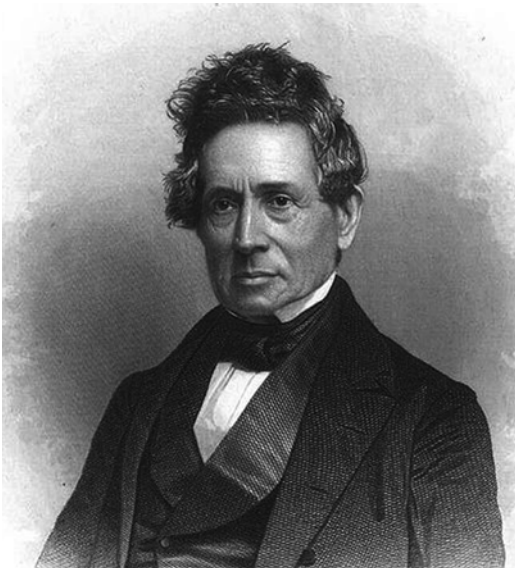


Fig. 2.2 Denison Olmsted (courtesy: en.wikipedia.org)

receive responses from across the country, well beyond the normal purview of the *Herald*. His significant two-part article summarizing what he gleaned from these reports was published the following year in the *American Journal of Science and Arts*. In Part I Olmsted (1834a, pp. 363–411) first reported on his own observations, and he followed this with a summary of the reports received from others. In Part II Olmsted (1834b, pp. 132–174) revisited some earlier Leonid meteor showers, and he then compared and contrasted the data derived from these with observations made in 1833.

Olmsted observed the shower from New Haven, and he received reports from as far south as Georgia and Mississippi, as far west as Missouri and Louisiana, and as far north as Niagara Falls. He also was sent reports from outlying areas further to the east or south, from ships at sea. Alexander Catlin Twining (1801–1884) sent Olmsted the results of reports received in New York from 15 ships that were located in different positions in the Atlantic when the shower occurred. A student of civil engineering at West Point, Twining provided "… the most careful observation and thoughtful analysis …" (Littmann 1998, pp. 17–18). Those further to the east or south of the United States generally gave negative reports, even when there were clear skies. Some closer to the shores of the nation, such as Captain Gideon Parker on the *Junior*, were more successful in their observations. The professions of those who had contributed reports were not always stated in Olmsted's article, but included college professors and physicians, among others. Olmsted also drew on reports printed in local newspapers from non-professional citizens, including ministers and farmers.

At this time, the most common theory on the origin of meteors linked them to the weather, so the study of meteors was not considered to be under the purview of astronomy.

Thus, the most complete reports received by Olmsted would include meteorological data. Olmsted (1834a, p. 385, his italics) summarized:

> Throughout the entire region where the Meteors were observed, there was a sudden and extraordinary *change of weather from warm to cold*, accompanied by an uncommon transparency of the atmosphere … It is hardly possible to persuade ourselves that two concurrent phenomena, both so remarkable as the change of weather and the falling stars, were independent of each other.

However, he could not explain this possible relationship. Was it that of cause and effect between the two, or was there something else involved that "… gave origin to both the change of weather and the meteors?" (Olmsted 1834a, p. 402).

The meteors were at their most striking in frequency and brilliance between 2:00 a.m. and 5:00 a.m. It was concluded that determination of an accurate number of meteors could not reasonably be made. Some more methodical observers worked in groups and attempted to keep count of specific sections of the sky. Some compared the number of meteors seen in a section of the sky with the number of known stars. Olmsted (1834a, p. 389) recognized a discrepancy in numbers: "… some describing them as 'thousands' at a time, and some even by 'millions'." While it was not mentioned in Olmsted's article, the distinguished French astronomer and Paris Observatory Director François Arago (1786–1853) reported that no less than "… two hundred and forty thousand meteors were at the same time visible above the horizon of Boston." (Devens 1878, p. 300). Professor Joseph Henry (1797–1878), an authority on electromagnetism and then at Princeton University, estimated a rate of 72,000 per hour (Littmann 1998, pp. 14–15).

Olmsted (1834a, p. 389, his italics) described three varieties of meteors, the most common being phosphoric lines. There were also large fireballs, and among these were those "… *luminous bodies that continued for a long time in view*." One of these last was described by an observer in Poland, Ohio, as lasting more than an hour (Devens 1878, p. 331). These last rare bodies could be valuable in that their height might be determined by applying trigonometry to any of these unique entities observed at sites distant from each other. In particular, the large fireball that exploded near the star Capella may have been seen by four individuals: "… by Mr. Barber at Frederic, Maryland, by Mr. Tomlinson at Brookfield, a few miles north west, and by Dr. Lee at New Britain, a few miles north east of New Haven, and by Lieutenant Crane at West Point." (Olmsted 1834a, pp. 403–404). At the time this article was written the appropriate calculations had not been made. Most observers agreed the phosphoric lines were no more than two or three miles above the Earth. Olmsted (1834a, p. 403) felt the large fireballs were undoubtedly at a greater height. Edward Hitchcock (1834, p. 356) would state that even the common phosphoric lines must be at a height greater than that of the clouds as none were observed between the clouds and the Earth.

In the second installment of Olmsted's article (1834a, p. 368) he described meteor showers of different times and venues. He had already recognized the shower observed by the renowned German naturalist Alexander Humboldt (1769–1859) and the French botanist and explorer Aimé Bonpland (1773–1858) on 12 November 1799 from Cumana, Venezuela, as most like that of 1833. In their personal narrative,

Fig. 2.3 Hubert Anson Newton (courtesy: en.wikipedia.org)

Humboldt and Bonpland (1907, p. 352) described a shower of "… extraordinary luminous meteors …" that began a little after the hour of two in the morning. This was witnessed by almost all the inhabitants who had risen for early morning mass. The oldest of these "… remembered that the great earthquake of 1766 was preceded by a similar phenomena." (Humboldt and Bonpland 1907, p. 353) Humboldt and Bonpland (1907, p. 352) described their own observations of the shower of 1799:

> … from the first appearance of the phenomena, there was not in the firmament a space equal in extent to three diameters of the moon, which was not filled every instant with bolides and falling stars … All these meteors left luminous traces from five to ten degrees in length.

It would later be determined, as these dates seem to support, that there was a cycle to the peak of these November showers of about 33 or 34 years. It was the astronomer and Professor of Mathematics at Yale University, Hubert Anson Newton (1830–1896; Fig. 2.3; see Hoffleit 1992, pp. 47–56), who first recognized this (Dick 1998; Littmann 1998). Thus, predictions could be made.

There were consistencies and inconsistencies in these reports that Olmsted would try to sort out. Based on the accumulated data he would look at a number of parameters, draw some conclusions, make some speculations, or in some cases advise on the need for future investigation.

Among his conclusions was that:

> *The meteors consisted of combustible matter, and took fire and were consumed in traversing the atmosphere.* That these bodies underwent combustion, we have the direct evidence of the senses. We saw them glowing with intense light and heat, increasing in size and splendor as they approached the earth. (Olmsted 1834b, p. 151, his italics).

It is now known that Olmsted was only partially correct. This was frictional vaporization, not the conventional burning of combustible material in oxygen (Littmann 1998, p. 21).

One point of disagreement among Olmsted's reports was whether or not there was any sound associated with the shower meteors. There were reports of hissing sounds, slight explosions or popping sounds, or no sound at all. Although Olmsted himself heard nothing, he did not dismiss the possibility, as many of the reports were similar in nature (Olmsted 1834a, pp. 392–393, 404). The New Zealand radar meteor astronomer Professor Colin Keay (e.g. 1980a, b) has since clearly documented that electrophonic meteors—those producing sound effects—do indeed exist, although they are rare. Olmsted (1834a, p. 397) also described another discrepancy: "Phenomena resembling more or less the Aurora Borealis, were visible in some places, although in many other places no appearances of the kind were observed." He felt this issue could be resolved at a future event by means of magnetic observations.

A significant point of agreement was the fact that the meteors seemed to originate from a common point, which is now referred to as the 'radiant':

> The meteors, as seen by most observers, appeared to proceed from a fixed point in the heavens, which some referred to the zenith, and others to a point a little S.E. of the zenith. Those who marked its position among the fixed stars, observed it to be in the constellation Leo … (Olmsted 1834a, p. 394).

In his discussion Olmsted (1834b, p. 163, his italics) would put forth the inquiry: "*What relations did the body which afforded the meteoric shower, sustain to the earth*?" He considered the possibilities of a satellite, a comet or "… a collection of nebulous matter …" He drew no conclusions on the nature of the body but he would incorrectly conclude (Littmann 1998, pp. 25–26) that this meteor shower derived from "… a nebulous body, which revolves around the sun in an orbit interior to that of the earth …" (Olmsted 1834b, p. 172).

The cometary origin of these phenomena would first be suggested by Daniel Kirkwood (1814–1895; Fig. 2.4), Professor of Mathematics at Indiana University: "… the debris of ancient but now disintegrated comets, whose matter has become distributed around their orbits." (*Danville Quarterly Review* 1861). The comet associated with these Leonids was determined to be what is now known as Comet P55/Tempel-Tuttle, as demonstrated independently by the German-American astronomer Carl Friedrich Wilhelm Peters (1844–1894), the noted Austrian astronomer and mathematician Theodor von Oppolzer (1841–1886) and the Italian astronomer Giovanni Schiaparelli (1835–1910), all of whom published papers on this topic in the *Astronomische Nachrichten* in 1867 (Mason 1995; Yeomans 1981).

As the name indicates, this comet was discovered independently by two different astronomers. One was the German-born amateur Ernst Wilhelm Leberecht Tempel (1821–1889), usually known as Wilhelm Tempel, who lived in Marseilles (France) at the time and detected the comet on 19 December 1865 using a custom-made Steinheil 10.8-cm comet-seeker (Bianchi et al. 2010). The other was the American, Horace Parnell Tuttle (1837–1923), who at the time worked at the U.S. Naval Observatory, and made his independent discovery on 5 January 1866 (Kronk 2003). This comet has a period of 33 years, and each time it reaches perihelion material is ejected from the nucleus, which is thought to have a radius of 1.8 ± 0.2 km (Hainaut et al. 1998), a mass of around 1.2×10^{13} kg (Jewitt 2004, p. 672) and a rotation

Fig. 2.4 Daniel Kirkwood (courtesy: findagrave.com)

period of 15.31 ± 0.03 h (Jorda et al. 1998). Although debris is now spread along the entire orbit of the comet and a Leonid meteor shower is observed every year, it is the concentration of material encountered by the Earth every 33 years—as in November 1833—that gives rise to the spectacular Leonid meteor storms.

The November meteor storm of 1833 was a subject of great public interest, as reflected in the local newspapers of the time. Olmsted's original article in the *New Haven Herald* was recapped and shared with a number of other publications, including the *Pittsfield Sun* of 21 November 1833 (Curious phenomenon 1833) and the *New Bedford Mercury* of 22 November 1833 (From the *New Haven Herald* 1833).

In some newspapers, personal reports were on occasion made in letters submitted to the editor. Nathan Daboll described in the *Norwich Courier* of 27 November 1833 the blazing skies, and he offered the theory that:

> … the meteors are generated and produced by exhalation drawn up by the Sun from aqueous, nitrous, sulphureous, bituminous and various other substances, animal and vegetable … This is, however, a matter of opinion. (Remarkable phenomena 1833).

D. Leavitt's letter of 10 December 1833, of his observations in Meredith, New Hampshire, was printed in the *New Hampshire Patriot* of 16 December 1833: "… The whole horizon seemed to be illumined …" He recounted, and drew comparisons with, the experiences of Humboldt and Bonpland in South America, and he provided his own theory on the nature of meteors:

> … the principal materials which compose those meteors, are phosphorus, nitre, and hydrogen gas, of which the first is the basis … If any [one should] ask why there are more meteors in the air at some time than at others, the answer is because the matter, which composes them accumulates slowly, like the cause which produces earthquakes, and the eruptions in most volcanoes … (Remarks on the phenomena and nature of meteors 1833).

Local citizens' reports might also be quoted or described within articles. In the *New Hampshire Sentinel* of 21 November 1833 there was the following statement:

"In Portsmouth, an elderly lady, of 'wiry nerves' was thrown into the most frantic delirium and fainted. She was positive the world was coming to an end!" (Keene 1833). The *New Bedford Mercury* on 22 November 1833 quoted this item from the *Portsmouth Journal* of one witness of the meteors:

> An old sailor said he had been all over the world, he had been on deck at all hours of the night, and in every sea in all weathers, and he had never seen such a light as this since his name was Sam. (From the *New Haven Herald* 1833).

This meteor shower would emerge as a significant event in personal memoirs. In his autobiography, Elder Samuel Rogers (1789–1877) described the sharing of this event with his family and friends. The phenomenon was seen as he and his family were preparing for a move to central Indiana. One child feared: "… the world is surely coming to an end." Another said: "The whole heavens are on fire! All the stars are falling!" Samuel Rogers, himself, was more detailed. He would describe tracks of light: "… visible for several seconds" and some meteors "… as large as the full moon." (Rogers 1880, pp. 133–135). Another short memoir was included in *Turnbo's Tales of the Ozarks*. Herein John Tabor told of his experience with his brother waking to a sky: "… brilliantly illuminated with hundreds and thousands of stars shooting swiftly down toward the earth." He expressed a common fear as he

> … believed the earth and all living creatures would succumb to the wrath of God that night. I was a wicked man then, but after that date of the falling stars, I did not live so sinful toward God. (Kwas 1999, pp. 321–322).

It was evident that readers might be further interested in previous showers. Subsequent to the shower of 1833 several newspapers printed the remarks of Captain Hammond of the ship *Restitution* who witnessed a similar shower in the Red Sea at Mocha on 13 November of the previous year (From the *New Haven Herald* 1833; The recent phenomena of the heavens 1833; A bundle of coincidences 1833). The last-cited article, which was from the *Richmond Enquirer*, stated the coincidence noted in the *Salem Register* that the three greatest meteoric showers on record all took place on the morning of 12 November, i.e. those observed by Humboldt and Bonpland in 1799, Captain Hammond in 1832 and the most recent of 1833.

Newspapers recognized a sustained interest in meteors, in particular those of 1833, and printed relevant articles over years to come. Announcements of lectures would reflect the lingering interest in the recent meteor shower. For example, in the *New-Bedford Mercury* of 26 February 1836 there was an item announcing a lecture that evening on "… brilliant Meteors of November, 1833." (Astronomical lecture 1833). Other newspapers which would continue to provide details of this shower included the *Pittsfield Sun* (Meteoric shower 1838), *The New York Times* (The meteors of 1833; 1884) and the *Advocate* (Meteoric showers 1925). Mention of other meteor showers were included in articles as well. See the *Baltimore Patriot*'s comparison of 1834 and 1833 (e.g. The meteors 1834). A review of the showers over the past 6 years was printed in both the *Rhode Island Republican* (From the *New Haven Herald* 1837) and the *New-Bedford Mercury* (Meteoric shower of November 1837; 1837). Mathematician and astronomer Professor Elias Loomis (1811–1889; Fig. 2.5) of Yale College, wrote a general article on meteor showers for

Fig. 2.5 Elias Loomis (courtesy: en.wikipedia.org)

the *Farmer's Cabinet*, where he remarked on the anticipated periodicity of that of 1833 (Miscellaneous Readings … 1866). The personal account of Parson J.H. Campbell of the 1833 shower was reprinted in *The New York Times* in 1879 (An eye-witness's account of the display of 1833 …, *The New York Times* 1879). The *Afro-American Advocate* wrote a general article on the subject (The November meteors 1892, p. 4), and the Chicago *Broad Axe*, printed a short article on meteors in 1926 (Shower of stars 1926).

As we have already mentioned, Leonid meteor storms (rather than showers) only occur at about 33-year intervals. It is of interest to ask how the 1833 event we have been describing compared with the previous one seen in 1799, and the following one, witnessed in 1866? Yeomans et al. (1996) have addressed this question and shown that the distance of the Earth from the comet when the two orbits crossed determined the intensity of each Leonid meteor storm. They published the plot that we reproduce here as Fig. 2.6, which shows that the storms of 1796 and 1833 were particularly intense, as they lie close to the critical zero (0) line, and prior to this period were mirrored only by the storms of 934, 967, 1238 and 1566. In comparison, the 1866 event was also intense, but not quite as spectacular as these earlier storms.

Consequently, the 1833 and 1866 Leonid meteor storms have a very important place in astronomical history:

> The celestial origins of the Leonids, the determination of their periodic nature, the recognition that they resulted from an orbiting stream of objects, and the identification of this stream with a parent comet, are all landmark events that take on added significance because they represent the origin of the relatively-recent science of meteor studies. Although the 'August meteors' (now known as the Perseids) also played a concurrent role (Littmann 1998), they were not so important as the 'November meteors' (later known as the Leonids), which periodically tended to storm, and thus demanded an immediate explanation. (Dick 1998, p. 2).

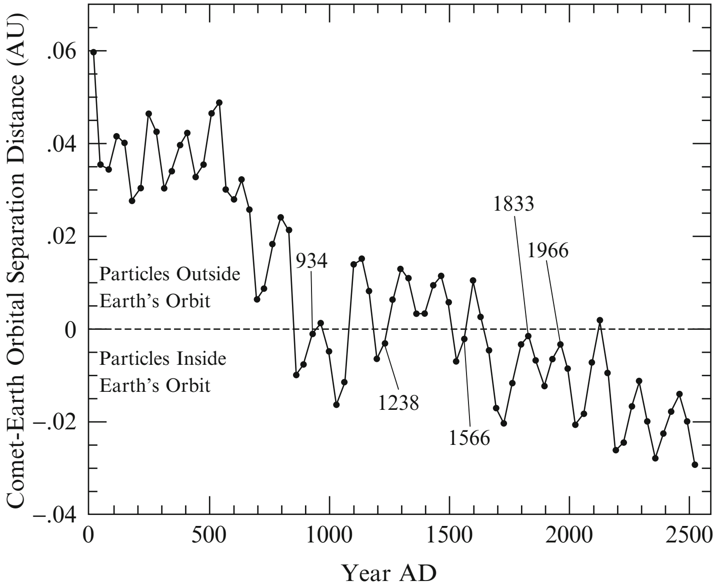


Fig. 2.6 A plot of the minimum distance between Comet 55P/Tempel-Tuttle and the Earth's orbit at the time of the comet's passage through its ascending node (after Yeomans et al. 1996)

Backtracking for a moment to other periodic meteor showers, it was as early as 1834 that one would find in the *Baltimore Patriot & Mercantile Advertiser* a reprint of the *Cincinnati Daily Gazette*'s report by John Locke (1792–1856), a physician, scientist and educator of that city. His observations were of a meteor shower which took place in August of that year. Paling by comparison with the Leonids of the previous November, he approximated there were about 120 meteors visible in 2 h. However, the number was sufficient for him to determine that the 'radiating point' was in Perseus (From the *Cincinnati Daily Gazette* – Meteors 1834). Nowadays the Perseid meteor shower is very popular with amateur astronomers, and is known to be associated with Comet 109P/Swift-Tuttle (e.g. see Brown and Jones 1998; Hughes 1995a; Jenniskens et al. 1998; Jewitt 1996). As we have already seen, this comet played a supporting role in the emergence of meteor astronomy as a scientific discipline (Dick 1998).

2.2 The Great Comet of 1843 (C/1843 D1)

Like meteors, comets were initially deemed to be meteorological rather than astronomical phenomena. Ptolemy's *Almagest* made no mention of comets, while Galileo thought them an optical illusion caused by reflected sunlight (Seargent 2009, pp. 22–23).

Fig. 2.7 The Great Comet of 1843 (after Flammarion 1955, p. 357)

Zochert (1974, p. 449) made the arguable statement:

> Of the many aspects of astronomy, it was comets … which exercised the strongest claim upon the popular mind. The Great Comet of 1843 … generated a popular interest and enthusiasm which persisted throughout its passage.

Marc Rothenberg (1990, p. 45), in his research paper about the Harvard College Observatory, stated: "The Great Comet of 1843 presented Harvard scientists with an opportunity to remind the leaders of Boston that the community leaders were not fulfilling all their responsibilities." David Seargent (2009, p. 233) stated that this spectacular comet, shown here in Fig. 2.7, "… was almost certainly the brightest since 1106 and was probably the most conspicuous … daylight comet on record."

This Great Comet of 1843 was yet another astronomical object noted as among the 100 most significant events in the first century of the United States according to R.M. Devens. He described it as

> … perhaps, the most marvelous of the present age, having been observed in the day-time even before it was visible at night, –-- passing very near the sun, –-- exhibiting an enormous length of tail, –-- and arousing an interest in the public mind as universal and deep as it was unprecedented. (Devens 1878, p. 425).

Camille Flammarion (1842–1925; Fig. 2.8) also noted the initial daylight appearance of this comet: "Cette merveilleuse apparition s'est montrée à tous pour la première fois *en plein jour* le 28 février, a côté du Soleil." (Flammarion 1955, p. 356, his italics).

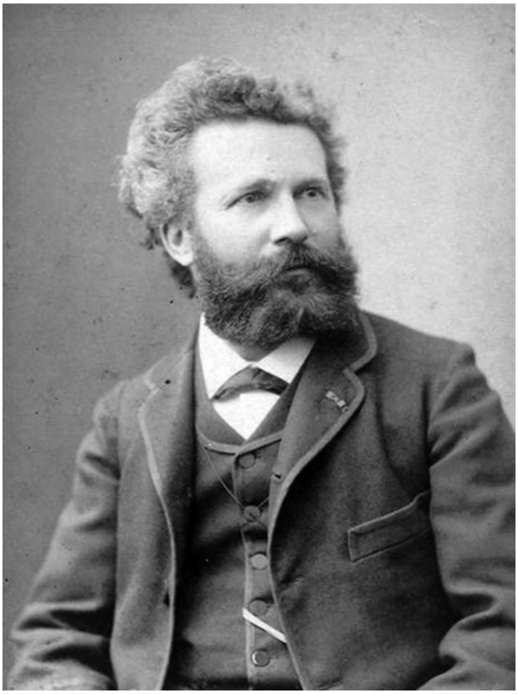


Fig. 2.8 Camille Flammarion (courtesy: en.wikipedia.org)

Reports of the comet were made from sites around the world, including Rome, Naples and Bologna, in Italy; Pernambuco in Brazil; Trivandrum in India; Van Dieman's Land (now Tasmania) in Australia; Concepcion in Chile; Berlin in Germany; Saint Thomas in the Caribbean; and the Cape of Good Hope in South Africa (Devens 1878, pp. 425–426). The United States also contributed to this: "… permanent scientific history …" largely due to the work of Professor Loomis of Yale College. Loomis stated that the most complete recorded observations were carried out by Walker and Kendall of Philadelphia who followed its course until 10 April of that year (Devens 1878, p. 425). At the time Sears Cook Walker (1805–1853; Fig. 2.9) was an amateur astronomer in Philadelphia, but 2 years later he joined the U.S. Naval Observatory, while his half-brother, Ezra Otis Kendall (1818–1899), was Professor of Theoretical Mathematics and Astronomy at the Central High School in Philadelphia—which had one of the best-equipped observatories in America. Some of their data collected at the Observatory were published in *The American Journal of Science and Arts* (Walker and Kendall 1843), in *Astronomische Nachrichten* (Kendall 1843a), and in the *Monthly Notices of the Royal Astronomical Society* (Kendall 1843b, pp. 304–308; Sabine 1843, pp. 294–295).

Many astronomers computed the comet's orbit and found the perihelion distance from the Sun to be quite small, estimated to be within 78,000 miles (Clerke 1902, p. 104). Loomis' opinion was that this accounted for its great brilliance (Devens 1878, p. 429). The comet's velocity around the Sun was quite large at 366 miles a second, enabling it to escape from the Sun's gravity (Clerke 1902, p. 104). The head

Fig. 2.9 S.C. Walker (courtesy: en.wikipedia.org)

was noted to be small in comparison to the very long tail, which on 21 March reached its greatest visible length (Devens 1878, p. 427).

Numerous professional accounts of visual impressions and observations were published in 1843 in the *Monthly Notices of the Royal Astronomical Society* (Henderson 1843a, p. 266; Henderson 1843b, pp. 267–269; Forster 1843a, pp. 269–270; Nasmyth 1843, pp. 270–271; Littrow 1843, pp. 271–272; Schumacher 1843a, b, pp. 272–275; Close 1843, p. 293; Belam 1843, pp. 293–294; Hopkins 1843, p. 295; Montojo 1843, p. 295; Jacob 1843, pp. 295–296; Forster 1843b, p. 296; Pollock 1843, p. 296; Cowper 1843, p. 296; Smyth 1843, p. 297; Caldecott 1843, pp. 302–304; Kendall 1843a, pp. 304–308). E.C.H. (1843, p. 175) published observations and data in the *American Journal of Science and Arts*.

Also in the *Monthly Notices of the Royal Astronomical Society* were extracts from popular reports found in local newspapers. The *Boston Courier* of 1 April 1843 printed a letter from Professor Benjamin Peirce (1809–1880), who taught mathematics at Harvard University, regarding several observations made by William Cranch Bond (1789–1859; Fig. 2.10), inaugural Director of the Harvard College Observatory during the previous month (Peirce 1843, p. 298). There were also reports from elsewhere around the world including Milan, Italy; Madras, India; and Georgetown, Guyana (Abstract, by the secretary 1843, pp. 298–302). Later that year the *Monthly Notices* would note similar newspaper reports from Port Louis, Mauritius (Abstract from an article in *Le Cernéen* 1843, p. 8); Sydney, New South

Fig. 2.10 William Cranch Bond (courtesy: en.wikipedia.org)

Wales (An article extracted from the *Colonial Observer* 1843, p. 8); and New Zealand (Copy of a letter … 1843, p. 8; cf. Orchiston 2001c).

Examples of personal accounts and letters to the editor may be found in numerous American newspapers. In the *New-Hampshire Statesman and State Journal* of 10 March 1843 a writer commented that there were only three previously-recorded comets that were seen during the day and he was excited to report that: "This day, Feb. 29th, a comet of great brilliancy has been seen, visible through the day, without the aid of a glass, and its brilliancy almost equal to that of Venus." (The Comet of 1843; 1843). On 5 April 1843 Sears Walker sent a letter to the editor of the *Boston Courier* providing additional data on the comet, then disappearing from naked-eye visibility, enabling others to follow it for some days to come. On 18 April 1843 a letter was sent to the *Pennsylvania Inquirer and National Gazette* regarding the aforementioned observations by Walker and Kendall at the Central High School Observatory in Philadelphia (To the editor of the *Pennsylvania Inquirer* 1843). On 16 March 1843 the *Pittsfield Sun* printed a copy of a letter from Princeton's Professor Alexander presumably James Waddel Stephen Alexander, 1804–1859 to Sears Walker dated 7 March, in which details of the comet were brought to the latter's attention. On that same page the *Sun* reprinted several articles from other United States newspapers regarding the comet, including one from a correspondent of the *New Bedford Mercury*, one from 'a Vermont Paper' and one from the *National Intelligencer* (Comets and Commentaries 1843). For the benefit of the public, local newspapers might print some of their own researched informative articles. On 11 March 1843 the *Hudson River Chronicle* printed a recap from a report from the

Fig. 2.11 Dionysius Lardner (courtesy: en.wikipedia.org)

Hydrographical Office on the history of previous comets, as well as specifics on sighting the comet currently in the sky (The "Strange Light" Again 1843).

There were public lectures on the Comet of 1843 and the newspapers would print summary articles that might be of interest and of benefit both to those who could and those who could not attend. On 24 March 1843 the *Mississippi Free Trader and Natchez Daily Gazette* printed a summary of such a public lecture given by the well-known Irish science popularizer and former Professor of Natural Philosophy and Astronomy at University College, London, Dionysius Lardner (1793–1859; Fig. 2.11). A topic of concern was the likelihood of a collision of this comet with the Earth, and Professor Lardner assured his audience that the calculation had been made by the French and the odds of the occurrence of such a calamity were determined to be two hundred and eighty million to one (N.O. Bulletin 1843). The report of another lecture was printed in the *Pennsylvania Inquirer and National Gazette* on 29 March 1843. Professor Peirce speculated on the nature of the comet's tail and described how orbits were determined. He also allayed public fears about a possible collision, stating the same odds as Lardner (The Comet of 1843; 1843).

There were short filler articles to remind and update readers on the current comet. On 31 March 1843 the *Farmer's Cabinet* of New Hampshire, in an article on the political news of the day, had a two-sentence paragraph that the present comet was now receding from view and it had been "… one of the most splendid sights which man has ever been permitted to see." (Practical reform 1843). The *New-Hampshire Patriot* of 13 April 1843 published a two-paragraph summary of the receding comet.

Further calculations to determine the complete orbit would be necessary, but its nearest approach and the inclination of the orbit were stated (Comet of 1843; 1843). It is interesting that recent analyses would suggest an orbital period of 742 years, making this a major (possibly the largest) fragment of Comet X/1106 C1 which fragmented in AD 1106, giving rise to the so-called Kreutz Group of bright Sun-grazing comets (see Sekanina and Chodas 2008).

This comet also would inspire the writing of poetry. On 23 March 1843 the *Daily National Intelligencer* reprinted the poem of eight stanzas, "The Comet," which had been submitted to the *New York American*. A common theme, the final lines recognized the part the poet's God had played:

Father of Light! to thee we bow
We seek not more to know, than Thou
Host in thy wisdom given.

On 14 April 1843 another poem of the same title, submitted by H.J.S., was printed in the *Barre Gazette,* again wondering at the mysterious ways of the Lord:

Whence comest thou? aye tell me whence,
Bright wanderer of the skies.

Lingering interest in this particular comet would be evident in newspaper articles years later. On 7 March 1880 *The New York Times* printed an extract from a current lecture by Professor Peirce on the Comet of 1843 (The Great Comet of 1843. *The New York Times*, 7 March 1880 AND The Comet of 1843 *The New York Times*, 28 August 1881). On 28 August 1881 *The New York Times* reprinted an article from *Frazer's Magazine* which presented some details of its historical appearance (The Comet of 1843, 1881).

The Great Comet of 1843, or Comet C/1843 D1 as it is known to astronomers, was best seen from the Southern Hemisphere (e.g. see Fig. 2.12), and from an historical viewpoint was one of the most impressive celestial visitors of the nineteenth century. It was one of the Kreutz group of Sun-grazing comets, and at perihelion, on 27 February 1843, was a mere 830,000 km from the Sun. Less than 2 weeks later, on 6 March, it was closest to the Earth. At this time it was visible during the day, and was brighter than Venus, but it remained visible to the naked eye at night until 19 April. During and after perihelion passage this comet exhibited a remarkably long tail that reached high into the sky, and we now know to have extended for more than 2 A.U., that is, more than twice the distance from the Sun to the Earth (Kronk 2003).

While the Great Comet of 1843 was certainly one of the most impressive comets to grace the skies of North America following the European settlement of that continent, it was by no means the only one to reach naked eye visibility and create a spectacle. Indeed, during the nineteenth century alone, and prior to 1861, at least 7 comets could be observed without the aid of binoculars or a telescope (see Orchiston 1997a, 2002b), and two of these, seen in 1811 (C/1811 F1) and 1858 (C/1858 L1 Donati, also known colloquially as Donati's Comet), were designated Great Comets (Kronk 2003; Seargent 2009). Just 1 year later, in 1861 they were joined by yet another Great Comet, C/1861 K1 Tebbutt, perhaps the most spectacular of them all (see Orchiston 1998b, c), so we anticipate that in the first six decades of the

Fig. 2.12 Drawing of comet C/1843 D1 by Mary Morton Allport, as viewed from Tasmania (courtesy: en.wikipedia.org)

nineteenth century there must have been few Americans who could not claim to have seen at least one naked eye comet. The Chinese liked to call comets ‘broom stars’, and we have seen they also succeeded in sweeping up a public fascination for astronomy in the United States.

2.3 American Astronomy in the Early 1800s

American interest in astronomy in the early 1800s was almost always characterized as ‘utilitarian’, but Zochert (1974, p. 464) refers to an awakening based on *social* utility. More than:

> … the application of science to the needs of production, transportation and material life … [it was for] the social advancement of one’s self in terms of wealth, prestige or culture [and] the social advancement of one’s class, community or nation.

Indeed there was a new cultural nationalism in the United States driven, in part, by a need for intellectual independence from the Europeans. Initially, however, American scientific achievements would be measured against European standards. Starting in the 1830s many of America’s best scientists would travel to Europe to gain a useful knowledge base for their own scientific community.

In the early 1800s astronomy of a practical nature was taught in secondary schools. Students would learn how to calculate figures of the type found in nautical almanacs. At the college level little science of any sort was part of a typical curriculum. Josiah Meigs (1757–1822; Fig. 2.13), the first President of the University of Georgia (1801–1810) had an interest in astronomy and introduced a course on the subject dealing with its mathematical theory only, there being no telescope available for observation (Williams 1996, p. 15). In 1836 Denison Olmsted became Professor of Natural Philosophy and Astronomy at Yale University (Warner 1979). In the years 1846–1847 scientific schools were finally established at both Yale and Harvard Universities. As yet, though, there were still no graduate degree programs available in these subjects (Hubbell and Smith 1992). The pioneering American astronomer Benjamin Apthorp Gould (1824–1896; Fig. 2.14), who among other accomplishments established the *Astronomical Journal*, received his Ph.D. in Germany, and was the first American to do so (Gingerich 1999; Warner 1979).

In Britain and Europe in the 1700s and 1800s public lectures were a popular avocation whereby adults could learn about the sciences (e.g. see Inkster 1980, 1982; Jones 2005). Lectures were attended by women as well as men, and astronomy was a particularly popular subject (Stephenson et al. 2000, p. ii). It took a while for the popularity of the scientific lecture to gain momentum in the United States (e.g. see Inkster 1978), though there were such lectures predating the American Revolution. Sally Gregory Kohlstedt (1990) points out that Benjamin Franklin’s interest in electricity was piqued by such a lecture on the subject of chemistry.

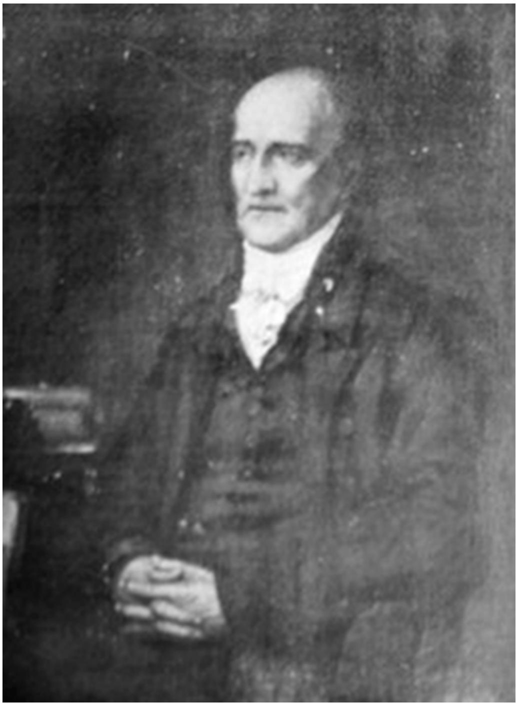


Fig. 2.13 Josiah Meigs (courtesy: www.findagrave.com)

Fig. 2.14 Engraving of Benjamin Apthorp Gould (after *Harpers Encyclopaedia* …: 99, 1905)

Fig. 2.15 Jean Louis Rodolphe Agassiz (courtesy: en.wikipedia.org)

Formalizing the lecture circuit for the education of the American public, associations known as lyceums evolved. In 1829 the Boston Society for the Diffusion of Useful Knowledge was founded (Greene 1958). By 1839, the educational reformer Horace Mann (1796–1859) counted 137 such lyceums in Massachusetts alone. These lyceums would, during the evening hours, convey to the public practical science by means of lectures and demonstrations. At Boston's Lowell Institute there were lectures on religion and science, science being the more popular. Scientists' lectures would need to be repeated to reach all the interested subscribers. Among the popular scientists and educators who lectured at this time were Louis Agassiz (1807–1873; Fig. 2.15) of Harvard University and Ormsby MacKnight Mitchel (1810–1862; Fig. 2.16), who in Cincinnati established an observatory (Fig. 2.17) primarily through donations from the city's citizens (Rossiter 1971).

Among the most influential speakers on the subject of astronomy must be included John Quincy Adams (1767–1848; Fig. 2.18), the sixth President of the United States. Ever an advocate of the study of astronomy, he undertook a number of speaking engagements to promote astronomy and encourage the use of part of the generous bequest from the British chemist and mineralogist James Smithson (1765–1829) to establish a national observatory. In 1839 he answered an invitation by the Lyceum of the Apprentice Mechanics' Association to speak in Quincy and Boston. His lectures were open to the public. Adams described one of his audiences: "The hall was filled to its utmost capacity with two or three women to one man." (Portolano 2000, p. 499).

In its earliest years the mission of Harvard College had been to prepare its students for the ministry. However, in 1642, there were students who defended astronomical theses. As early as 1646, students would be selected to gather astronomical information for publication in the Harvard almanacs. As Genuth (1990,

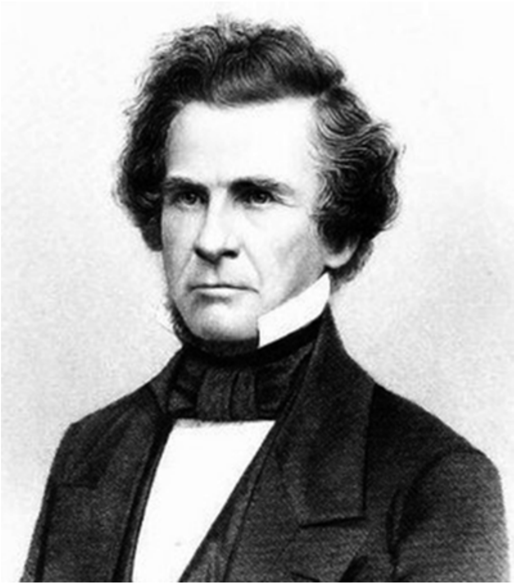


Fig. 2.16 Ormsby MacKnight Mitchel (courtesy: en.wikipedia.org)

Fig. 2.17 The Cincinnati Observatory, which was founded in 1842 by Professor O.M. Mitchell from Cincinnati College (courtesy: www.cincinnatiobservatory.org)

Fig. 2.18 Details from as portrait of John Quincy Adams, painted by George Caleb Bingham in about 1850 from an original dated 1844. Quincy was a U.S. President with a passion for astronomy (courtesy: en.wikipedia.org)

pp. 9–10) notes, "Almanacs were the most widely distributed item to issue from the colonial press, and prior to the advent of newspapers in the eighteenth century, they were the sole form of periodic literature in New England." These almanacs were printed for the public and served to popularize astronomy with such articles as those on Copernicus, Kepler, comets and telescopic observations.

According to the Boston publication of 1804, *The Catalog of All the Books Printed in the United States*, no more than 20 of the 1,338 titles listed dealt with scientific topics, not counting medical texts (Greene 1958). Kohlstedt (1990) recognized that the early nineteenth century in the United States was a period of increased literacy. Printed matter regarding science in journals, newspapers and books was becoming increasingly desirable and available to the public. Reading became physically easier with the production of eyeglasses and improved lighting. The distribution of books spread from the bookstore and the street hawkers to include mail distribution subsequent to mass advertising. Books also became available through subscription libraries (Zochert 1974).

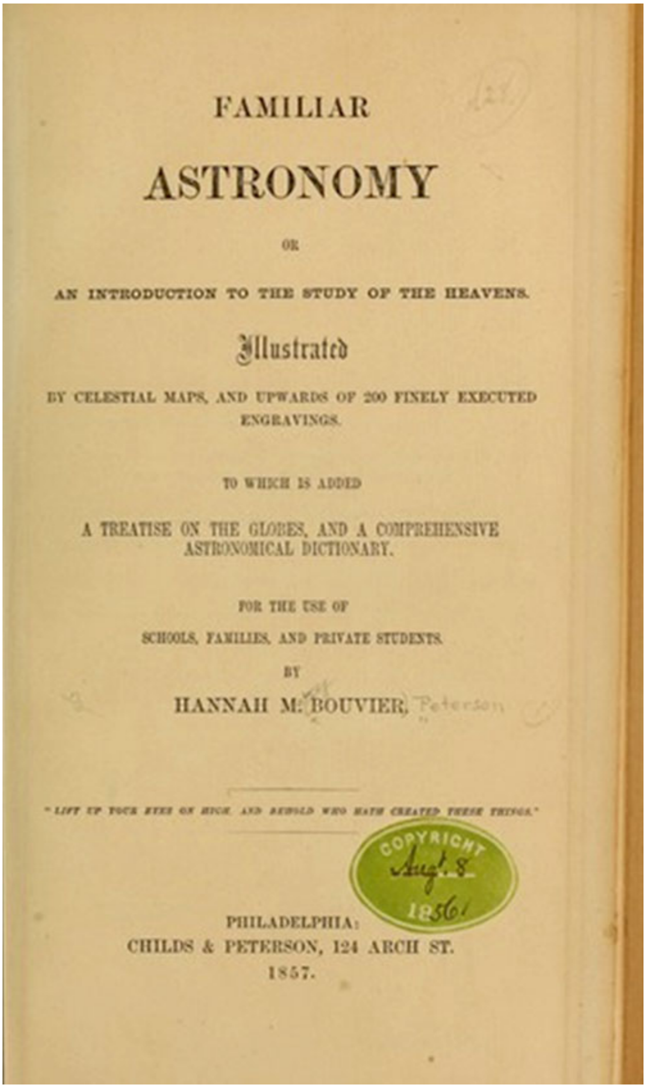
Most of the earliest astronomical texts in the United States of any scholarly maturity were reprints of English works. Among such valuable works was the first edition of John Herschel's *Treatise on Astronomy*, published in 1824. In his preface to the American edition Sears C. Walker (1842, p. vii) assures the reader that in this volume one would find: "… information nowhere else to be obtained." To read his *Treatise* Herschel (1842, p. 10) recommends only a familiarity with decimal arithmetic, though some knowledge of geometry and/or trigonometry might be helpful for the understanding of the optics of the telescope. According to Deborah Jean Warner (1979) the first such American publication of comparable value was John Gummere's *Elementary Treatise on Astronomy*, first published in 1822. Gummere

Fig. 2.19 John Gummere, the first American to publish a popular textbook book on astronomy (courtesy:www.haverford.edu)

(1784–1845; Fig. 2.19) was a highly-skilled educator who taught at Haverford College, in Haverford, Pennsylvania. However, we could say that Gummere was partially 'trumped' by fellow-American Elijah Burritt, who in 1818 as a talented 24-year old student at William College penned his first book, *Logarithmick Arithmetick*. Despite the off-putting title, about half of this book deals with astronomy. Elijah Hinsdale Burritt (1794–1838) initially taught himself astronomy before continuing his studies more formally at Williams College. Later, while living in New England and running a school equipped with an observatory he wrote *Geography of the Heavens*. This was first published in 1833, and was intended as an astronomy textbook for children. Burritt (1849 edition: preface) also wished it to be considered for "… proper instruction …" for the general public. His book covered the description of the constellations, and some science of celestial phenomena. In his biographical study of Burritt, Brooks (1936, p. 297) says:

> He had a thorough knowledge of the astronomy of that period, and also a gift of writing in such a simple, interesting and attractive way as to hold the attention of the reader. Consequently his books became popular and were used in many schools and colleges.

Women, too, through the printed word, were able to share in the growing popular enthusiasm for astronomy. Magazines intended for women, such as *Godey's Ladies Book* would often contain scientific articles (Kohlstedt 1990). There also were books and pamphlets written specifically for the female audience, for example, Elijah Burritt's 28-page pamphlet titled *Astronomia … Designed for the Amusement and Instruction of Young Ladies and Gentlemen* … (1821) and Denison Olmsted's *Letters on Astronomy Addressed to a Lady* (1840). At the time he wrote *Astronomia* … Burritt was a school teacher in Milledgeville, which was then the capital of the state of Georgia (Brooks 1936). Meanwhile, we have already met Denison Olmsted, the gifted Yale Professor who pioneered meteor studies.



FAMILIAR

ASTRONOMY

OR

AN INTRODUCTION TO THE STUDY OF THE HEAVENS.

Illustrated

BY CELESTIAL MAPS, AND UPWARDS OF 200 FINELY EXECUTED ENGRAVINGS.

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FOR THE USE OF

SCHOOLS, FAMILIES, AND PRIVATE STUDENTS.

BY

HANNAH M. BOUVIER, Peterson

"LIFT UP YOUR EYES ON HIGH, AND BEHOLD WHO HATH CREATED THESE THINGS."

COPYRIGHT Aug. 8 1856

PHILADELPHIA:
CHILDS & PETERSON, 124 ARCH ST.
1857.

Fig. 2.20 Front cover of Familiar Astronomy … (courtesy: openlibrary.org.books)

Eventually women would even write books themselves, e.g. Hannah Mary Bouvier Peterson's *Familiar Astronomy* … (see Fig. 2.20), which was first published in 1855 and was reprinted in 1856 and 1857, and then followed by two later editions, both published in 1858 (Reed n.d.). In the preface to *Familiar Astronomy* Peterson (1857) states that her book is intended

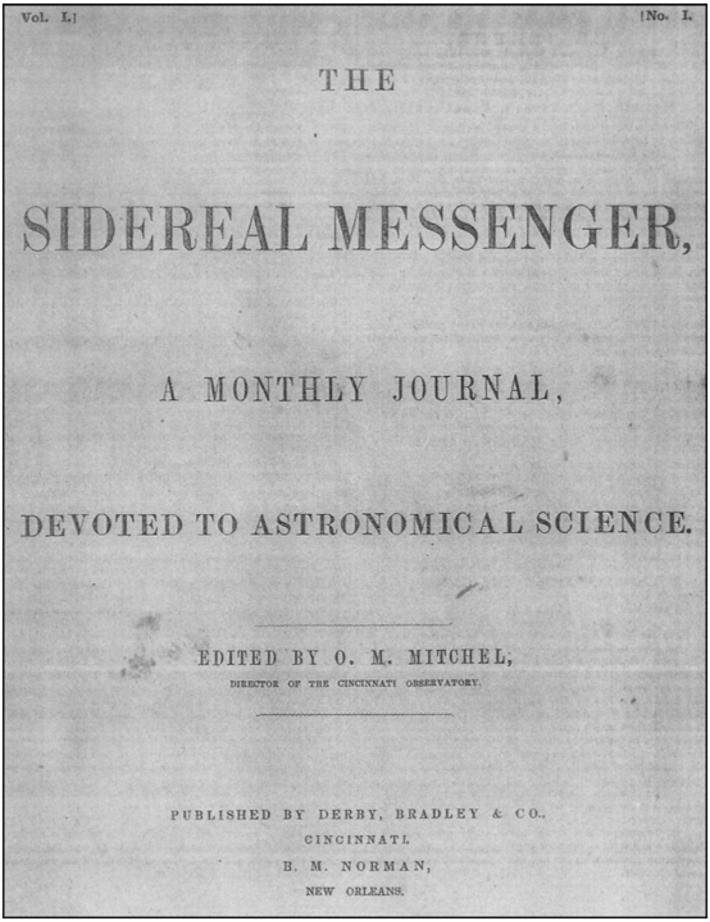
Fig. 2.21 A painting of Benjamin Silliman (courtesy: en.wikipedia.org)

> … to be a complete treatise on Astronomy conducting the pupil step by step from the base to the summit of the structure; explaining as far as practicable, by figures and diagrams, all the celestial phenomena, and the laws by which they are governed, without entering into those mathematical details which properly belong to treatises designed for those who propose to make astronomy their chief study.

According to Warner (1978, p. 64), the 499-page 1857 book was: "… highly commended by George Airy and John Herschel." This is high praise indeed and reflects Peterson's talent as a writer, yet we know very little about her. She was born Mary Bouvier, in Philadelphia, in 1811, and her father was a prominent author and jurist so he made sure his daughter received a good education. Astronomy was one of her interests, but it was only after she married the physician Robert Evans Peterson that she had the time, knowledge and inclination to pen *Familiar Astronomy* … She died in Long Branch, New Jersey, in 1870 (Reed n.d.).

American scientific periodical literature was also coming into its own in the United States during these years. Benjamin Silliman (1779–1864; Fig. 2.21) founded the *American Journal of Science* in 1818. Though intended for an audience of scientific men its nature was not very technical and it covered a variety of non-mathematical subjects, including astronomy (Holden 1897).

The publication of a journal, *The Sidereal Messenger* (see Fig. 2.22), by O.M. Mitchel of the Cincinnati Observatory began in July 1846. This was the first astronomical journal in the United States. Of the few astronomical journals in the world, it was the only one of a popular nature. Mitchel planned to have 12 issues per



Vol. I.] [No. I.

THE

SIDEREAL MESSENGER,

A MONTHLY JOURNAL,

DEVOTED TO ASTRONOMICAL SCIENCE.

EDITED BY O. M. MITCHEL,

DIRECTOR OF THE CINCINNATI OBSERVATORY.

PUBLISHED BY DERBY, BRADLEY & CO.,

CINCINNATI.

B. M. NORMAN,

NEW ORLEANS.

Fig. 2.22 The *Sidereal Messenger* (courtesy: Cincinnati Historical Society; photograph by the first author)

year with occasional extra issues that would be scientific. He endeavored to keep language simple, to define all scientific terms and to keep the reader current in all significant astronomical research worldwide. The journal was eight pages in length and would include one engraving. He learned to do the engravings himself to save money. Mitchel hoped the journal would be a money-maker to help support the Cincinnati Observatory but he found it increasingly difficult to collect subscription payments. Financial circumstances forced him to end publication after a little more than 2 years (Mitchel 1846–1848).

Broadsides were another form of published matter useful for conveying scientific information to the public. These might provide facts and simple explanations or announce upcoming events. Edmund Halley (1656–1742) published a broadside for the public “Description of the Passage of the Shadow of the Moon over England” describing and illustrating the predicted path for the upcoming solar eclipse of 1715 (Pasachoff 1999). He published a second one for the solar eclipse of 1724 (ibid., Walters 1999). The previously-alluded to presentations of astronomical theses delivered at Harvard were advertised by commencement broadsides (Genuth 1990). Figure 2.23 is an example of one printed in Massachusetts in 1838, advertising and describing a series of lectures on an astronomical topic. Broadsides were inexpensive, frequently illustrated and simple in vocabulary, therefore appealing to the general public (Veron and Tammann 1979).

Kohlstedt (1990, p. 435) pointed out that during the Antebellum period, the years just before the American Civil War, newspaper circulation increased at twice the rate of the population. Zochert (1974, p. 448) quotes the poet William Ellery Channing (1817–1901) who wrote in 1841: "Through the press, discoveries and theories, once the monopoly of the philosophers, have become the property of the multitudes … Science, once the greatest of distinctions is becoming popular." Zochert (1974, p. 449) goes on to state: "… astronomy was clearly the most accessible and appreciated." Of peculiar interest might be the filler material used in newspaper columns relating scientific facts. Zochert (1974, p. 452) shared one from the Milwaukee *Courier* of 1 December 1841 reporting that "… the density of the planet Mercury was equal to that of lead, while that of Saturn was closer to that of cork." *The New York Times* began publication in 1851 and usually was eight pages in length during its early history. It was published daily except on Sunday, until the period of the Civil War when it began daily publication. It has been published continuously up to present day (Mott 1941, pp. 428–429), and it should provide some evidence of the degree of interest in the specific astronomical events to be considered in this study.

Astronomical instruments and equipment available to the American public were frequently imported from abroad in the young nation's history. Available were sundials, globes, orreries, star maps and telescopes, but these were frequently crude conversation pieces, of little value for astronomical studies. James Wilson (1763–1855) of Bradford, Vermont, and later Albany, New York, was America's first commercial globe-maker, producing both terrestrial and celestial globes by 1815 (Warner 1979). Figure 2.24 is a drawing of Wilson at work in Bradford, while the following figure shows one of these globes that is now in the Adler Planetarium in Chicago, Illinois. This was manufactured out of wood, paper, plastic and metal by J. Wilson & Sons in 1831.

Placed next to the celestial globe in Fig. 2.25 is an example of a pocket globe. It was created by the Holbrook Manufacturing Company of Westerfield, Connecticut out of wood and paper in about 1850. Figure 2.26 shows the pocket globe opened. These two items were tools of instruction and popularization, and possibly symbols of class stature. They would be of little or no use to a professional astronomer.

During the Antebellum period more complex apparatus for astronomical demonstrations, such as orreries, were also coming into popularity. The renowned Pennsylvanian self-taught astronomer, surveyor and scientific instrument-maker David Rittenhouse (1732–1796; Fig. 2.27) and the famous Boston clock-maker Joseph Pope (b. ~1750) created 'elegant orreries' for Princeton and Harvard Colleges, respectively (Warner 1979, p. 58). Warner (1979, p. 57) describes how: "… public education for women, practically non-existent in the colonial and early

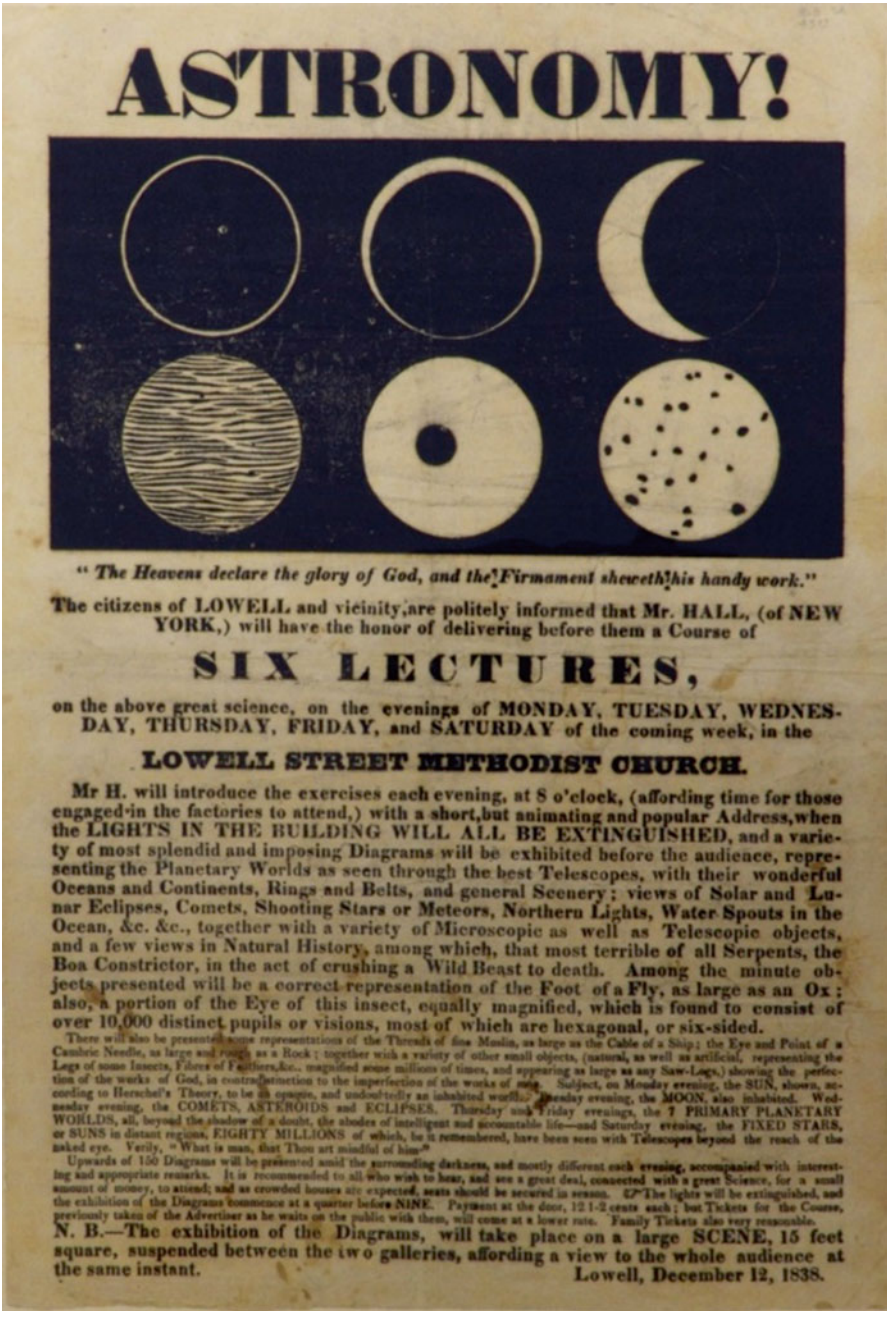


Fig. 2.23 An American broadside (courtesy: Adler Planetarium and Astronomy Museum, Chicago, Illinois)

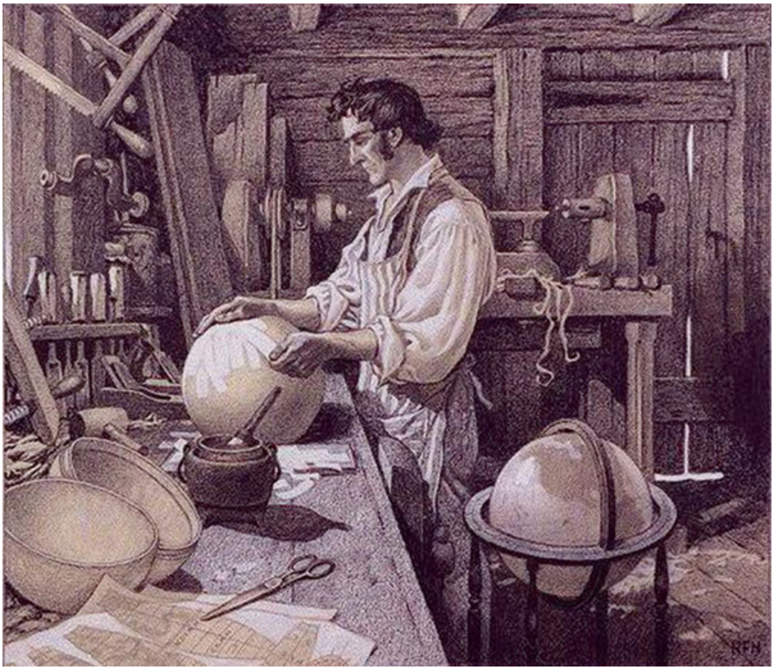


Fig. 2.24 "James Wilson, the Vermont Globe Maker, Bradford, Vermont, 1810" by Roy Frederick Heinrich (courtesy: www.findagrave.com)

Fig. 2.25 A celestial globe made by J. Wilson & Sons in 1831 (courtesy: Adler Planetarium and Astronomy Museum; Chicago, Illinois, photograph by the first author)

Fig. 2.26 A pocket globe made by the Holbrook Manufacturing Company (courtesy: Adler Planetarium and Astronomy Museum; Chicago, Illinois, photograph by the first author)

Fig. 2.27 Oil painting of David Rittenhouse by Charles Wilson Peale (courtesy: en.wikipedia.org)

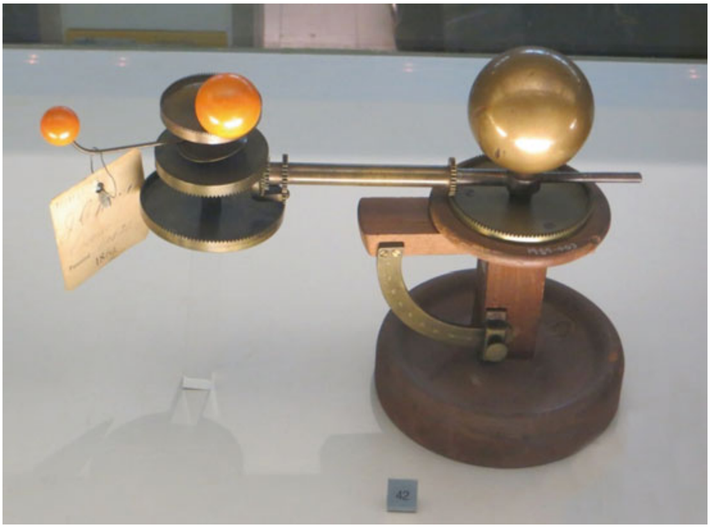


Fig. 2.28 An orrery made by the American John G. Moore, Inventory Number 1989-463 (courtesy: Science Museum, London; photograph by the first author)

republican periods, began to flourish in the 1820s." Female colleges and seminaries evolved and scientific paraphernalia were frequently prime attractors to potential students. The Young Ladies' High School in Boston owned an orrery that it claimed was: "… one of the best instruments of the kind in the country." Warner (ibid) points out that these items served more as public relations devices than as proof of the quality of science education. Figure 2.28 is a photograph of an orrery made by John G. Moore of Philadelphia in 1865. As described where displayed at the Science Museum in London, "This model is an improved design of orrery in which the Earth's axis moves round a small circle to give an elliptical orbit around the Sun."

According to Warner (1979), William Croswell drew the first American-made star chart, published in 1810. It introduced two new uniquely American constellations, the Flying Squirrel and the Bust of Columbus. Though a crude perspective of the sky, it was useful for some basic astronomy instruction (e.g. see Kanas 2009).

A particular kind of star map known as a planisphere was developed in the mid-eighteenth century and became very popular in the nineteenth century (Hughes and Stott 1995; Orchiston 1997a, 2003b). These cardboard devices were based on a circular star map developed for a particular latitude with an overlaying disk that might be adjusted to reveal the particular part of the sky that would be visible for a certain time on a certain date (Hughes and Stott 1995). As stargazing was becoming a popular pastime, planispheres were very helpful in the identification of the constellations. Figure 2.29 is an American-made planisphere dating to about 1828 which is part of the Adler Planetarium collection. Note that decorative planispheres, like this one, with the outlines of the constellation figures, were gradually replaced by the less artistic, but more functional, black-and-white versions over the years.

Fig. 2.29 A nineteenth century American-made planisphere (courtesy: Adler Planetarium and Astronomy Museum, Chicago, Illinois)

According to Warner (1979), the most significant advance in astronomy in the Antebellum period of the United States was the new telescope technology. Telescopes were of better quality and they were cheaper, becoming more accessible to more institutions and individuals. At this time refractors were still favored over reflectors, which did not gain popularity until speculum metal mirrors were replaced by silver on glass mirrors later in the century. The newer technology also permitted the manufacture of larger and higher-quality lenses for refracting telescopes. In the 1840s Henry Fitz (1808–1863), the first significant professional telescope-maker in the United States, made refractors that were cheaper than those of his European counterparts (Abrahams 1994), and as a consequence American schools and colleges started buying American telescopes. Thus, Fitz telescopes like the one shown in Fig. 2.30 went to the Elmira Female College, Mount Holyoke Seminary and the Packer Collegiate Institute. Steven Turner (2010) from the National Museum of American History in Washington D.C. notes that between 1840 and 1855 Fitz manufactured about 80 % of the telescopes made

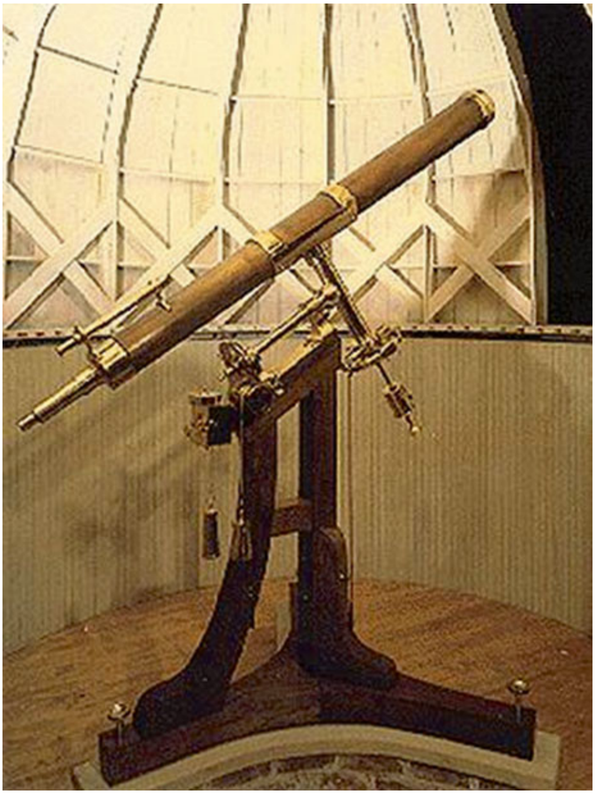


Fig. 2.30 A 7-in. Fitz refractor manufactured in 1849 (courtesy: Robert Ariail)

in America, and these "… were important in increasing American interest [in] and knowledge of astronomy." Later, in the 1850s, Alvan Clark (1804–1887; Fig. 2.31) would make telescopes generally recognized to be equal in quality to those of the Europeans (see Warner 1968).

There was industrial and technological growth in the United States throughout this period, which continued during the turmoil of the Civil War in the early 1860s. After the War this growth was more dramatic. Machine manufacturing was rapidly replacing manual labor, leading to more leisure time for indulgence in entertainment, cultural and scientific pursuits. During this period of growth several significant astronomical events took place. Besides the afore-mentioned meteors and comets, there were the two transits of Venus, in 1874 and 1882. Also of interest were numerous solar eclipses, which would now be better studied and understood due to the new technological advances of recent years. It was during the solar eclipse of 1868, visible from Aden to the Dutch East Indies, that the science of spectroscopy was first applied, but the next total solar eclipse, in 1869, and another in 1878, would be visible over much of the United States.

Fig. 2.31 A portrait of Alvan Clark (after Gerry 1891)

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Eclipses, Transits, and Comets of the Nineteenth Century
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